Volume XVIII May, 1918 Number 4

TECHNICAL PUBLICATION NO. 10

OF

THE NEW YORK STATE COLLEGE OF FORESTRY

AT

SYRACUSE UNIVERSITY

I. Notes on Insects Bred from the Bark and Wood of the American Larch

BY

M. W. BLACKMAN and HARRY H. STAGE

II. On the Insect Visitors to the Blossoms of Wild Blackberry and Wild Spiraea—A Study in Seasonable Distribution

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I. NOTES ON INSECTS BRED FROM THE BARK AND WOOD OF THE AMERICAN LARCH — LARIX LARICINA (Plu Roc.) Koch.

By

M. W. Blackman, Ph. D., and Harry H. Stage, M. S.

NOTES ON INSECTS BRED FROM THE BARK AND WOOD OF THE AMERICAN LARCH — LARIX LARICINA (Du Roc) Koch

By M. W. Blackman, Ph. D., and Harry H. Stage, M. S.

Several years ago the senior author was impressed by the fact that in comprehensive reports upon forest insects, such as those of Packard ('90), Hopkins ('93, '99) and Felt ('06) a considerable number of boring insects are recorded from pine, spruce and several other conifers but only a very few are reported from the American larch. For instance, Packard ('90) mentions only three borers in larch — *Dendroctonus* sp. (doubtless *D. simplex*), *Hylesinus opaculus* (probably *Polygraphus rufipennis*) and *Tomicus* (*Ips*) *pini*, — although he treats at considerable length thirty-three insects affecting the trees in other ways. Hopkins ('93) in his Catalogue of Forest and Shade Tree Insects of West Virginia mentions no insects from larch, while Felt ('06) lists but three boring insects from larch — *Leptura sub-hamata* Rand, *Tomicus* (*Ips*) *pini* Say and *Tomicus* (*Ips*) *caelatus* Eich. More recent papers by Swaine ('11) and by Hewitt ('12) dealing with larch insects list *Dendrotonus simplex* Lec., *Ips balsameus* Lec., *Dryocoetus autographus* Ratz., *Dryocoetus* n. sp. and *Ips caelatus* Eich. as borers attacking recently felled larches or trees weakened by the defoliation of the sawfly.

As it was believed that this paucity of forms known to inhabit the bark and wood in the larch was due at least in part to lack of study of this tree as a host for boring insects, it was decided to take the first opportunity of making such a study. Such an opportunity was offered when the junior author on his return from his home reported the presence of many dying and dead larch near Crittenden, Erie county,

N. Y. He was persuaded to return immediately and to ship to the laboratory a liberal amount of material showing as great a variety of conditions as possible.

On account of the fact that the infested larch was at a considerable distance from Syracuse (about one hundred and thirty-one miles) the ideal method of procedure in such studies — which should consist of field work and insectary work so co-ordinated as to check each other and to give the best results — were necessarily modified. The field work was reduced to a minimum and all field observations were made by the junior author at such odd times as opportunity offered. However, the work was so planned and conducted that the results obtained were in no way weakened. In fact, in a study of this sort the field work aside from the actual collecting of the infested wood, can be dispensed with much more readily than the insectary work; which, on the other hand, is indispensable because of the impossibility in the present state of our knowledge of identifying the immature stages of many boring insects.

The method followed consisted in bringing to the laboratory generous samples of various parts of infested trees. A careful and full record of the character and history of each lot was kept and each lot was placed in a separate breeding cage. The cages were then placed out of doors so that the conditions would be normal and as near as possible what they would have been if left in their original location. The breeding cage used consists of a strong, well-constructed frame of 2 x 2 cypress. The top is covered with fine copper wire mesh, while the sides are sheets of glass lowered into grooves in the frame. To the bottom of the frame is attached a metal flange which may either be fitted into an especially constructed base or may be pressed down into the soft earth. In most of our work the latter method was used and this was true of all of the outdoor breeding work. In these cages the sticks were propped up with one end resting upon the loose soil or embedded in it, and, except in very dry weather, the wood absorbed enough moisture from the loose earth to keep it in fit condition for the insects living within. When the weather was too dry, water was occasionally sprinkled on the pieces of wood to prevent conditions from becoming too unfavorable. In any event the conditions were doubtless as uniformly favorable as they would have been had the material remained undisturbed in its natural environment.

The various breeding cages were examined daily and all insects which had emerged were kept separate with full data. As the exact source of each insect emerging was scrupulously recorded it was an easy matter later to find the various sorts of insects associated in the same pieces of wood and in similar wood from other trees or regions of trees. By supplementing such data with later study of the wood it is often possible to secure evidence to establish either absolutely or probably that certain insects bear the relation of parasite and host to each other. Whenever practicable the exit hole made by an emerging insect was found and marked with the same lot number as the insect which came from there. Later this burrow was opened and the character of the larval mine and pupal chambers studied. Specimens of several sorts of larvæ were also taken at intervals; and, by a later careful comparison of such records of adults, burrows and larvæ as was thus obtained, it was often possible to connect absolutely the various stages of the insect and the burrow it produced.

Description of Woodlot From Which the Larch was Secured

With the exception of five pieces obtained from Wanakena, N. Y., all of the infested larch used in this study was secured from near Crittenden, N. Y. Crittenden is twenty-one miles east of Buffalo, in the northwestern part of Erie county. The woods from which the larch was taken is one of considerably larger dimensions than is usually met with in that section. The tract comprises about one hundred acres. The larger part of it is owned by the New York Central Railroad, the rest belonging to the adjoining farms.

The greater number of tree species in this track belong to the climax forest type — the principal ones being hard-maple, beech and hemlock. On the higher areas a few white pines are scattered among the hardwoods. Only in two areas is the larch to be found. This tract of timber is practically in a virgin condition, doubtless owing to the fact that it is owned by the railroad. The area has apparently never been lumbered and presents fairly good forest conditions — that is the general conditions are excellent for tree growth.

As previously stated the larch is to be found in two separated areas, a western group having between thirty and fifty trees, and an eastern one of between four and five hundred trees. These two areas, which are lower and therefore moister than the surrounding woods, are about two hundred and fifty yards apart and between them is a dense undergrowth consisting principally of poison sumach, willow, etc. In these areas, the larch predominates, the total number of larch outnumbering all other species of trees combined. All sizes of larches are present, from saplings up to trees of about 14 inches D. B. H. Reproduction is good although of course many of the smaller trees have been killed by suppression due to shading.

A number of the larger larch trees (6 inches D. B. H. and up) have been weakened or killed each year for a number of years by the removal of the bark by farmers. A decoction made by steeping this bark is thought to make an excellent spring tonic for horses and is used by the farmers of this locality for that purpose. On all parts of the tract, trees may be found from which more or less bark has been stripped — these often being completely girdled from the ground up to a height of about six feet. Trees completely girdled in this way are of course killed immediately while trees stripped of their bark on one side only, are not killed outright but are greatly weakened. Both dead and weakened trees serve as favorable breeding places for many different sorts of insects, and it is with insects entering the tree under such conditions that we deal with principally in this paper.

Aside from these trees killed or weakened by the stripping off of the bark, the larch trees are under conditions such as exist in practically virgin timber. This means that many of the trees have reached their maximum growth — have become matured — and some such trees are deteriorating more or less rapidly. The presence of the excellent breeding places offered by the girdled larch had resulted in an increase of many insect enemies — several of which have increased beyond the danger level. These are already successfully attacking and killing not only the trees weakened by stripping off part of the bark but also apparently have in the last year or two killed a number of trees which were over-mature but were otherwise uninjured. Indeed the conditions here are in many respects similar to those reported by Swaine ('11) in a larch wood near St. Anne's, Que. There several trees had been allowed to remain in the forest after felling and these had acted as an excellent breeding place for a number of scolytid beetles. Several of these were bred up to such numbers that they were able to attack and kill the living larches remaining. Of the five bark beetles breeding in this larch, including *Dendroctonus simplex*, *Ips balsameus*, *Ips caelatus*, *Dryocoetes autographus* and *Dryocoetes* sp., Swaine considers only the first two as serious enemies of the larch.

In the larch woods at Crittenden, the trees which had been girdled by farmers in obtaining bark, had acted in much the same manner — as incubators for a number of insects breeding in dying or dead larch. The numbers of several of these had increased beyond the danger level and they were able to attack and kill trees over-mature and deteriorating. Several of the trees from which most of the material for this study was derived had apparently been killed in this manner.

In our study Trees I and X, as described later, were trees weakened by over-maturing and their death is believed to have been caused or at least much hastened by insect work. Insects found in both of these trees and in others under nearly similar conditions included the scolytids *Polygraphus rufipennis* and *Eccoptogaster piceae*, the cerambycid *Asemum moestum*, always working very near the base of the tree, and the melandryid *Serropalpus barbatus*. *Dendroctonus simplex* was present in the bark of the basal twenty feet of the trunk of Tree I and of others examined in 1915 and 1917, but no signs of it were to be found in Tree X. There can be little doubt that these insects working in the trunk together with a number of borers which typically attack the branches and the uppermost parts of the trunk such as *Neoclytus longipes, Leptostylus sex-guttatus, Pogonocherus mixtus,* and the three species of *Chrysobothris* — *C. blanchardi, C. sex-signata* and *C. dentipes* — greatly hasten the death of many weakened trees. *Melanophila fulvoguttata* and *Phymatodes dimidiatus* are two other borers which are often associated with them (the latter only in the lower trunk) the first of these being a well-known enemy of weakened spruces and hemlocks.

However, in the bit of woodland studied, these insects are not working unhampered, but natural forces are at hand which to some extent at least are tending toward the reestablishment of the normal balance of forces and toward the return to a more favorable condition for the larch. The work of woodpeckers is much in evidence and seems to be an efficient agency in reducing to some extent the numbers of the brood of several of the more numerous bark-boring insects. The birds seem to work in two ways — first by making small conical holes through the bark into the sapwood to obtain the larvæ of the larger species of beetles which have gone there to hibernate or to pupate, and secondly by removing practically all of the bark on large areas of the trunk to uncover the brood (larvæ, pupæ and young adults) of the bark beetles.

In some cases this work reached an unusual degree of efficiency. For instance one particular tree forty or fifty feet high and about 14 inches in diameter, had had nearly all of the bark removed from the ground to the very tip. (Figs. 5, 6.) This tree had been heavily infested with *Dendroctonus simplex, Polygraphus rufipennis* and other borers, but only a small per cent of the original infestation had survived the woodpeckers' thorough search for food. Of course all of the infested trees had not been so thoroughly gone over by the birds and a number of such trees had apparently not been found by them at all. However, it is safe to say that the woodpeckers were an efficient force, working toward the return of the normal balance of nature which had been upset by the breeding of certain species of insects above the danger level, due to the girdling, season after season, of a number of the larches by farmers. It is not believed that the woodpeckers will be able unaided to reduce the numbers below the danger level, as long as more trees are girdled each year, but should this practice cease it is possible that they would be able eventually to obtain the upper hand and that conditions would return to normal.

Field Work

The field work consisted in locating the infested trees, securing as many species of insects from them in the field as possible, noting the condition and probable date of death of the host tree, and securing all other data that was thought might be of value. The fact that many of the trees had been partially stripped of their bark by woodpeckers in search of grubs was made use of in readily finding such trees under winter conditions. The infested trees were cut down and samples of the various parts of the trunk, of the top and of the branches were selected. These different lots were labeled and shipped to the laboratory where they were placed in outdoor breeding cages as recorded previously.

The larger part of the material was obtained in the field April 28 and 29, 1916, but from this time till April, 1917, as occasion offered smaller lots were added. The material placed in breeding cages and from which insects were bred out was derived from eleven different trees showing a variety of different conditions. Some of these samples were from standing trees only recently dead, some from standing trees dead 1, 2 or more years and some from trees which had been blown over several years.

In the following pages these various trees are described and the insects derived from each are listed. The material from the first eight of these trees was shipped from Crittenden April 29, 1916, while the rest was obtained later, at various times, as indicated.

Tree No. I was a large larch of about 14 inches D. B. H. and about 50 feet high. It had probably died late in 1914 from unknown causes as it had not been stripped of its bark. It was the one tree found in the spring of 1916 which contained living specimens of *Dendroctonus simplex*. The lower part apparently had survived longer than the branches as the lower trunk was still somewhat sappy. This tree was rather interesting from the fact that a large part of the bark from the ground to the tip had been removed by woodpeckers in search of various bark boring insects. Under the portions of bark still adhering many specimens of *Polygraphus rufipennis* and *Dendroctonus simplex* still remained, but it needed only a casual examination of the bark to discover that a very large percentage had been uncovered and destroyed by the birds.

More material was taken from this tree than from any other one source. In one cage was placed the first segment of the trunk, the lower end of which was taken from only 6 inches above ground. The bark on this section was riddled by the burrows of *D. simplex* and *P. rufipennis* and the sapwood contained many larvae of *Asemum moestum*. These latter were so numerous that just above the root 6 larvae were taken from an area of the wood only 6 inches square. In addition to these, three other species were bred from this section of the tree: the buprested *Melanophila fulvoguttata*, the weevil *Dryophthorus americanus*, and a small fly *Pollenia rudis.*

In another cage was placed the next section of the trunk taken from 18 inches above ground. In the field *D. simplex*, *P. rufipennis* and the larva of a clerid, apparently *Phyllobaenus dislocatus*, and of a cerambycid, *Asemum moestum*, were taken. The adults of all of these and in addition of *Serropalpus barbatus* were bred from this wood.

In another cage was placed a section of the trunk from 3 feet above ground, this and the two pieces already described having been continuous and forming the base of the tree.

From it were derived *P. rufipennis, D. simplex,* several specimens of *Phyllobaenus dislocatus* and two hymenoptereous parasites,— a small undetermined chalcid and *Spathius tomici*,—these being parasitic upon the bark beetles. It is worthy of note that *A. moestum* so numerous in the first segment and still present in the second is no longer found in this section beginning three feet above ground.

In another cage was placed a portion of the trunk taken from 30 feet above ground. Burrows and specimens of *P. rufipennis* were quite numerous but none of *D. simplex* occurred this far up. In the breeding cage this section of trunk yielded in addition to *P. rufipennis*, one specimen each of the clerid *P. dislocatus*, the lampyrid *Podabrus diadema* and a small undetermined chalcid.

Another sample was taken of the trunk at its extreme tip about 50 feet above ground. *P. rufipennis* was taken from this in the field and the engravings were nearly as numerous proportionately as in other regions of the trunk (Fig. 2). No other insects came from this section of the tree in the cages although the bark shows exit holes of both cerambycids and buprestids. These had apparently emerged before the sample was placed in the breeding cage, showing that the tip of the tree had probably begun to die earlier than the lower part — this being in line with the conditions found in the lower branches where *E. piceae* was breeding and in the lower trunk which was still sappy in some parts.

Numerous specimens of the limbs of this tree were taken. These are from 1 to 2 inches in diameter and are from a height of from 18 to 45 feet above ground. The bark upon these limbs is thin with only a small scaly and corky layer and was apparently quite dry and clung tightly to the wood. Some of the burrows in it, however, contained drops of resin showing that the bark had been attact while still sappy. In the field these samples yielded *P. rufipennis* and the larvae of a clerid, of a buprestid and of a small cerambycid. This material was kept out doors in two separate breeding cages (there being too much for one) during the summer till September 28, and the following insects emerged during that time: *P. rufipennis, Eccoptogaster piceae, P. dislocatus,* a small moth *Epicallima argenticinctella* Clem., several undetermined psochids, and several parasitic hymenoptera — *Cheiropachus* sp., *Heterospilus* sp., *Spathius tomici,* and also another hymenoptera *Prosopis* sp.

On September 28 this material was moved into the laboratory, the contents of one cage being placed in tight storage boxes while that of the other was left in cages indoors. During January, February and March of 1917, this material both in the breeding cages and storage boxes again became active and gave rise to a large number of species not previously taken from it. These are the two-year forms and their parasites and comprise the following insects: the cerambycids — *Pogonocherus mixtus, Leptostylus sex-guttatus, Neoclytus longipes;* the buprestids — *Chrysobothris blanchardi, C. sex-signata, C. dentipes, Melanophila fulvoguttata,* and *Anthaxia quercata;* the hymenopterous parasites — *Phasgonophora* sp., *Odontaulacus bilobatus* and *Atoreutus astigmus;* and the small fly — *Pollenia rudis.*

Tree No. II was a larch of about 8 inches D. B. H. in the west group of trees of this species. It had been killed by having the bark removed from near the base in 1914. No insects were taken from this tree in the field, but a segment about 20 feet from the base was seen to be infested and this was placed in a breeding cage to breed out the inhabitants. The insects derived from this material are *P. rufipennis, Phyllobaenus dislocatus,* the supposedly parasitic fly *Medeterus* sp. and the siricid *Urocerus albicornis* represented by a female and a male. Samples of this one region of this tree were the only ones brought from the field.

Tree No. III was killed by the bark having been peeled off of it — probably in 1914. Above the peeled portions the bark was well riddles by the engravings of *P. rufipennis* and also contained the larvae and burrows of several cerambycids, of species unknown at the time the material was examined in the field. A sample of the trunk of this tree about six inches in diameter taken from about five feet above ground was placed in a breeding cage and the following specimens were bred from it: The cerambycids *Phymatodes dimidiatus* and *Leptostylus sex-guttatus;* the clerids *Phyllobaenus dislocatus* and *Cymatodera bicolor* which were preying upon *P. rufipennis* principally; six hymenopterous parasites including the two large pimploid forms *Rhyssa lineolata* and a new species of *Pseudorhyssa*, both of them apparently parasitic upon *Phymatodes dimidiatus*, and four smaller forms; three species of *Doryctes* (all probably new) and *Eurytoma* sp. Of these the three species of *Doryctes* are probably parasitic upon *P. dimidiatus* and the latter on *P. rufipennis.*

Tree No. IV was a tree which was still living but much weakened. One of the larger roots which was exposed and free of the ground for several inches had been dead about two years (killed 1914). The bark was rather thick and still adherent, although the wood was beginning to decay. Examinations of this root in the field showed the presence of adults of a scolytid — *Dryocoetes americanus* — and the larva of a cerambycid which later proved to be *Leptura vittata.*

This root was removed without felling the tree and was confined in a breeding cage. During the summer two adults of *Leptura vittata* and two specimens of a small fly — *Phorbia fuscipes* — were taken from this cage.

This material was left in the breeding cage out of doors until November 2, when it was brought in and gone over thoroughly. The bark was removed, disclosing the burrows and dead adults of *Dryocoetus americanus*, also a living clerid larva of unknown species. Deeper in the wood were found the larvae of *Leptura vittata* and the adults of the small weevils *Dryophthorus americanus.* The sample of root was placed in a tight storage box, and later gave rise to one specimen of *L. vittata.* This was found dead January 13, 1917, and the exact date of emergence was unknown. However, from the general date of its appearance in the laboratory it would have appeared under natural conditions in May or early June.

TREE No. V had been dead probably three years (since 1913). The tree was about seven inches D. B. H. The lower trunk had been injured upon one side many years before (at least ten years), probably by having part of the bark removed. However, it had not been entirely girdled and the tree had survived. The uninjured bark had partly overgrown the injury but not entirely — the result being that finally the sapwood exposed and all of the heart wood was well along in decay. (Figs. 29, 30.)

Two specimens were taken from the wood of this tree in the field — an adult of the elaterid *Adelocera brevicornis* from the decayed heart wood, and a larva of *Serropalpus barbatus* from the sounder wood. The old burrows of *P. rufipennis* were numerous, but no living specimens remained.

Samples of this tree from two regions were shipped to Syracuse and placed in breeding cages. Several segments of the trunk from four to ten feet from the base contained considerable dead sapwood and heart wood well along in decay. Another sample from twenty feet above ground contained only sound wood. These samples yielded the following insects during the summer: The cerambycids *Phymatodes dimidiatus* and *Asemum moestum;* the melandryid *Serropalpus barbatus,* these coming from the more recently killed wood; the tenebrionid *Tenebrio tenebriodes* and the weevil *Dryophthorus americanus* coming from the decaying wood. In addition two hymenopterous parasites were bred out — the large *Rhyssa lineolata* which is parasitic upon *P. dimidiatus* and a small undetermined chalcid possibly parasitic on *Dryophthorus americanus.*

TREE No. VI was killed by peeling probably late in 1913. When examined April 29, 1916, in the field it contained no living *P. rufipennis,* although abandoned burrows of this scolytid were very numerous. These abandoned burrows had been utilized by the small scolytid *Crypturgus atomus,* which habitually starts its own burrows from those of other bark-boring beetles. This one species was the only form taken from this tree in the field. When confined in the breeding cage samples of this tree taken from one foot above ground and ten feet above ground yielded numerous specimens of *Serropalpus barbatus* and nothing else.

Tree No. VII was one which had been felled by the wind about four years previously (1912), but the trunk was still free of the ground. The bark was quite loose and showed evidence of some decay. Burrows of *P. rufipennis* were numerous, but of course the insects responsible for them had long since left this tree. In the field a few larvae of "scavenger beetles," species undetermined, were found, and also several larvae of a cerambycid, which was later shown to be *Monohammus scutellatus.* A sample taken from the trunk about forty feet from the base (the trunk had, however, been recumbent but free of the ground for several years) yielded two specimens each of *M. scutellatus* and *Serropalpus barbatus.* No other forms were bred from this material.

Tree No. VIII was a small tree about ten feet high and having a D. B. H. of two inches. It had been killed by shading. No insects were taken from this tree in the field. The bark was quite dry and tight and altogether it did not form a breeding place which would be suitable for many wood-boring or bark-boring insects. From the general character of the wood and bark one would expect insects to arise from it similar to those coming from the limbs of larger trees. In fact this expectation was realized when in the breeding cage three specimens of *Leptostylus sex-guttatus* and one of *Chrysobothris sex-signata* appeared. Later examination of this stick revealed a few burrows of *P. rufipennis,* but these were not normal and in only one or two cases were any larval galleries present.

All of the preceding material was shipped to the laboratory from Crittenden, N. Y., on April 29, 1916. In addition to this, material which was obtained at other times or other localities is listed below.

Tree No. IX was obtained from the College Forest near Wanakena, N. Y. This tree of about five inches diameter had been blown down by a heavy windstorm late in May, 1916. The roots still adhered and the lower part of the tree was still alive and green in August. The tree had fallen across a trail, however, and the top about five feet from the base had been sawed off to clear the trail. In August this top was found to be heavily infested by *Polygraphus rufipennis* and several sections of the trunk from eight to twenty feet from the base were shipped to Syracuse and there placed in a breeding cage on August 18. During the rest of the season the following insects were taken from this cage: numerous adults of *P. rufipennis,* a specimen of a small chalcid of undetermined species, *Erytoma* sp. and *Spathius tomici.* On October 24 some of the bark was removed, disclosing numerous young adults of *P. rufipennis* and also the larva of a clerid undetermined and the larva of an unknown cerambycid. The material was left out of doors until early in January, 1917, when it was brought into the heated basement, and later, in February, was transferred to a cool room, where it remained till June, when it was again transferred to an outdoor breeding cage. On July 3, 11 and 18, specimens of *Neoclytus longipes* emerged. All of the evidence from other sources goes to show that this cerambycid is one which normally requires two years for the completion of its life history. It is believed that the normal life history was shortened by the treatment the material received. The outdoor conditions from which it was removed early in January corresponded to the first winter, the month in the heated basement where the temperature varied from about fifty degrees to seventy-five degrees corresponded to the second summer and the low temperature in the storage room from February to June simulated the second winter. It is worthy of note that the specimens of *Neoclytus longipes* from this material are rather undersized although normal in other respects. The three specimens in question measure 7, 8 and 8 mm. respectively, while those from other lots of larch were from 9 to 9.5 mm. The length mentioned by Blatchley as characteristic of this species is from 9 to 11 mm.

During July there was also evidence of the presence of a larvae of *Monohammus*, probably *M. scutellatus*, in the continued casting out of the coarse "sawdust" characteristic of this genus.*

Tree No. X was a large tree about eighteen inches D. B. H., which was not observed to be infested with insects in April, 1916, when the material from most of the other trees was obtained. This tree had not been killed by stripping of the bark. It stood in a rather moist situation in a dense part of the wood about fifty feet from Tree I. It had died from causes unknown probably late in 1915, or early in 1916. When examined in January, 1917, it still contained the brood of *Polygraphus rufipennis* and of *Eccoptogaster piceae*, which must have entered the bark during the summer of 1916. The wood was still quite sappy and contained resin pockets with the contents still unhardened. Also the bodies of several adults of *E. piceae* were found embedded by a copious flow of pitch in their egg galleries showing that the tree had been attact while still partly alive.

A large part of the trunk of this tree from near the ground up to the very tip had had much of the bark removed by woodpeckers in search of the contained brood. Much of this barking had been done quite recently, for when the tree was found on January 5, 1917, the fresh chips covered the surface of the snow. The first samples from this tree were taken at this time. These, consisting of strips of the sapwood with adherent bark, were brought in with the hope of breeding out specimens of *Eccoptogaster piceae*, the brood of which, together with that of *Polygraphus rufipennis*, were found in the trunk near the ground. In addition to these two scolytids, the larvae of *Serropalpus barbatus* was also

* During the winter of 1917–18, this material was examined and found to contain living cerambycid larvæ. It was stored in a cool store room and in the following May and early in June gave rise to a number of specimens of *Neoclytus longipes*, a single *Monohammus scutellatus*, a single *Chrysobothris dentipes*, several specimens of *Xylotrechus undulatus* Say and to a number of hymenterais parasites which are apparently *Odontaulacus bilobatus*. *X. undulatus* had not been previously bred from larch.

taken in the field from near the base of the tree. In the breeding jar these chips gave rise to specimens of *P. rufipennis, E. piceae,* the predator *Phyllobaenus dislocatus* and the parasite *Phasgonophora* sp.

On February 26 this tree was felled and samples were taken from the trunk at various levels. The first section was taken from about eight feet above ground and gave rise to the following insects when placed in the breeding cages. The two scolytids *Polygraphus rufipennis* and *Eccoptogaster piceae* with the hymenopterous parasites *Rhyssa lineolata, Doryctes* sp. a., *Spintherus pulchripennis, Spathius tomici, Spathius* sp., an undetermined pteromalid and the parasitic fly *Medeterus* sp.; the predator *Phyllobaenus dislocatus,* which preys indiscriminately upon all scolytids and upon other small bark-boring insects; the cerambycid *Phymatodes dimidiatus,* which was parasitized by *Doryctes* sp. and *Rhyssa lineolata;* the melandryid, *Serropalpus barbatus;* and the siricids *Urocerus albicornis* and *Sirex abbotii.* Examination of the base of this tree in the field showed numerous larvae of *Asemum moestum.*

A second section of the trunk taken about twenty feet from the base of the tree yielded exactly the same association of insects. *A. moestum* is of course missing just as at the eight-foot level. This form, as we have already seen, is one attacking only the basal part of the tree trunk and has not been found higher than a few feet from the ground.

The third region of the trunk included all of it above a point thirty feet from the ground and consisted of six pieces each a little less than two feet long. The insects taken from this material included the two scolytids and their parasites and predators as in the lower trunk, *Serropalpus barbatus* and *Urocerus albicornis.*

Tree No. XI was a small tree of about three inches D. B. H. which had been killed several years before (probably 1913) by shading. The wood was partly decayed by a "dry rot" and contained numerous specimens of the curculionid *Stenocellis brevis.* The wood was in such condition February 26, 1917, that it could be easily pulverized between the fingers. No other insects were taken from this tree in the field and none were bred from it.

Insect Associations in Larch Wood and Bark

It is a well-recognized fact that in many cases certain species of insects not only live exclusively upon certain species of trees, but also that in many cases it is just as true that a certain insect is to be found only in a definite region of a tree. This, however, by no means holds for all species of bark or wood inhabiting insects, for many seem to attack indiscriminately any part of the tree from the trunk to branches an inch or even less in diameter, just as many insect forms attack a large number of tree species with no apparent preference.

There are doubtless several factors which influence the choice by the insects of certain regions for breeding purposes. Perhaps the most important of these is the character of the bark, but actual height from the ground is an important factor in the case of some insects, especially such as are clumsy fliers.

The character of the bark may apparently influence oviposition in several ways. The actual thickness of the bark on the lower trunk of large trees undoubtedly deters many borers from ovipositing on account of the mechanical difficulty or even impossibility some find in piercing the thick outer layers and placing their eggs where the young on hatching will find the proper nourishment. Entirely aside from this factor of the thickness of the bark offering mechanical resistance to the oviposition of certain forms, the bark on the trunk has thicker layers of the edible and more or less fibrous and spongy inner bark, and this absorbs a greater amount of moisture and retains it longer. This maximum of moisture, while it offers conditions which are favorable or even necessary for the proper development of some species of borers, is just as truly unfavorable for other species. We shall presently see that certain borers are characteristically found in the thin-barked tops and limbs which in the next summer after the death of the tree appear to be absolutely dry, but which nevertheless apparently offer conditions which are ideal for certain two-year forms. Moisture conditions during the second summer in the trunk and in the thinner barked limbs is so extremely different that one would hardly expect to find any forms in common between them. As a matter of fact this expectation is nearly realized, for of the two-year forms, or of forms occurring under the bark during the second summer after the death of the tree, only two species were bred both from the limbs and from the lower or middle trunk.

The Lower Trunk in Dying or Recently Killed Larch Trees. The trunk region itself can be subdivided into two or more regions or habitats upon the basis of the insects found therein. In the dying or recently killed trees *Dendroctonus simplex* is perhaps the most characteristic bark beetle inhabitant of the lower trunk. It was not found in the bark at a greater distance than twenty feet from the ground and was most numerous in the lower ten feet. In felled trees, however, *D. simplex* occurs throughout the trunk even around the bases of the branches. Apparently, then, the limiting factor here is distance from the ground, and doubtless the clumsy build of the beetle and its rather poor powers of flight are responsible.

Another bark beetle often found in the lower trunk is *Polygraphus rufipennis.* It breeds in all regions of the trunk and even in the tops and larger limbs. It is worthy of note that when it occurs in the same tree trunk as *D. simplex* it is much less numerous in the lower regions of the trunk where the latter species occurs, than it is in the middle and upper trunk. This is not true of trees not infested by *D. simplex.* The explanation of this seems apparent. The *Dendroctonus* enters the tree slightly earlier than *Polygraphus*, which on finding the lower trunk already occupied by numerous broods of the other species, seeks other parts of the tree to construct its brood burrows. In trees infested by both it is interesting to note that as we go farther and farther from the ground the burrows of *D. simplex* become fewer and fewer in number and those of *P. rufipennis* become correspondingly numerous, until at a height of about twenty feet *D. simplex* no longer occurs and *P. rufipennis* is correspondingly numerous.

A somewhat similar condition holds for another bark beetle — *Eccoptogaster piceæ*. This scolytid breeds most often in the thin-barked tops and limbs of the larch. However, sometimes it is also found in the thicker-barked, lower trunk, as was the case in Tree X. In this tree it was more numerous in the upper trunk and tops, but some brood burrows containing living brood were found at a distance of only a few feet from the ground, where the inhabitants of the bark were predominately *P. rufipennis*.

Still another bark beetle occasionally found in the lower trunk of the larch during the first summer after the death of the tree is *Crypturgus pusillus*, although this form is a more characteristic resident of the bark during the second year. This minute beetle seems always to construct its brood-burrow as an offshoot from the burrow of some other beetle. Usually the burrows so utilized are made by some other scolytid — in the larch most commonly by *P. rufipennis* — the entrance of this beetle being used in gaining access to the inner bark. In other host trees the entrance burrows of other scolytids are often utilized and in *Abies balsameus* several cases have been observed where the tunnels of *Monohammus scutellatus* had been so invaded, entrance to the burrows being gained by way of the "ventilation openings" through which the "sawdust" of this sawyer was cast out. In the larch, however, the only species with which *Crypturgus* has been observed to associate itself are *P. rufipennis* and *D. simplex*.

Several species of predaceous beetles were found associated with these scolytids in the bark. The most common of them is the ubiquitous *Phyllobaenus dislocatus*, which is the most common clerid beetle bred from wood infested by bark-boring insects in this region. It has been found associated with all four species of bark beetles mentioned above, and specimens of larvae as well as adults have been taken from bark infested with *Polygraphus rufipennis* and *Dendroctonus simplex* especially. The clerid *Cymatodera bicolor* and the lamperid *Podabrus diadema* were also bred from bark infested with *P. rufipennis.* Both of these are perhaps predaceous, although no reference to the food habits of the latter species was found in the literature.

A number of hymenopterous parasites were also bred from material containing the brood of these various species of scolytids. Of these the most common is *Spathius tomici,* which was constantly associated with *P. rufipennis, E. piceae* and *D. simplex.* It was especially numerous in Trees I, IX and X. Of these Tree IX was from near Wanakena and of scolytids contained only the brood of *P. rufipennis.* Tree X contained numerous brood not only of this bark beetle but also of *E. piceae.* Tree I contained all three scolytids and all regions of the tree gave rise to specimens of this small parasite. There can be no doubt that *S. tomici* is parasitic on both *P. rufipennis* and *E. piceae,* as different lots of material which were practically pure cultures of either one or the other of these species yielded the parasite when placed in a breeding jar or cage. We cannot state so definitely that *D. simplex* serves as its host, for the reason that the *Dendroctonus* infested material from which the parasite was bred contained also the brood galleries of *P. rufipennis.* However, it seems very likely that a considerable number of small bark beetles may act as host for *Spathius tomici.*

Heterospilus sp., *Spathius* sp., *Spintherus pulchripennis,* and *Cheiropachus* sp. were obtained from material containing both *P. rufipennis* and *E. piceae,* and each may be parasitic upon either one or both of these bark beetles. *Eurytoma* sp. was bred from material containing the brood of *P. rufipennis* and is probably parasitic upon it. Several specimens of a small undetermined chalcid were obtained from material containing *P. rufipennis* and *D. simplex* and may be parasitic on either one or both of these or may be a hyperparasite upon their parasitic forms. A number of specimens of *Medeterus* sp. were bred from material containing large numbers of *P. rufipennis* and some *E. piceae.*

M. nigripes Loew. has been previously recorded by Hopkins (1899, p. 450) as a parasitic enemy of the larvæ of *P. rufipennis.*

Other boring insects which oviposit in the lower trunk of the larch either while it is dying or during the first summer after death, include the cerambycids *Asemum moestum, Monohammus scutellatus, Phymatodes dimidiatus,* and *Leptostylus sex-guttatus;* the buprestid *Melanophila fulvoguttata;* the melandryid *Serropalpus barbatus,* and the two siricids *Urocerus albicornis* and *Sirex abbotii.* Of these, *Asemum moestum* and *Phymatodes dimidiatus* seem to be the only forms which were bred exclusively from the lower trunk. *A. moestum* is a sapwood borer and was found only in the lowermost few feet of the lower trunk. The eggs are often laid in trees which are merely weakened and without a doubt the work of the numerous larvae in the bark and sapwood greatly hastens the death of the tree. However, oviposition may also occur in recently killed trees, and as the insects require at least two years to develop, the adults are often bred from trees dead two years or slightly more.

Phymatodes dimidiatus, the other cerambycid, which was found to breed only in the lower trunk of larch, is more typically a dead tree form. Eggs may be laid either in trees recently killed or in those dead as much as a year. The life history requires a single year for its completion and the larvae burrows in the inner bark until it reaches full growth. This species may be associated with *A. moestum* then during either the first or second year of the latter's life cycle.

Monohammus scutellatus, Leptostylus sex-guttatus, and *Melanophila fulvoguttata* are three forms which may breed not only in the lower trunk but also in other regions of the tree. All three are two-year forms, the larvae of which feed in the inner bark and sapwood, and which enter the wood only when preparing to hibernate or to pupate. *M. scutellatus* and *M. fulvoguttata* are characteristically trunk inhabiting forms, but on occasion do breed in the tops or limbs of trees. Indeed, more specimens of the latter were obtained from limbs than from the trunk. *Leptostylus sex-*

guttatus, on the other hand, most commonly breeds in the tops and limbs when it infests larch. There can be little doubt that it prefers the thin-barked parts of the tree.

The melandryid *Serropalpus barbatus* is the wood-boring insect most often found in and most characteristic of injured, dying, or recently dead larch. It was bred in considerable numbers from Trees I, V, VI, VII, and X. The larvae are wood-boring insects which live two or possibly more seasons in the sapwood or heartwood. This species is found throughout the trunk, but is most common in the lower trunk below the lowest branches.

The siricids *Urocerus albicornis* and *Sirex abbotii* occur more or less throughout the trunk even up among the branches. It is probable that they may even breed occasionally in the larger branches. However, these forms are all typically inhabitants during the larval state, of the wood of the part of the trunk free of limbs, as is shown by the fact that of twenty-five specimens of the two species bred from larch, all but four were from the tree below the level of the first still adhering limbs.

There are several parasites which were bred from wood or bark containing one or more or these borers. These include *Rhyssa lineolata, Pseudorhyssa* sp., *Odontaumerus canadensis,* and three species of *Doryctes,* all of which are apparently new. These six species, four of which are new, were derived from three distinct lots of material in three separate breeding cages. They were associated with *P. dimidiatus, M. scutellatus, L. sex-guttatus, A. moestum, S. barbatus,* the two predators *Phyllabaenus dislocatus* and *Cymatodera bicolor* and with *Tenebrio tenebriodes* and *Dryophthorus americanus* (the latter two inhabiting dead and partly decayed wood in one of the lots). However, of these numerous wood and bark-inhabiting forms only two (*P. dimidiatus* and *S. barbatus*) were derived from all three lots, thus establishing the probability that one or both of them served as hosts for these parasites.

A later detailed study of all of the material in these lots was made with very interesting results. When the bark was carefully removed, bit by bit, forty-five cocoons were exposed in one lot consisting of a piece about six inches in diameter and two feet long. Nine of these were twelve mm. or more in length and all the rest were below ten mm. Several of the latter were about nine mm. long and all of the rest smaller than 7.5 mm. The smaller ones were found in the burrows of *P. rufipennis* only and were doubtless the cocoons of *Spathius tomici* which had emerged the previous season before the material was brought to the laboratory. The cocoons of the two larger sizes, however, were found only in the burrows of *P. dimidiatus*, although careful search was made in the burrows of other species in both the wood and in the bark. The identity of these burrows was absolutely established by the finding in several of the pupal chambers of dead adults which had never emerged. In the same pupal chambers were found the cast larval skins, the mandibles and head armature of which are quite characteristic. Close to each of the parasitic cocoons, the larval remains of the host were found and these on comparison with the larval casts found in pupal chambers containing dead adults of *P. dimidiatus* established absolutely the identity of the parasitized form.

By comparing the sizes of the adult hymenoptera taken from this material it was readily established that *Rhyssa lineolata* and *Pseudorhyssa* sp. come from the larger cocoons in the burrows of *P. dimidiatus* (the cocoons of the two being indistinguishable) while the species of *Doryctes* and probably also *Odontaumerus canadensis* came from the cocoons about eight to nine mm. long, found in the burrows of the same borer.

The Upper Trunk in Dying or Recently Killed Larch Trees contained the same borers with several exceptions as did the lower trunk. Those occurring in this region include the scolytids — *P. rufipennis* and *E. piceae* and their predators — *P. dislocatus* and *C. bicolor*, and parasites — *Spathius tomici*, *Spathius* sp., *Spintherus pulchripennis*, *Phasgonophora* sp., *Cheiropachus* sp. and *Heterospilus* sp.; the cerambycid — *Monohammus scutellatus;* the melandryid — *Serropalpus barbatus;* and the two siricids *Urocerus albicornis* and *Sirex abbotii.* There can be no doubt that *Leptostylus sex-guttatus* and *Melanophila fulvoguttata* may also breed in this upper trunk region, as each of these is found both in the lower trunk and in the tops and branches, but the limited amount of material confined in our breeding cages did not give rise to any. *L. sex-guttatus* breeds by preference in the thin barked tops and limbs and would therefore be more likely to be found in the upper trunk than in the lower. *M. fulvoguttata* on the other hand is more typically a trunk-inhabiting form and in spruce and hemlock is found throughout the trunk region and only to a lesser extent in the tops and limbs. It is likely that its preferences in larch would be similar but the small number bred from larch does not allow us to draw an adequate conclusion.

D. simplex, as previously stated, is confined entirely to the lower trunk of standing trees, but may breed in the upper trunk of felled trees. The limiting factor here is then very apparently height from ground rather than the character of the bark. The cerambycids *Asemum moestum* and *Phymatodes dimidiatus* are two other beetles which have been bred only from the lower trunk. Of these the former is practically confined to the lowermost part of the trunk and none were bred from wood more than three or four feet from the ground. *P. dimidiatus* while not confined to such a limited area of the lower trunk was not obtained from wood more than ten feet from the ground.

The Tops and Limbs of Dying or Recently Killed Larch Trees.— The tops and limbs of recently killed larch present conditions quite different in several respects from those in the trunks. In the first place they are inaccessible to a number of forms which are clumsy fliers. Aside from this, the much thinner bark allows the beetles more ready access to the inner bark and sapwood. The inner bark, however, neither furnishes so plentiful an amount of food as does the thick bark nor does it retain so much moisture. However, the thin-barked parts of the tree seem to offer conditions which are more suitable for many forms than are to be found in other parts of the tree. This is indicated by the fact that five species of borers were obtained exclusively from tops and limbs while a number of other species taken from other regions occur also in the thin-barked parts. Of these latter two in particular show a decided preference for the newer growths.

Most of these forms which characteristically inhabit thin-barked regions are species requiring two years for the completion of their growth. During the second summer of this period the moisture conditions in the thin-barked parts are strikingly different from that existing in the thick-barked regions. Indeed it is hardly conceivable how the bark or sapwood here can be of use as food during times of drought when these parts are apparently dessicated, and indeed it may well be that during such periods the larva ceases feeding and becomes more or less torpid. But however that may be, it is a fact that regions showing such conditions are apparently sought by a considerable number of species in preference to other parts of the tree where moisture conditions are different. Other factors may enter into this choice and it is possible that these may determine the beetle's choice of breeding places, but our data seem to indicate that this question of lack of excessive moisture is one of the determining factors. This applies not to the forms requiring only a single year for their life cycle, but to those which remain under the bark for two years.

A total of ten species of *boring beetles* were bred from thin-barked larch. This includes two scolytids, three cerambycids and five buprestids. The scolytid most characteristic of larch limbs and tops is *Eccoptogaster piceae.* This seems to be its favorite breeding place and study of old engravings shows conclusively that there is a larger percentage of larvæ reaching full growth here than in the trunk region. This is especially true of the tops of a diameter of from 1½ to 3½ inches, although the larger limbs also offer favorable conditions. The other scolytid *P. rufipennis*, while often numerous in the tops and occasionally in the limbs is typically a trunk-inhabiting form and is probably found in the limbs only when crowded out of other regions of the tree or when more suitable breeding places are lacking.

The cerambycids bred from limbs and tops in the order of the number of each obtained are *Pogonocherus mixtus, Neoclytus longipes* and *Leptostylus sex-guttatus.* These are all three two-year forms. Another species which is almost certain to breed in larch tops is *Monohammus scutellatus,* although none were actually taken. In pine, spruce, and balsam this sawyer breeds in all parts of the tree from the base to limbs an inch in diameter, and it doubtless will on occasion breed in larch limbs as well as in larch trunks.

Of the ten borers actually bred from thin-barked larch, five are buprestids. These are *Melanophila fulvoguttata, Anthaxia quercata, Chrysobothris sex-signata, C. dentipes,* and *C. blanchardi.* Of these only one species, *M. fulvoguttata,* was bred from any other region of the tree. All of these forms live for two seasons as larvæ under the bark, but groove both bark and sapwood. They enter the wood only to pupate at the completion of their larval growth.

Associated with these borers are the predator *Phyllobaenus dislocatus* and various parasites. *P. dislocatus* doubtless invades principally the burrows of the bark beetles *P. rufipennis* and *E. piceae*, but both larvæ and adults have been found in the burrows of cerambycids and buprestids. The parasites *Spathius tomici*, *Heterospilus* sp., and *Cheiropachus,* which are probably parasitic upon one or both of these bark beetles were bred from cages containing limbs and tops and emerged at approximately the same time as their supposed hosts.

Three other parasites of a somewhat larger size were obtained from this material, namely — *Odontaulacus bilobatus* Prov., *Atoreutus astigmus* Ashm., and *Phasgonophora* sp. These are not only larger in size but also emerged a season later than did the bark beetles and the other parasites mentioned. Therefore it is believed that these are parasitic upon the larger sized species (flatheads and roundheads) listed above. It has been impossible to assign these to their hosts, even provisionally, as it was not practicable to identify the species with the cocoon (their size being so nearly similar) nor was it possible absolutely to identify the burrows in which the cocoons occurred owing to some extent to their not having been completed by the dying larva. Therefore it is not safe to make any more definite statement than that cocoons, which from their size were probably those of one or more of these forms, were found both in burrows which had been made by *P. mixtus* and also in other burrows made by *C. blanchardi*.

Perhaps the most striking difference between the larch trunk association and that in the limbs and tops is shown when it is stated that the latter includes five buprestids (just half of the borers actually taken from thin-barked wood) while the trunk association includes but one of this family. Thus the buprestids characterize the thin-barked-larch association and this might well be spoken of as the buprestid or flat-headed-borer association.

All of the borers working in the limbs and tops are bark-borers as distinguished from wood borers. By this it is meant that the larvæ work in the inner bark and outer sap-wood, grooving both with their burrows, although making their pupal chamber in the wood. One would expect to find in such a location in thin-barked wood either very flat borers or rather small ones. This perhaps is correlated with the fact that such a great per cent of the larvæ here are of the flathead type and that the remaining forms (*P. mixtus*, *L. sex-guttatus* and *X. longipes*) are all quite small and of slender form.

Decaying Larch.— No very thorough data regarding the later insect inhabitants of dead larch is at hand, but the few observations made should be here recorded. From Tree No. IV was obtained a piece of root several inches in diameter and a foot or more long. This had been dead several years as shown by the fact that the wood had begun to decay. The bark, however, was still adherent and had served as the breeding place for *Dryocoetes americanus,* the young adults of which were found in the inner bark next to the sapwood.

The wood served as a breeding place for the curculionid *Dryophthorus americanus*, the cerambycid *Leptura vittata* and an unidentified elaterid. The larvæ of *L. vittata* tunnels longitudinal burrows in the sapwood and outer heartwood thus hastening decay materially. From the same region of this punky wood adults of *Dryophthorus americanus* were removed the following fall (November 2, 1916). These had not appeared in the breeding cages during the summer but there was evidence that they had bred in the wood two or more generations without change of host.

Several specimens of the fly *Phorbia fuscipes* Lett. were also bred from this root. The larvæ probably lived either under the decaying bark or in the punky wood as scavengers although they may possibly have been parasitic upon some of the other insect inhabitants.

Our records also furnish data of several other species of insects from decaying wood or from wood dead several years. Tree V had been partly stripped of its bark several years before its death and the exposed wood had never been overgrown. This wood was well along in decay and contained the burrows of former insect inhabitants, probably *Serropalpus barbatus* among others. In the field a single adult of *Adelocera brevicornis* was taken from this punky wood and in the breeding cage it gave rise to adults of the cossoninid *Dryophthorus americanus* and the tenebrionid, *Tenebrio tenebriodes*. Other specimens of *Dryophthorus americanus* were found under similar conditions in other trees and in the same sort of wood numerous specimens of another cossoninid, *Stenocellis brevis*, were taken.

The following tables will show something of the relations of these various insects to each other as well as something of their habits and the character of the material in which they breed.

Ecological Associations of Various Predators and Pasasites in Larch.

Name of Predator or Parasite	Borers with which Associated	Certain or Probable Host	Predators and Parasites Associated
Phyllobænus dislocatus Say.	*Polygraphus rufipennis*, *Dendroctonus simplex*, *Phymatodes dimidiatus*, *Eccoptogaster piceæ*, *Crypturgus pusillus*, *Leptostylus sex-guttatus*, *Neoclytus longipes*, *Pogonocherus mixtus*, *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *Chrysobothris dentipes*, *Chrysobothris sex-signata*, *Anthaxia quercata*, *Serropalpus barbatus*, *Sirex abbotii*, *Urocerus albicornis*.	*P. rufipennis*, *D. simplex*, *P. piceæ*, Probably others.	*Cymatodera bicolor*, *Podabrus diadema*, *Spathius tomici*, *Heterospilus* sp., *Cheiropachus* sp., *Eurytoma* sp., *Rhyssa lineolata*, *Pseudorsyssa* sp., *Doryctes* sp., a, b, c, *Phasgonophora* sp., *Odontaulacus bilobatus*, *Atoreutus astigmus*, Small chalcid (undetermined). *Medeterus* sp.
Cymatodera bicolor Say.	*Polygraphus rufipennis*, *Phymatodes dimidiatus*, *Leptostylus sex-guttatus*.	*P. rufipennis*.	*Phyllobaenus dislocatus*, *Doryctes* sp., a, b, c, *Pseudorhyssa* sp., *Eurytoma* sp., *Rhyssa lineolata*.
Podabrus diadema Fab.	*Polygraphus rufipennis*.	*P. rufipennis*.	*Phyllobaenus dislocatus*, Small chalcid (undetermined).
Rhyssa lineolata Kirby.	*Phymatodes dimidiatus*, *Leptostylus sex-guttatus*, *Asemum moestum*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*.	*Phymatodes dimidiatus*.	*Phyllobaenus dislocatus*, *Cymatodera bicolor*, *Pseudorhyssa* sp., *Doryctes* sp., a, b, c, *Eurytoma* sp., *Spathius tomici*, *Spathius* sp. *Pteromalid* (undetermined), *Medeterus* sp.
Pseudorhyssa sp.	*Phymatodes dimidiatus*. *Leptostylus sex-guttatus*. *Serropalpus barbatus*, *Polygraphus rufipennis*.	*Phymatodes dimidiatus*.	Same as above except the last three.
Odontaumerus canandensis Prov.	Same as for *Pseudorhyssa* sp. above.	*Phymatodes dimidiatus*.	Same as for *Pseudorhyssa* sp. above.
Odontaulacus bilobatus Prov.	*Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *Chrysobothris sex-signata*, *Chrysobothris dentipes*, *Anthaxia quercata*, *Pogonocherus mixtus*, *Neoclytus longipes*, *Leptostylus sex-guttatus*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*.	*Chrysobothris blanchardi*, *Melanophila fulvoguttata*, *Pogonocherus mixtus*.	*Phyllobaenus dislocatus*, *Phasgonophora* sp., *Cheiropachus* sp., *Atoreutus astigmus*, *Heterospilus* sp., *Spathius tomici*, *Pollenia rudis*.
Spathius tomici Ashm.	Same as above; also *Dendroctonus simplex*, *Phymatodes dimidiatus*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*.	*P. rufipennis*, *E. piceæ*, *D. simplex*.	Same as above, except *Pollenia rudis*.
Spathius sp.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*.	*Phyllobaenus dislocatus*, *Spathius tomici*, *Rhyssa lineolata*, *Spintherus pulchripennis*, *Doryctes* sp., a, Undetermined *pteromalid*, *Medeterus* sp.
Doryctes sp., a, b, c,	*Phymatodes dimidiatus*, *Leptostylus sex-guttatus*, *Polygraphus rufipennis*, (Sp a, also with *Eccoptogaster piceæ*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*).	*P. dimidiatus*.	*Phyllobaenus dislocatus*, *Cymatodera bicolor*, *Rhyssa lineolata*, *Pseudorhyssa* sp., *Eurytoma* sp., (Sp.a also with *Spintherus pulchripennis*, *Spathius* sp. and *Medeterus* sp.).
Heterospilus sp.	Same as for *O. bilobatus* above.	*P. rufipennis*, *E. piceæ*.	Same as for *O. bilobatus*.
Atoreutus astigmus Ashm.	Same as for *O. bilobatus* above.	*Chrysobothris blanchardi*, *Pogonocherus mixtus*.	Same as for *O. bilobatus* above.
Spintherus pulchripennis Cwfd.	Same as for *Spathius* sp. above.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*.	Same as for *Spathius* sp. above.
Eurytoma sp.	*Polygraphus rufipennis*, *Phymatodes dimidiatus*. *Leptostylus sex-guttatus*, *Neoclytus longipes*.	*Polygraphus rufipennis*.	*Phyllobaenus dislocatus*, *Cymatodera bicolor*, *Rhyssa lineolata*, *Pseudorhyssa* sp., *Doryctes* sp., a, b, c.
Phasgonophora sp.	Same as for *O. bilobatus* above.	*Chrysobothris blanchardi*.	Same as for *O. bilobatus* above.
Cheiropachus sp.	Same as above.	*P. rufipennis*, *E. piceæ*	Same as above.
Small *pteromalid* (undetermined)	Same as for *Spathius tomici*.	*P. rufipennis*. *E. piceæ*, *D. simplex*.	Same as for *Spathius tomici*.
Medeterus sp.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Serropalpus barbatus*. *Urocerus albicornis*, *Sirex abbotii*.	*P. rufipennis*.	*Phyllobaenus dislocatus*, *Spathius* sp., *Doryctes* sp., a. *Rhyssa lineolata*

ARIOUS RODERS IN LAR

Ecological Relations and Associations of the Various Borers in Larch.

Name of Borer	Location in Tree	Condition of Tree when Eggs Were Laid	Time Required for Life History	Location of Larval Burrow	Location of Pupal Chamber	Dates of Emergence	Associated Borers	Associated Predators	Associated Parasites
Dendroctonus simplex Lec.	Lower trunk.	Living, dying or recently dead.	One or two generations per year.	Inner bark.	Inner bark.	May 25, 26.	*Polygraphus rufipennis*, *Crypturgus pusillus*, *Asemum moestum*, *Melanophila fulvoguttata*, *Serropalpus barbatus*	*Phyllobaenus dislocatus*.	*Spathius tomici* small chalcid (undet.) (both probably parasitic on *P. rufipennis*)
Polygraphus rufipennis Kirby.	Entire trunk and sometimes tops and limbs.	Dying or recently dead (sometimes dead one year).	One generation per year.	Inner bark.	Inner bark.	May 22, 25, June 2, Oct. 24.	*Dendroctonus simplex*, *Crypturgus pusillus*, *Eccoptogaster piceæ*, *Asemum moestum*, *Monohammus scutellatus*, *Phymatodes dimidiatus*, *Pogonocherus mixtus*, *Leptostylus sex-guttatus*, *Neoclytus longipes*, *Serropalpus barbatus*, *Melanophila fulvoguttata*, *Chrysobothris dentipes*, *Chrysobothris sex-signata*, *Chrysobothris blanchardi*, *Anthaxia quercata*, *Urocerus albicornis*, *Sirex abbotii*	*Phyllobaenus dislocatus*, *Cymatodera bicolor*, *Podabrus diadema*.	*Spintherus pulchripennis*, *Spathius tomici*, *Spathius* sp., *Heterospilus* sp., *Cheiropachus* sp., *Eurytoma* sp., Pteromalid (undet.), *Medeterus* sp
Eccoptogaster piceæ Swaine.	Entire trunk and limbs, but especially thin-barked portions.	Dying recently dead.	One generation per year.	Inner bark.	Inner bark.	June 6, July 8, 12, 31.	Same as above except *D. simplex*, *A. moestum*, and *M. scutellatus*.	*Phyllobaenus dislocatus*.	*Spintherus pulchripennis*, *Spathius tomici*, *Spathius* sp., *Heterospilus* sp., *Cheiropachus* sp., *Medeterus* sp
Crypturgus pusillus Gyll.	Trunk (possibly in tops and limbs also).	Dead.	One generation per year.	Inner bark.	Inner bark.	Taken from bark April 29, Sept. 16.	*Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Asemum moestum*, *Serropalpus barbatus*	*Phyllobaenus dislocatus*.	None taken
Dryocoetes americanus Hopk.	Exposed root.	Dead.	One generation per year.	Inner bark.	Inner bark.	June 8 (from burrows April 22, Sept. 28)	*Leptura vittata*, *Dryophthorus americanus*.	None taken.	None taken
Dryophthorus americanus Bedel.	Root and lower trunk.	Dead and decaying.	Probably one generation per year.	Decaying wood.	Decaying wood.	July 3, 7 (from wood Nov. 2).	*Dryocoetes americanus*, *Leptura vittata*, *Tenebrio tenebriodes*, *Adelocera brevicornis*, *Stenoscelis brevis*	None taken.	None taken
Stenoscelis brevis Boh.	Trunk.	Exposed decaying wood.	Probably one generation per year	Decaying wood.	Decaying wood.	(From wood April 5, 28, Feb. 26)	*Dryophthorus americanus*, *Tenebrio tenebriodes*, *Adelocera brevicornis*.	None taken.	None taken
Phymatodes dimidiatus Kirby	Lower trunk	Recently dead	One generation per year	Inner bark and sapwood	Outer sapwood	May 26, 29, 31, June 8, 15	*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Leptostylus sex-guttatus*, *Asemum moestum*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*	*Phyllobaenus dislocatus*, *Cymatodera bicolor*.	*Rhyssa lineolata*, *Pseudorhyssa* sp., *Doryctes* (three undescribed species), *Odontaumerus canadensis*, *Eurytoma* sp
Asemum moestum Hald.	Base of trunk.	Dying or recently dead.	One generation in two years.	Sapwood and heartwood.	Outer sapwood.	May 29, June 15.	*Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Melanophila fulvoguttata*, *Serropalpus barbatus*.	None taken.	None taken
Monohammus scutellatus Say.	Trunk and tops.	Recently dead.	One generation in one or two years.	Inner bark and sapwood.	Sapwood or heartwood.	June 5, 20.	*Eccoptogaster piceæ*, *Polygraphus rufipennis*, *Serropalpus barbatus*	None taken.	None taken.
Leptura vittata Oliv.	Exposed root.	Dead.	One generation in two years.	Sapwood and heartwood.	Outer sapwood.	June 15, 28.	*Dryocoetes americanus*, *Dryophthorus americanus*	None taken.	None taken
Leptostylus sex-guttatus Say.	Trunk, tops or limbs (usually thin-barked parts).	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	July 6, 8.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Pogonocherus mixtus*, *Neoclytus longipes*, *Phymatodes dimidiatus*, *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *Chrysobothris sex-signata*, *Chrysobothris dentipes*, *Anthaxia quercata*	*Phyllobaenus dislocatus*, *Cymatodera bicolor*.	*Phasgonophora* sp., *Odontaulacus bilobatus*, *Atoreutus astigmus*.
Neoclytus longipes Kirby.	Tops and limbs.	Dying or recently dead.	One generation in two years	Bark and sapwood.	Outer sapwood.	July 3, 11, 18.	*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Leptostylus sex-guttatus*, *Pogonocherus mixtus*, *Chrysobothris blanchardi*, *Chrysobothris sex-signata*, *Chrysobothris dentipes*, *Melanophila fulvoguttata*, *Anthaxia quercata*.	*Phyllobaenus dislocatus*.	Same as above
Pogonocherus mixtus Hald.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15	Same as for *Leptostylus sex-guttatus*.	*Phyllobaenus dislocatus*.	Same as above
Melanophila fulvoguttata Harr.	Trunk, tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 10, 13, 24.	In the trunk—*Dendroctonus simplex*, *Polygraphus rufipennis*, *Asemum moestum*, In the top and limbs—Same as for *N. longipes*, above.	*Phyllobaenus dislocatus*.	Same as above
Chrysobothris blanchardi Horn	Tops and limbs	Dying or recently dead	One generation in two years	Bark and sapwood	Outer sapwood	June 15 to July 15	Same as for *N. longipes* above	*Phyllobaenus dislocatus*	Same as above
Chrysobothris dentipes Germ.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood	June 15 to July 15	Same as for *N. longipes*, above	*Phyllobaenus dislocatus*.	Same as above.
Chrysobothris sex-signata Say.	Tops and limbs (also thin-barked trunk 2½ in. dia.).	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15.	Same as for *N. longipes*, above	*Phyllobaenus dislocatus*.	Same as above.
Anthaxia quercata Fabr.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 22.	Same as for *N. longipes*.	*Phyllobaenus dislocatus*.	Same as above
Serropalpus barbatus Schall.	Entire trunk.	Injured, dying or recently dead.	One generation in two years.	Sapwood.	Outer sapwood.	June 5, 6, 7, 8, 13, 15, 19, July 12, 16, Aug. 3.	*Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Crypturgus pusillus*, *Asemum moestum*, *Monohammus scutellatus*, *Phymatodes dimidiatus*, *Melanophila fulvoguttata*, *Urocerus albicornis*, *Sirex abbotii*.	*Phyllobaenus dislocatus*.	None taken.
Urocerus albicornis Fabr.	Entire trunk.	Recently dead.	One generation per year.	Sapwood and heartwood.	Sapwood.		*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Serropalpus barbatus*, *Sirex abbotii*	*Phyllobaenus dislocatus*.	None taken
Sirex abbotii Kirby	Entire trunk	Recently dead	One generation per year	Sapwood and heartwood	Sapwood		Same as for *U. albicornis*	*Phyllobaenus dislocatus*	None taken
Tenebrio tenebriodes Beau.	Lower trunk.	Decaying wood	No new data.	No observations	No observations	July 7	*Dryophthorus americanus*, *Adelocera brevicornis*	None taken	None taken
Adelocera brevicornis Lec.	Lower trunk.	Decaying wood.	No new data.	No observations.	No observations.	April 28 (from wood in field).	*Tenebrio tenebriodes*, *Dryophthorus americanus*.	None taken.	None taken.

DISCUSSION OF SPECIES

In the following pages each of the species of insects bred from larch are discussed in some detail. In writing this discussion all of the material upon the habits and biology of each species which was available has been read and much of it incorporated. In addition considerable new material in the way of biological notes will also here be found, in fact, for a number of species practically all of the account here given is new and in all except a few cases much of it is new.

I. Dendroctonus simplex Lec.

Dendroctonus simplex is distributed throughout the northeastern part of the United States and eastern part of Canada apparently occupying the same range as its host plant, the eastern or American larch. Its most southern range is reported by Hopkins ('98, p. 343), who has taken it from West Virginia. He also ('09, p. 120) records it from several localities in Michigan, Maine, New Hampshire and Canada. Swaine (1910 a, p. 81) also reports having seen specimens of this species from Mackinac, Man., and (1909, p. 99) records it from Colorado, California and New Mexico. That the record for the latter three localities is a mistake is claimed by Hopkins ('09, p. 118).

This species apparently confines its attacks to the American larch *Larix laricina*, Hopkins ('09, p. 120) although Swaine ('09, p. 99) gives *Larix* and *Picea* as hosts.

Dendroctonus simplex attacks injured, dying and felled trees, excavating long, slightly winding egg galleries in the inner bark which slightly groove the surface of the wood. The eggs are placed in groups of three to six or more, alternately along the sides of the galleries (Fig. 1). The larval galleries are short and extend out perpendicularly from the main egg gallery. According to Hopkins ('09a, p. 104) " The broods occupy the bark of stumps and logs and the trunks of standing trees from the ground to the branches or on into the tops. Fresh attacks on living trees cause a flow of resin or red boring dust in the loose bark and around the base of the trees. This species is capable of extensive depredations on the largest and best larch, but apparently prefers to infest injured, dying and felled trees."

The winter is passed principally in the adult stage, within the inner bark of trees and stumps in which the larvæ have spent the preceding summer. Activity begins with the first warm weather in the spring. There is apparently but one generation annually, although under certain circumstances there may be at least a partial second generation. The larvæ of the first generation begin to transform to the adult stage at Crittenden during August, and by the first of September practically all the brood are callow adults.

In our work this species was taken during three successive seasons but in each year was found only in one tree. In the springs of 1915 and 1916 the wintered-over brood was found under the bark of the lower part of the trunk associated with *Polygraphus rufipennis*. No pitch tubes were seen and while the egg galleries in many cases did contain some pitch, there was not evidence of a copious flow of the material. In midsummer, 1917 (July 24), a large larch tree was observed which had numerous streams of pitch from one to seven inches long running down the bark. No pitch tubes were present but this material came from recently made burrows of *D. simplex*. On examining the inner bark, many dead bodies of the adults were found embedded in the pitch which completely filled many of the egg galleries. Other egg galleries had been kept free of pitch by the work of the adults. The larvæ were nearly full grown but no pupæ were observed.

This tree was about one foot in diameter. A strip of bark about ten inches wide and five feet long had been removed from one side. The tree was still quite green but had made practically no growth during the season. The streams of pitch were present upon the bark from the base to a height of about fifteen feet. A few -- but only a few — burrows of *Polygraphus rufipennis* were found on this tree but the attack of this insect seemed to have been unsuccessful on account of their inability to combat the excessive flow of resin. In Tree No. I also *P. rufipennis* was found associated with *D. simplex* near its base, but as the *P. rufipennis* became more numerous farther from the base the *D. simplex* became less abundant and above twenty feet none were to be found. In this tree no pitch tubes were present showing that the tree was either dead or in a very weakened condition at the time of the entrance of the beetles.

Adults of *D. simplex* were taken from their burrows in the field on April 5 and April 22. They were taken from the breeding cages under natural conditions on May 25 and 26. Swaine records (1910, p. 81) finding the egg-tunnels containing eggs in the outer ends and larvæ of all sizes boring in the bark on July 10. On August 6 these tunnels were occupied by grown larvæ. Pupæ, recently transformed adults as well as emergence holes were present. Eggs of a second brood were found as late as August 26. This variation in life history is no more than should be expected. No dogmatic statements concerning the seasonal history of an insect can safely be made, for life cycles are more subject to variation than are structural details. It would seem to be axiomatic that a physiological process should be more readily altered by unusual environmental influences than would be anatomical structure, yet some of our entomologists speak of the seasonal histories of insects as if they were immutable.

D. simplex is usually not preceded in larch by any other insect but in some cases may be. Trees injured by blaze scars or by abrasions often attract *Serropalpus barbatus.* Diseased or weakened trees also may be infested by *Asemum moestum* or *Melanophila fulvogutta* even before the entrance of the brood of *D. simplex*. As we have already seen *P. rufipennis* is a bark beetle often associated with *D. simplex* in the bark.

The predator *Phyllobaenus dislocatus* is often found not only in the burrows but also is frequently seen actively scurrying over the bark of infested trees. *Spathius tomici* and an undetermined chalcid have been bred from material containing both *D. simplex* and *P. rufipennis.* The former of these is certainly parasitic upon *P. rufipennis* and may well parasitize *D. simplex* also.

Polygraphus rufipennis Kirby

Polygraphus rufipennis has a wide range throughout the greater part of the United States and Canada. It has been recorded from Alaska, from many regions of Canada and from throughout the northern and eastern United States, extending as far south as Georgia and Louisiana (Hamilton, 1894, p. 35); Packard (1890, p. 721) reports it from Colorado and from Tacoma, Washington; and Fall and Cockerell (1907, p. 217) have found it in New Mexico. Correlated with its wide distribution, *P. rufipennis* breeds in a variety of host trees. Packard (1890, p. 722) records it from white pine and Rocky Mountain pines and spruces, Hopkins (1899, p. 249) reports it in spruce, larch and scrub pine and Felt (1906, p. 386) has found it associated with *Dryocoetes* sp. in spruce and with *Pityogenes punctipennis* ("*Tomicus balsameus*") in balsam. The senior author has numerous specimens of this insect from red spruce (*Picea rubens*) associated with two species of *Dryocoetes, Pityogenes punctipennis, Ips caelatus, Crypturgus pusillus* and other forms and has also taken it from stumps of white pine in company with the latter two species. In the Northeastern United States the red spruce is the favorite host tree.

Dr. Hopkins (1899, pp. 246–251) has given us the fullest and one of the earliest accounts of the biology of this insect. He says: "The adults emerge in May and June, and are attracted to the stumps, trunks and tops of recently felled trees and such trees as are weakened in vitality from the attack of insects like that of the destructive pine bark beetle [*Dendroctonus frontalis*], diseases or any other cause. They then commence to excavate their entrance galleries through the outer bark . . . . This entrance burrow is extended to the outer surface of the inner soft bark, where a broad cavity is excavated which is utilized as a nuptial chamber. In the meantime the female which appears to do the greater part of the first excavating, is joined by a male which stations himself in the entrance gallery to keep out enemies and objectionable visitors [doubtless also other males], and to render assistance in expelling the borings. The female then excavates a gallery from one edge of the nuptial chamber through the inner bark to the wood, thence through the inner layer of bark, usually at right angles to the bark fibers, for a distance of one or two inches. Along the sides of this so-called brood or egg-gallery, she deposits her minute, pearly white eggs in a succession of small notches. By the time the first female has her egg-gallery fairly started, one to three other females are admitted, and each excavates a similar egg-gallery in different directions from the nuptial chamber. Before all of the galleries are finished, the first eggs commence to hatch into minute white grubs, which burrow through the inner bark, on which they feed. By the time all the eggs have hatched, the surrounding bark is filled with these grubs of various ages and sizes, and soon, all of the bark from the inner to the outer layer, for a radius of two to four inches, is completely perforated with their irregular burrows. In the meantime, the male guards the entrance and the females either rest in the nuptial chamber or egg-galleries or emerge to enter the bark in another place to start a new brood. When the grubs and larvæ have attained their full growth, they excavate a broader cavity at the end of their burrow or mine, in which they change to the pupæ stage, thence to the adult and either emerge from the bark and start a second brood, or remain until the following spring. Probably two or three broods may occur in one season, commencing with the first eggs deposited in the spring, but my observations lead me to believe that owing to the shortness of the season at the high elevations occupied by the spruce of this State [West Virginia] there is generally but one brood."

But little can be added to the observations upon the phases of the activity of *P. rufipennis* covered in the above account. However, observations upon the behavior both of this species and of other species of polygamous beetles leads us to doubt very much if the female ever normally starts the excavation of a brood burrow. In all cases, observed by the senior author where the burrow was started by a female the excavation was continued as a simple gallery with no sign of a nuptial chamber. In most cases such burrows were for feeding purposes only, with not only the nuptial chamber lacking but also with the egg niches omitted. In a few cases where the female operating had been removed from a burrow already occupied by a male and several females she constructed egg niches in the side of the independent burrow and deposited eggs therein, but made nothing resembling either a nuptial chamber or a nuptial recess. In fact in such burrows it was necessary for her to back out at the entrance in order to turn around, no place in the gallery being wide enough for this manoeuver.

Some interesting observations have been made upon the proportion of the sexes as they occur in their burrows in larch and the bearing of this upon fecundity. This work is based on a careful study of fifty engravings and burrows — all the uninjured ones available in the material at hand. Had more engravings in larch been available they would have been used, although it is believed that a study of a greater number would not have materially changed the general results.

The following tables based on the study of fifty engravings are self-explanatory:

Number of engravings having one-egg gallery	6
Number of engravings having two-egg galleries	22
Number of engravings having three-egg galleries	14
Number of engravings having four-egg galleries	6
Number of engravings having five-egg galleries	2
Total number of egg galleries studied	126

Minimum length of egg gallery	4	mm.
Maximum length of egg gallery	60	mm.
Average length of egg gallery	24.55	mm.
Average length of egg gallery in uniramous type	*34	mm.
Average length of egg gallery in biramous type	26.36	mm.
Average length of egg gallery in triramous type	22.38	mm.
Average length of egg gallery in quadriramous type	26.37	mm.
Average length of egg gallery in quinquiramous type	18	mm.

* In one case the single egg gallery measured 60 mm. in length which in so small a number would unduly raise the average. If this case is left out of consideration the average length would be 28.8.

Minimum number of egg niches in egg gallery..........	1
Maximum number of egg niches in egg gallery..........	53
Average number of egg niches in egg gallery............	20.84
Average number of egg niches in uniramous gallery......	29.4
Average number of egg niches in biramous gallery.......	25.36
Average number of egg niches in triramous gallery......	18.52
Average number of egg niches in quadriramous gallery...	16.10
Average number of egg niches in quinquiramous gallery..	14.3

It would seem from the above that each female produces a larger number of eggs when her mate serves no other females, *i. e.*, under conditions of monogamy. However, in order to get at what might be styled the *individual efficiency* the total number of eggs in all the egg-galleries of the burrow should be divided by the total number of individuals (male and females) in the burrow. The following results then appear:

Number of eggs		Male		Females		Eggs per Individual
29.4	÷	(1	+	1)	=	14.7
50.72	÷	(1	+	2)	=	16.91
55.56	÷	(1	+	3)	=	13.89
64.40	÷	(1	+	4)	=	12.88
71.5	÷	(1	+	5)	=	11.91

Thus the following facts appear: The greater the number of females in a burrow, the greater is the total average number of eggs per burrow but the less per individual female. Under average conditions the males outnumber the females in the ratio of two and one-half to one and the greatest reproductive efficiency is shown in burrows containing one male and two females. Should the sexes occur in nature in equal numbers the greatest efficiency would be shown in burrows having one of each sex, for then each female on an average would deposit 29.4 eggs although the individual efficiency is only half that amount; while in a biramous burrow each female lays, on an average, 25.36 eggs, but the individual reproductive power is greater than in the former case. However, if in nature the females should outnumber the males at the ratio of four to one or five to one the greatest number of eggs would be produced by their breeding in the same ratio.

It is perhaps worthy of remark that in engravings of *P. rufipennis* in spruce observed both in the Adirondacks and Catskills there is a greater preponderance of females than in the larch material from Crittenden. The exact significance of this can only be guessed at, but to one who has for a number of years spent several weeks in each of these regions at the season of the year when the greater number of these insects are establishing themselves in their new breeding quarters, an explanation which has occurred to the senior author may appeal with some force. The young adults are leaving their old hosts and entering new ones during the early and middle parts of June when violent rains are a nearly daily occurrence. It is the male which first leaves the old host and which makes the entrance burrow and prepares the nuptial chamber in the new host, while the female does not emerge from the old host until several days later. During the early construction of the new burrow the males are exposed to various dangers, and to one who knows in general the habits of bark beetles it is very apparent that in a rainy season, many lose their lives by the very frequent and violent rain storms. On the other hand the females, leaving the protection of the old host later, are not subject to so many dangers as a large percentage of them find nuptial chambers already prepared for their reception.

Thus if the sexes occur in about equal proportions in the old host as has been shown to be the case in *Pityogenes hopkinsi*, Swaine (Blackman, 1915), the preponderance of females over males in the new brood chambers would vary with the occurrence of storms at the time of transferring from old to new host. It is believed that the more equable climate in Erie county, N. Y., from which region the infested larch was obtained had allowed a larger number of males to establish their new breeding quarters than is usually possible in the Adirondacks and Catskills where violent storms are of nearly daily occurrence.

Hopkins (1899, p. 248) has said that: "Probably two or three broods may occur in one season — but my observations lead me to believe that . . . there is generally but one brood." We agree thoroughly with this statement. In New York it is within the possibilities for two or even two and a half generations to occur in one season but under field conditions it is doubtful if this possibility is ever realized. It is certain that a single generation is the rule and that occasionally a partial second generation is to be found — this second generation wintering over as partly grown larvæ. In larch, adults have been taken from under the bark on February 9, 29, April 22, 29, and October 24, and have been bred out in cages throughout the latter part of May and the early part of June. Larvæ were obtained from beneath bark April 22, 29, and October 24. In the Adirondacks the eggs of the main generation which has wintered over in the adult stage are laid throughout June, the exact date at which laying begins being of course dependent upon the season and varying from year to year.

P. rufipennis is associated with a great variety of other insects, borers, predators and parasites — the actual relations sometimes being quite close while in other cases they are quite remote. The scolytids *Dendroctonus simplex, Eccoptogaster piceæ,* the cerambycid, *Phymatodes dimidiatus,* and the two siricids, *Urocerus albicornis* and *Sirex abotii* are often associated with *P. rufipennis* throughout their life history. Of these the four beetles are inhabitants of the bark and therefore are influenced by each other much more than they are by the siricids which spend their larval life in the wood entirely. In general perhaps, each of these bark-inhabiting species is influenced adversely in that their food is limited by the presence of the other. However, under some conditions the association may be of mutual advantage. For instance it is apparently true that *P. rufipennis* is ordinarily unable to breed to advantage in a living tree yet when such a tree is attacked simultaneously by *D. simplex, P. rufipennis* and *E. piceæ,* or by the first two of these, its resistance is more readily overcome and it not only serves as a more favorable breeding place for these forms but for others as well. It is believed the *D. simplex* is able to kill weakened larch unaided but no cases were observed where it had attacked living trees unaccompanied by the ubiquitous *P. rufipennis.*

The relations of this bark beetle with the various species requiring two years for their life cycle is complicated by the fact that the association may be with either the first or the second year of the life of these beetles. Our data shows that the cerambycid *Asemum moestum* and the melandryid *Serropalpus barbatus* may be associated with *Polygraphus* during either the first or second year of their life history. In other words either of these forms may enter the tree at least a year earlier than *P. rufipennis* or may enter during the same season. Neither of these would affect the bark beetle directly as they are both wood borers throughout their larval life. Those which precede it would aid in weakening the resistance of the living tree, thus making it a more suitable host for various bark beetles, while those which enter at the same time would have little or no either direct or indirect effect.

The large majority of two-year forms, however, enter the larch during the same season as *P. rufipennis.* This list includes the cerambycids — *Monohammus scutellatus, Leptostylus sex-guttatus, Pogonocherus mixtus, Neoclytus longipes;* and the buprestids, *Melanophila fulvoguttata, Chrysobothris dentipes, C. sex-signata, C. blanchardi* and *Anthaxia quercata.* All of these feed under the bark and therefore act the rôle of robbers by eating the inner bark before the smaller bark-beetle larvæ can complete their growth. In some cases also they may kill the smaller brood outright (Hopkins, 1899, p. 410) when they by chance meet them under the bark.

The associated predators and parasites are mentioned in another connection and it will suffice to say here that the predators include *Phyllobaenus dislocatus,* which appears to be ever present in infested larch, *Cymatodera bicolor,* and *Podabrus diadema.* The parasites include *Spathius tomici, Spathius* sp., *Heterospilus* sp., *Cheiropachus* sp., *Eurytoma* sp., *Spintherus pulchripennis,* a small undetermined pteromalid and the parasitic fly *Medeterus* sp.

Eccoptogaster piceæ Swaine

Eccoptogaster piceæ has been previously recorded from only two localities — Hudson, Quebec (Swaine, 1910, p. 33), and from Steuben county, Ind. (Blatchley and Leng, 1916, p. 589). Swaine obtained his specimens from the brood burrows in the branches of white spruce (*Picea canadensis*) while Blatchley and Leng record it from tamarack (*Larix laricina*).*

Swaine (1910) accompanies his original description of this insect with notes upon its habits and descriptions of its engravings. Full grown larvæ and pupæ were abundant in the latter part of May and the adults began emerging in the laboratory June 6 and egg-laying began early in July. Regarding the burrows he says: "The egg-tunnels deeply score the wood lengthwise of the grain. The tunnels are divided into two portions by a nuptial chamber, situated usually near the middle, and from the nuptial chamber a short, oblique tunnel leads to the entrance-hole above. From ten to thirty eggs are laid in shallow nitches along each side of the tunnel, and well packed in with fine bits of wood. The larval galleries arise from the tunnels in a fairly regular manner, but soon through their windings cross each other in every direction, but still show a general tendency to follow the grain of the wood, which they deeply score."

Our study of a large number of engravings of *E. piceæ* bring out some additional facts. In the first place, the egg-galleries in larch at least are normally not only considerably longer than those figured by Swaine but also contain a considerably larger number of egg-niches as will be readily seen by referring to the tabulated data given later. In a study of the engravings certain facts appear at first sight. The number of egg-galleries in a single burrow varies from one to three, by far the greater number of engravings having two egg-galleries (Fig. 7). This means, doubtless, that

* Engravings which were undoubtedly made by this species have been observed by the senior author in *Picea rubens* in the region of Cranberry Lake, but specimens of the beetles have never been obtained from this host.

normally two females and one male occur in a brood burrow. The beetles breed by preference in tops, *i. e.,* in the upper part of the trunk among the limbs where the bark is thin but they may occur anywhere in the trunk or limbs. When in the trunk, the entrance gallery leads from the outside obliquely upwards through the bark to the nuptial chamber which is excavated nearly entirely from the sapwood. This is usually roughly triangular in shape with one of the angles continuous with the entrance and the other two above.

The first egg-gallery constructed is apparently invariably upward, proceeding with the grain of the wood from one of the upper angles of the nuptial chamber (Figs. 9, 10). The second egg-gallery starts from the other upper angle, but immediately turns downward and as soon as it clears the nuptial chamber proceeds nearly, but usually not exactly parallel with the grain of the wood in a direction opposite the first gallery (Figs. 7, 8). When a third gallery is present it arises from the side of the nuptial chamber opposite to the second, turns outward and downward nearly with the grain of the wood but diverging slightly (Figs. 7, 9).

It is interesting to note that the upper egg-gallery, *i. e.,* the one first constructed, is longer (or longest) in sixty per cent of burrows having two or three galleries. In seventy-three per cent the upper gallery contains the larger number of egg-niches, showing a greater fecundity of the female first fertilized over those fertilized later. This data is based on careful measurements and counts of one hundred brood burrows. Further study shows that the average length of the first (upper) egg-galleries is 30.34 m. m. and of the latter ones is 23.67 m. m.; the average number of egg niches in the first egg-galleries is 38.12 and of the lower only 24.75.

In gathering this data burrows having three galleries were used as well as those having two, and in the former cases *both* lower galleries were included. It might be objected that this would seem unfair as one of the three is so likely to be abnormal, it being logical that if the second contains fewer eggs than the first, the third would contain fewer than the second. There being no way to determine which of the lower galleries was first constructed, the upper gallery was compared in fourteen engravings with the lower gallery having the most egg-niches. The average for the upper gallery is 33.64 eggs and for the lower gallery 29.07 eggs. Of the fourteen burrows the greater number of eggs is found in the upper gallery in eight cases, in one of the lower ones in five cases, and one case shows the two equal.

The eggs are laid in May and June and the beetles prefer dying or very recently dead trees in which to breed. They often, however, breed in bark which is still quite sappy, and cases have been found where the excessive flow of pitch in the egg-gallery has caused the gallery to be abandoned. Other cases are numerous where a considerable amount of pitch had exuded into the egg-gallery but where the beetle had been able to overcome the resistance of the tree and to rear its brood.

An attempt was made to induce reared material to re-enter larch anew in order that their habits and life history could be studied more in detail. Material containing the brood of *E. piceæ* was brought into the laboratory on January 5 and February 26, 1917. The larvae, which were in various stages from half-grown to nearly full-sized larvae, readily transformed and emerged in large numbers as adults. Larvae which were observed to be full-grown and ready to pupate were removed from the bark and placed in slender dishes upon slightly moistened sawdust. A number of these pupated and transformed to adults while under observation. Full notes were taken of all observations. The length of the pupal stage under laboratory conditions was found to be about nine to eleven days. Extracts from the notes on one individual are given below.

A larva pupated May 20. During its pupal stage it showed little activity, practically the only movement being a wriggling motion of the abdomen. This pupa transformed into the adult stage at 8:45 A. M. on May 31. The newly emerged adult showed considerable motion of the head and legs and contraction and expansion of the abdomen. It would seem to contract as much as possible with head bent downward and then thrust out its abdomen, head and legs in a " stretching " movement. The true wings were extended at full length and the elytra were in a nearly normal position. The true wings were apparently gradually drawn up under the elytra and folded. This was accomplished by expansion and contraction (lengthening and shortening) of the abdomen. During this process, which required several hours, the true wings remained very flabby, even at the main supporting veins. They apparently were kept moistened by some substance which did not harden. At 1 P. M. the tips of the true wings were still visible, but by 8 A. M. the following day they had been entirely retracted to their normal adult position. By this time the callow adult was able to walk very feebly, but did not attain its full strength until a day or two later. At the time the young adult arises, the head and prothorax shows considerable color as does the metasterum and the pygidium. The elytra, abdomen and legs were a faint yellowish brown. All these parts gradually grew darker, but the insect had not yet attained its full color a week later (June 6).

Although determined efforts were made to induce the new generation of adults to enter new larch, we were unsuccessful. At first young adults were confined in cages with suitable pieces of wood, but they refused to breed in it. As it is a well-known fact that other species of *Eccoptogaster* feed for a time upon new growth of their host tree, young adults were confined with portion of limbs, including new growth and new leaves. However, they resolutely refused either to feed upon this material or to breed either in freshly killed or less recently killed larch, and we were therefore unable to make thorough observations upon their habits and behavior. A few broods were, however, started in the old parent host, but these were not discovered until November, 1917, and therefore were of no value except as they prove that these small scolytids may breed for two successive years in the same host.

A careful study of the engravings give the results tabulated below:

Number of engravings studied	156
Number of engravings having one-egg gallery	25
Number of engravings having two-egg galleries	111
Number of engravings having three-egg galleries	20
Total number of egg galleries	307

Minimum length of egg galleries	2 mm.
Maximum length of egg galleries	90 mm.
Average length of egg galleries	27.36 mm.
Average length of egg gallery in uniramous burrow	34.00 mm.
Average length of egg gallery in biramous burrow	27.97 mm.
Average length of egg gallery in triramous burrow	22.35 mm.

Minimum number of egg niches in one egg gallery	2
Maximum number of egg niches in one egg gallery	126
Average number of egg niches in one egg gallery	30.65
Average number of egg niches in egg gallery of uniramous burrow	40.36
Average number of egg niches in egg gallery of biramous burrow	31.54
Average number of egg niches in egg gallery of triramous burrow	23.46

Average number of egg niches in entire uniramous engraving	40.36
Average number of egg niches in entire biramous engraving	63.08
Average number of egg niches in entire triramous engraving	70.38

Thus it would appear that just as in *P. rufipennis* each female of *E. piceæ* produces a greater number of eggs when she shares her mate with no other female. Here also, however, the greatest individual reproductive efficiency is shown in burrows occupied by one male and two females and the least when more than two females are present. This is shown by the following data:

Number of egg niches		Occupants of burrows Male		Females		Eggs produced per individual
40.36	÷	(1	+	1)	=	20.18
63.08	÷	(1	+	2)	=	21.03
70.38	÷	(1	+	3)	=	17.59

The larval burrows start out at right angles to the egg-gallery. At first they are parallel to each other but soon become winding in their course, often crossing and recrossing each other. They are rather longer than is usual for the larval burrows of scolytids of their small size. The data tabulated below will give the facts obtained by a careful measurement of forty larval mines:

Minimum length of larval burrow........................	58 mm.
Maximum length of larval burrow........................	103 mm.
Average length of larval burrow........................	75.8 mm.

Of the forty burrows measured nineteen were between 60 and 79 mm. long, ten were less than 70 mm. long, three were between 80 and 89 mm. long, five were between 90 and 99 mm. long, and three were more than 100 mm. long.

The same beetles are associated with *E. piceæ* as with *P. rufipennis* with the exception of those found typically only in the lowermost part of the trunk. These include *Dendroctonus simplex, Monohammus scutellatus*, and *Asemum moestum*. Of these probably the latter is the only one which would not likely to be associated with *E. piceæ*, as it is found only a few feet at most from the ground. *E. piceæ* is found more often associated with *P. rufipennis* than with any other insect. The latter starts its burrows somewhat earlier in the season and naturally when it is present in numbers sufficient to occupy all or nearly all of the bark of the entire trunk the presence of its brood often very much limits the available breeding places of the former. Thus, in most of the trees studied *E. piceæ* had been thus excluded from the trunk even well up in among the branches and was not found except in the tops and in the less desirable limbs. In other cases where the earlier infestation of the *P. rufipennis* was not so heavy, the two small scolytids were found associated in the upper, middle and even to some extent in the lower trunk. In such cases it is interesting to observe that the brood of *E. piceæ* becomes more and more numerous in the upper trunk as that of *P. rufipennis* becomes less so.

Of the other associated borers the relations with the five species of buprestids which are characteristic of the insect association in the tops and limbs are perhaps most close. These in their relation to *E. piceæ* must be classified as robbers, it being understood that this relation on the part of the larger borers, is a more or less casual or incidental one, in that the presence of their burrows in the inner bark destroys material which would otherwise serve as food for the scolytids. The fact that the most usual direction of these larger burrows is longitudinal increases the likelihood of disaster to the small larvae. On the other hand, the fact that the flatheaded and roundheaded larvae are two-year forms, is to the advantage of *E. piceæ* in that the latter is usually associated in the first year of the life of the two-year forms, when the larvae of these are small and comparatively not so voracious — it being a well-known fact that by far the greater per cent of the burrow is made during the latter part of a borer's life history.

Phyllobænus dislocatus is the only predator found associted with *E. piceæ*. The parasites associated include *Spathius tomici*, *Spathius* sp., *Spintherus pulchripennis*, *Heterospilus* sp., *Cheiropachus* sp., an undetermined pteromalid, and the fly *Medeterus sp.* It is impossible to state which of these are parasitic upon *E. piceæ*, but a number of cocoons were found in the burrows of this scolytid as well as in those of *P. rufipennis* in the same material, but we are unable to connect these up with the adults arising from them.

Crypturgus pusillus Gyll. (*C. atomus* LeConte)

Crypturgus pusillus is cosmopolitan in its distribution. Ratzeburg (1839, pp. 196) recorded it from Germany, Barbey (1913, pp. 143) has taken it in France, and E. P. Stebbing (1904, pp. 498) has written a short account of its habits as he observed them in North and West Himalaya. It has also been recorded from Japan by Swaine (1909, pp. 44), and in North America Packard (1890, pp. 727) reports the distribution as extending from Canada to Massachusetts and New York. Later literature has extended the range over a considerable portion of northeastern North America, specifically given as Canada and Maine south to West Virginia and westward to Ohio (Felt, 1906, pp. 360).

The European host trees as listed by Nüsslin (1913, pp. 259) are spruce, pine, fir and larch. E. P. Stebbing (1914, pp. 498) adds blue pine (*Pinus excelsa*) and spruce (*Picea morinda*) from India. In America the host trees recorded are: white pine, balsam fir, hemlock (Packard, 1890), pitch pine, scrub pine, yellow pine, table mountain pine, black spruce and Norway spruce (Hopkins, 1893, 1899).

This minute bark beetle, one of the smallest of our scolytids, has a very characteristic habit. It usually gains entrance to the inner bark in which it constructs its breeding quarters through some previously made opening. This is usually either the entrance hole or exit hole of the abandoned burrow of some other scolytid. However, a number of cases have been observed in which the burrow utilized in this manner was still occupied by its original constructors and their brood. In several other cases newly started colonies of *C. pusillus* were observed which were constructing their breeding quarters in balsam fir as an off-shoot from the mines of small larvae of *Monohammus scutellatus*. In these latter cases the so-called "ventilation openings" through which the coarse "sawdust" of this sawyer is extruded served as the place of entrance.

However, in most cases access to the inner bark is obtained through the burrows of another scolytid. Thus it appears always to enter the bark later than other bark borers and often does not enter until a season later. In larch it was found most frequently making its engravings from the abandoned burrows of *P. rufipennis*, although it was also associated with those of *D. simplex* and *E. piceæ* in a like manner. In several cases it was found associated with the living brood of the two former of the species mentioned. The brood of this insect have never been taken by us from really dry bark, but always from bark containing considerable moisture. For this reason it is to be found associated with the burrows of *E. piceæ* only in the thicker barked regions of the trunk, and as this latter is usually prevented from breeding in such places by the earlier preemption of these parts by *P. rufipennis*, the association of *C. pusillus* and *E. piceæ* is not common.

The burrows of *C. pusillus* are in the inner bark but are seldom on the surface of the sapwood. Usually as has been pointed out by Stebbing (1914, p. 500) a thin layer of the innermost bark remains between the egg-gallery and the surface of the wood, so that often infested bark may be stripped off without discovering the brood.

In attacking the bark the beetles seem to assemble in the burrow of some other insect in groups or colonies comprising from five or six to as high as thirty or more individuals. Perhaps the smaller numbers are more common, but several examples of colonies of twenty or thirty have been observed and recorded in our field notes and several engravings made by such groups have been obtained. Two of such engravings are especially interesting. One, from spruce (Fig. 12), shows twenty-two egg-galleries radiating from the nuptial chamber of an abandoned burrow of *P. rufipennis*, while several more originate from the one egg-gallery made by the original inhabitant. In another case taken from larch (Fig. 13) twenty-five egg-galleries of *C. pusillus* originate from the nuptial chamber of *P. rufipennis*.

The question suggests itself whether these groups of from six to thirty or more individuals represent a family or a colony made up of a number of families. Stebbing believes that the groups represent family groups consisting of one male and six or more females, while other writers are non-committal on the subject. With no conclusive evidence upon the subject, we are inclined to the view that these groups represent colonies of numerous individuals of both sexes. We are not prepared to state whether or not this species is polygamous, but believe that the relations existing in these colonies are more or less indiscriminate.

Various authors seem to agree in describing the egg-galleries of this insect as short, sinuous burrows about one-half inch long (Packard, 1890, p. 825; Stebbing, 1914, p. 499). Our observations do not entirely agree with these, however. Where the beetles are relatively few in number and where their egg-galleries arise from an egg-gallery of a larger form (Fig. 11), the brood burrows constructed are likely to be relatively short. The reason for this is believed to be that these small beetles tend to live socially in a common "assembly chamber" and where this is of adequate size for the members occupying it, the burrowers do not extend their mines to any great distance from the general meeting place: *i. e.*, each female may construct several short galleries. On the other hand, when the numbers are greater and the central assembly chamber inadequate to accommodate all members of the colony at once, the females are likely to construct their egg-galleries longer and to lay all of their eggs in one gallery. Indeed, in some cases, the gallery as finally made may represent the joint work of several females. This very likely is the case in the branched galleries which are by no means uncommon in the larger engravings having numerous egg-galleries, several of which may be seen in Figs. 12 and 13.

In the material at hand, the length of the egg-galleries varies from less than half an inch to two and three-fourths inches. No satisfactory counts of the number of larvae to a gallery could be made because the numerous larvae had destroyed most of the egg niches with their winding larval mines. These larval burrows are not on the surface of the sapwood but in the middle region of the inner bark.

Our observation seem to indicate that this insect spends the winter usually in the beetle stage, as adults begin to appear under the bark during the late summer, and these emerge the following spring. In the region of Cranberry Lake, the senior author has taken a number of colonies of these just after they had invaded the abandoned or still occupied burrows of other insects. In one case (June 9, 1915) a group of about twenty individuals were observed in the burrow of a larva of *Monohammus scutellatus.* Only a few of these had started egg-galleries, the remainder being grouped together in a little recess in the side of the burrow of the roundheaded borer near the ventilation opening.

Several bark beetles have already been mentioned as associated with *C. pusillus* in larch. In addition to these *Asemum moestum* and *Serropalpus barbatus* were bred from the same material, but these being wood-boring forms, their relations to the minute scolytid would not be at all close. *Phyllobaenus dislocatus* is the only predator associated and no parasites were bred from the same material.

Drycoetes americanus Hopkins.

Dryococetes americanus, according to Hopkins (1915, p. 51) is the eastern North American species which has heretofore been confused with *D. septentriones* and *D. autographus.* It has been recorded as the latter species, from Alaska, Hudson Bay Territory, Lake Superior, New Jersey, southwestern Pennsylvania, Virginia and West Virginia (Felt, 1906, pp. 672). It is probably found through the Rocky Mountain region also, for Fall and Cockerell (1907, pp. 217) lists it among the Coleoptera of New Mexico, and Hopkins (1915, pp. 51) states, " Specimens from the Rocky Mountain region show minor differences that are hardly distinctive enough to justify the designation of a different species." Several species of coniferous woods have served as hosts for this scolytid. It was first recorded from red spruce (*Picea rubens*) in West Virginia in 1890 by Dr. Hopkins. In 1891 he reported a parasite — *Spathius canadensis* Ashm.—from the bark of dead *Piceae* [Abies] *excelsa* in mines of *D. autographus.* Later it was taken from partly living and dead bark of black and Norway spruce and had also been found in pitch pine (Hopkins, 1899, pp. 445). It has also been taken from white pine and red spruce by the senior author at Cicero Swamp, N. Y., in September of 1914; at Cranberry Lake, N. Y., in June, 1915 and 1916; and in Greene Co., N. Y., in 1914 and 1915.

Very little in detail is recorded about the habits of this insect. It has generally been considered as preferring greatly weakened or dead bark in which to make its burrows. Another prominent characteristic is that the beetle almost invariably attacks the lower portion of the tree, even extending its galleries several inches below ground in extreme cases (Hopkins, 1899, p. 252). In the larch studied the insects were found under the thin bark of one of the larger roots that was free of the soil for a short distance. No definite pattern was noticed in the burrows, however, only a very few specimens were taken and the material upon which to base any opinion regarding the engravings was quite insufficient.

In the Adirondack and Catskill regions this species is one of those most often found breeding in the stumps and trunks of felled spruce and white pine. Immense numbers are found in spruce, especially where this is of a size having thin bark and where it is on or near the ground. Skidway timbers and other similar structures near the ground are very often infested. Other bark beetles often found associated in spruce and pine are *P. rufipennis, Ips pini, Ips cœlatus, Pityogenes punctipennis, Hylurgops pinifex,* and *Dryocoetes affaber.* Adults have been taken by the senior author from their old burrows in the bark at various times from September to July. New colonies are established during June and early July in the Canadian Zone regions of New York.

Only a few insects were found actually associated with *D. americanus* in larch, doubtless because the only larch found infested was an exposed dead root of a living tree which on account of its size did not offer breeding facilities for many insects. *Leptura vittata* was bred from the same material, some of the adults of this two-year form emerging the same year and some the year following the emergence of the *D. americanus.* The larva of an unidentified elaterid, possibly predaceous, was taken and a fly *Phorbia fusciceps* Zett. was bred from this material, while a small portion of exposed and decaying wood yielded adults of the weevil *Dryophthorus americanus.*

Dryophthorus americanus Bedel.

The range of this cossoninid includes Eastern Canada and the Eastern United States as far south as Florida and as far west as Wisconsin. It has been reported as occurring specifically in *Pinus rigida* (Chittenden, 1890, p. 172) and in general as being found under the bark and in decaying wood. (Insect Life, Vol. 1, p. 198.)

Very little specific information can be culled from the literature regarding the habits and life history of this insect. Further than that the adults may be obtained from beneath the bark and in the dead wood (especially of pine) during the winter and early spring, no information seems to be at hand. Specimens were obtained by us from three separate lots of material. In one case under bark killed only the previous year and infested with *D. simplex* and *P. rufipennis.* The small weevils perhaps fed upon the inner bark which as yet had only begun to decay. In both the other cases, exposed and decaying wood was the part infested (Figs. 29, 30). Here the beetles were taken from their burrows, which ran in all directions through the punky wood, without conforming to any discoverable pattern.

Adults were taken from breeding cages after emerging from their larval hosts July 3 and 7, 1916. Other specimens were taken from their burrows November 2, 1916.

Insects obtained from the same material include *Dryocoetes americanus*, *Leptura vittata*, *Stenocellis brevis*, *Tenebrio tenebriodes*, the elaterid *Adelocera brevicornis*, an unknown elaterid larva and the fly *Phorbia fusciceps.* Of the beetles mentioned all but *Dryocetes americanus* are wood-inhabiting forms and may bear very important relations to each other. The association with *L. vittata* and *Dryocoetus americanus* is perhaps not so common as with the other three beetles, though doubtless the larvae of the cerambycid prepare the wood for its later occupancy by the cossoninid. Its occurrence in the same bark with *D. simplex* and *P. rufipennis* is still less to be expected and perhaps may be explained by the individual of *Dryophthorus americanus* hibernating in the abandoned portion of the burrows of one of these scolytids. Perhaps the association with *Stenocellis brevis* is the most common, due to the fact that their habits and food are similar. However, any actual relations which the two forms may have are doubtless accidental or casual.

Stenocellis brevis Boh.

Stenocellis brevis ranges from New England and Canada to Michigan and Kansas and south as far as Florida (Blatchley and Leng, 1916, pp. 545). This cossoninid has been taken from a great variety of host trees. Packard (1890) lists it from dead wood of elm (pp. 284), wood of butternut (pp. 342), partly rotten stump of red maple (pp. 391), and from linden (pp. 381). Chittenden (1890, pp. 99) in addition to these records it from basswood, beech, birch, sycamore and willow. Hickory and poplar were added to the list by Harrington (1896, p. 75). Felt (1906, pp. 494) adds ash, and Blatchley states that Zabriskie has found it in apple wood (1916, pp. 545). It has been taken by the authors from larch, hickory, apple and horsechestnut. No specific record has heretofore reported it from coniferous woods so far as can be learned from the literature.

From observations in the field as well as from literature on the subject it appears that decaying wood or at least exposed dead wood is necessary for the insect's welfare. The burrows have been seen in apple and horsechestnut where the outer wood was still very hard and contained no evidence of fungi. In larch, however, it was found in one instance in the decayed wood of a small tree, about three inches in diameter, where the wood was soft and in such condition that the fibres could be readily pulverized between the fingers. In a second case they were taken from dead sapwood caused by the peeling of a strip of the bark down the trunk of a larch about fourteen inches in diameter. At this time both adults and larvae were found scattered through the galleries, the adults occasionally found in groups of three or four in enlarged chambers in the wood. The sapwood had begun to decay and the live bark had started to close over the wound, which had apparently been made about six years previously.

The beetles were taken from one to five feet above the ground. This was as far up as the tree had been peeled. They were found under much the same conditions in apple and horsechestnut wood.

It is believed that the beetles may possibly remain in the wood for a period of two or more years. At least they have been observed in a horsechestnut tree for two consecutive years. Evidently the insect lives in a somewhat social or colonial manner, as several groups of three or four were found in the enlarged burrows. The galleries are about 1.5 mm. to 2 mm. in diameter and extend irregularly up and down the tree with many transverse galleries connecting the longitudinal ones. Occasionally wider galleries occur. In the instances observed the wood was more or less riddled by the galleries. The eggs are probably laid in the primary gallery and the larvæ bore out into the wood in all directions. Adults have been taken from larch February 26, April 28; larvæ on April 28. Blatchley (1916, pp. 545) has taken the adults June 15 to July 30, beneath bark and by sifting rotten wood.

It is quite probable that *Serropalus barbatus* often precedes *S. brevis*, especially in weakened trees, and its galleries make the wood a more suitable breeding place not only for this cossoninid but for other forms living in decaying wood. It is also possible that *Asemum moestum* may precede *S. brevis* in a like manner. Both of these forms would bear a very important relation to the curculionid by preparing the wood for its purposes.

Insects actually associated with *S. brevis* were *Dryophthorus americanus*, *Tenebrio tenebriodes*, and *Adelocera brevicornis*. These all from dead wood which had begun to decay and which was more or less riddled with insect burrows. *S. brevis* may be preceded by any one of a great variety of forms atacking the dying or newly killed tree. It seems to prefer rather dry, punky wood, and perhaps for this reason seldom or ever enters the wood still covered by the bark. When it is preceded in the wood by the larvæ of such forms as *Leptura vittata*, *Asemum moestum*, or *Serro-*

palpus barbatus, the wood is in a condition more than usually favorable for its uses due to the burrows already present and to the introduction of decay by their presence.

Phymatodes dimidiatus Kirby.

Hamilton (1894, p. 31) records the distribution of *Phymatodes dimidiatus* as Unalaska, Vancouver, Washington, Idaho, through the Rocky Mountains to Mexico, thence across the northern part of the continent to Maine and Massachusetts. Hopkins (1893a, p. 192) reports it from Washington and Felt (1906, p. 669) from various points in New York and New Jersey. Evidently spruce has been practically the only host recorded for this cerambycid (Hopkins, 1899, p. 438), although it undoubtedly breeds in other species, especially in the Rocky Mountains. Davis (1891, pp. 81) states that he has taken it "from oak posts of a summer house." The senior author has taken the adults from beneath the bark of spruce in the Adirondacks.

P. dimidiatus lives during the greater part of its larval existence directly under the bark, excavating its winding galleries for the most part in the same direction as the grain of the wood. The eggs are laid during June under the small flakes of bark or injured places and even occasionally in the deserted or still occupied burrows of *P. rufipennis* in trees that have been killed the previous year. The larva, from the first grooves the sapwood, the burrow becoming deeper and wider as the larva becomes larger (Figs. 14, 15). However, during its larval existence the burrow is always directly under the bark, and it is not until the insect is ready for pupation that it extends its burrows into the sapwood. Just before it transforms into the pupal stage, which may occur either before or after hibernation, the larva burrows for about a quarter of an inch below the surface of the sapwood and here enlarges its mine to form a pupation chamber. Before pupation, however, the larva burrows up to the bark and packs the end of the gallery with coarse frass so that the adult when it is ready to emerge may work its way out with a minimum amount of labor. The rest of the larval mine is packed with fine, dust-like frass. Winter is most usually passed either in the larval or adult stage.

One year is usually required in this locality for the completion of its life history. However, it should be realized that this represents only the normal condition in the locality in which this form was studied (Crittenden and Syracuse). It is quite likely that it may occasionally, or even may usually, require two years for its development in the colder regions of the State. Dogmatic statements regarding the length of larval life are dangerous. Adults emerged May 26, 31 and June 8 and 15, 1916, from larch killed during 1914. The eggs of *P. dimidiatus* had doubtless been laid in 1915, as was shown in one case by the relation of the larval burrows of this species to the engravings of *P. rufipennis* occurring in the same material.

P. dimidiatus may be preceded in the bark of larch by several insects, notably by *P. rufipennis* mentioned above, by *Dendroctorous simplex, Eccoptogaster piceæ* and by *Asemum moestum.* On the other hand, it may in other cases enter the tree during the same season as any or all of these. It seems rather to prefer trees (whether spruce or larch) which are thoroughly dead, and, therefore, when any of the above species precede it in the bark they by so doing benefit rather than injure it as a place of breeding for *P. dimidiatus.* On the other hand, where the larvæ of this cerambycid occur in the same material as the brood of the various scolytids mentioned, it may be injurious to the latter by robbing them of their food. Other borers which have been bred from the same material include the cerambycid *Leptostylus sexguttatus,* the melandryid *Serropalpus barbatus,* and the two siricids *Urocerus albicornis* and *Sirex abbotii.*

Two predators, *Phyllobaenus dislocatus* and *Cymatodera bicolor,* were associated with *P. dimidiatus.* The parasites derived from the same material include *Rhyssa lineolata, Pseudorhyssa* sp., *Odontaumerus canadensis. Eurytoma* sp. and three apparently new species of *Doryctes.* The relations of these parasites have previously been discussed

(p. 32) and it has been pointed out that of these all but *Eurytoma* sp. are probably parasitic upon *P. dimidiatus.*

Asemum moestum Hald.

Asemum moestum has been recorded from Canada southward to Florida. It is known from Lake Superior and Packard (1890, pp. 697) has taken it from Colorado and states that it undoubtedly breeds in coniferous trees in the Rocky Mountain region. LeConte believes that it occurs in Alaska (Packard, 1890, pp. 697). The host trees include white pine (Packard, 1890, pp. 697), yellow pine and spruce (Hopkins, 1899, pp. 438). Apparently larch has never been recorded as a host, but it is likely that this borer will be found in a large number of coniferous trees throughout its range.

This beetle lives in the larval stage in the base of the trunk. We have never bred it from wood more than a few feet from the ground. It is then, as will be readily seen, most often found in the stumps of its host trees in regions which are being lumbered. The adults will apparently deposit their eggs only in green, sappy material, and our observations show that it very often enters the larch even before this shows any visible signs of weakness — sometimes a full year before the entrance of *Dentroctonus.*

The young larvæ on hatching burrow into the sapwood and often extend their mines deep into the heartwood. These mines, which are somewhat flattened in cross section, are more or less winding in their course, but with the general direction more usually longitudinal. The larvæ are often very numerous, in one case six larvæ of various sizes being taken from a space about six inches square. This beetle ordinarily requires two years to complete its larval growth and the probabilities are that occasionally a longer time is necessary. The pupal stage is passed in an enlarged chamber at the end of the larval burrows. This is constructed in the sapwood quite close to the bark. The adult emerges through an oval hole in the bark. Beetles emerged from larch May 29 and June 15, 1916. Numerous other adults have been taken by the senior author at Cranberry Lake, N. Y., during June and early July, both on the wing and from the wood of both pine and hemlock.

A. moestum is one of the primary insect enemies attacking the weakened tree. It is often associated in either its first year or second year with *Serropalpus barbatus*, which is also a wood inhabiting form. Quite often the burrows of these two forms occur in the same section of wood, although the melandryid, of course, bores the wood of a greater region of the trunk. Other beetles found to occur in the same samples of the trunk are *Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceae* (occasionally), *Phymatodes dimidiatus* and *Melanophila fulvoguttata*. These may be associated with *A. moestum* during either the first or second year of the latter's life; or in the case of *M. fulvoguttata*, the two forms may occur in the same trunk throughout two years. It should be borne in mind, however, that *A. moestum* seldom or never spends any considerable time between the bark and the sapwood, and therefore its relations with these forms (other than *S. barbatus*) are usually more apparent than real. However, where it enters the tree a full season ahead of its associates, as often occurs, there can be no doubt that its presence in any considerable numbers greatly weakens the tree and makes this a more attractive host for those forms entering later. This is especially true in the case of the bark beetles because the larvæ of *Asemum*, working in the wood, while they weaken the tree's resistance, do not destroy the inner bark.

Monohammus scutellatus Say.

Monohammus scutellatus is distributed throughout Canada and the Northern part of the United States from coast to coast, as far north as the Hudson Bay and Yukon regions (Hamilton, 1894, p. 31) and as far south as New Mexico and West Virginia (Hopkins, 1893, p. 195).

The hosts most usually recorded for this cerambycid are white pine and spruce. In the Cranberry Lake region and also in the Catskills the senior author has most often taken it from balsam fir. There can be no doubt, as is indicated by its distribution, that a large number of conifers may serve as host. In larch this beetle was bred only from the trunk region, but doubtless also occurs in the tops and larger limbs. In other hosts it occurs most often in regions having comparatively thin bark. Thus in white pine it is most usually found in the tops and limbs, while the two sister species *M. confusor* and *M. titillator* are more common in the trunk. In spruce this is true to a lesser extent, due to the thinner bark, and in balsam any part of the trunk and the limbs down to a diameter of less than an inch are likely to contain larvae, although they are here perhaps more common in the trunk.

The eggs are laid in material in a variety of different conditions. Eggs still unhatched and newly hatched larvæ have been taken from a balsam tree which was still entirely alive and green but slightly injured by lumbering operations. On the other hand, living, callow adults have been taken from their transformation chambers in balsam which had been down and dead at least four years. The larch from which specimens were bred was in similar condition when brought to the laboratory, the bark being loose and the tree having been dead three or four years. However, in other recently killed larches the larvæ have been found and burrows in such material from which the larvæ have been removed by woodpeckers are numerous.

The adults of this beetle are abroad throughout most of the summer and may oviposit at any time between the first of June and the first of September. However, the height of the breeding season is during July and August. On July 8, 1914, the senior author took twenty-one specimens of this insect in a few minutes while eating his lunch in a small, recently-made clearing near the summit of Twin Mountain, Greene Co., N. Y. These beetles were at the time creeping over the bark of recently felled balsam and spruce. Several pairs were taken in copulation, and in one case the female was ovipositing although still attended by a male.

Some interesting observations upon the breeding habits were made by Mr. A. J. MacNab, a graduate student in the laboratory, and these are supplemented by other observations made by the senior author at various times. On February 1 some branches from a tree which had been cut the preceding winter were brought into the laboratory and placed in a breeding cage. On March 7 adults of *M. scutellatus* began to emerge. Some fresh pine from one to two inches in diameter, was placed in a breeding jar and the beetles were introduced, the bottom of the jar being covered with a layer of moist earth for the purpose of keeping the humidity more constant and to furnish a suitable footing for the beetles.

When this jar was placed in the sunlight, or when the bright light from a tungsten bulb was directed upon the jar, the females climbed to the top of the pine sticks and made attempts to fly. They were followed by the males, all of the beetles showing apparent excitement. After being exposed to the heat and light of the tungsten bulb for about an hour, copulation began. In this process the male mounts the female, grasping her around the prothorax with his fore-legs, which are especially modified for this purpose, at the same time bending his abdomen downward and forward so as to bring the genital openings together. The penis is then extruded and sexual connection is established if the female denotes her willingness by opening the space between the last dorsal and ventral plates of the abdomen. When she is not ready for sexual intercourse, she often tries to escape, and sometimes an especially ardent male may be carried all over the limb for ten or fifteen minutes before the female becomes complaisant or until he is dislodged.

Copulation lasts a variable length of time. In several cases where the time was noted, it lasted from half a minute to considerably more than three minutes and was accompanied by a pumping movement of the abdomen of the male. The same male often copulates with the same female or with other females repeatedly. In one case, after a union lasting over three minutes, the connection was broken, but the male still clung to his mate and was dragged or carried all over the limb for five minutes before he was finally dislodged. Perhaps the most peculiar case illustrating the ardency of the male was the following: It being desired to examine the anatomy of the penis, a pair of beetles in copulation was chosen and the penis of the male was grasped with a pair of forceps and removed from the body. The male was then replaced in the jar with his mate. For a few minutes he rushed about in an excited manner acting as if in considerable pain. In a short time, however, he quieted down and his behavior became more normal. Just eighteen minutes after the amputation of his penis he again mounted the female and attempted copulation.

During actual copulation the female, however anxious she may apparently have been to escape, remains stationary or nearly so. She usually behaves with the greatest apparent indifference, very often continuing to feed by biting off bits of pine bark. Both males and females feed readily in captivity on the bark of fresh pine limbs, although perhaps the female is more voracious.

In depositing her eggs the female usually chooses a point near the juncture of twig with the limb or some location which has been roughened by having the bark chewed off in feeding (Fig. 17). In either case she bites away the outer bark constructing what might be spoken of as a shallow pit which extends into the inner green bark. She then turns around, places the end of her ovipositor in this shallow cavity and pushes it deeper and deeper into the inner bark in a direction parallel to the bark fibres. In four cases the depth of this egg puncture was measured and was found to vary from five and a half to seven and a half millimeters. Sometimes several eggs are deposited in punctures arising from one pit. In such cases they are arranged radially around the common point of entrance. In some cases no pit is constructed, but the ovipositor is thrust through the thin, outer bark as far as possible into the inner, green bark. The process of oviposition was timed in several cases and requires on an average about two minutes.

Small sections of the bark containing eggs, the time of depositing of which was known, were placed in a moist chamber for incubation. The incubation period in the laboratories was about twelve days. An egg laid at 4 P. M. March 8 hatched March 20 and others required a similar length of time.

Adults bred in the laboratory and confined in captivity with abundance of proper food lived from fourteen to thirty-one days, the average being between fourteen and twenty days. The male from which the penis had been removed lived the longest period of any — thirty-one days.

The larvæ burrow between the bark and the sapwood, grooving each about equally. The galleries are irregular, sometimes becoming rather long and winding, while in other cases they are confined to a small area. Very soon after hatching the larva makes an opening to the outside through the bark. This is always small, never being large enough for the passage of the larva's body, and is used in thrusting out the chips or "sawdust" of the sawyer, the larval mine near this opening being kept clear of this material (Fig. 16). Often this frass will collect to form piles of considerable size under the infested logs, resembling piles of sawdust. Some time during the summer the larva carries its mine into the sapwood, often for a depth of several inches when the burrow is in the trunk. This mine is used as a retiring chamber and, on occasion later, as a hibernating chamber and eventually as a pupation chamber. The winter may be passed as a full-grown larva or as a larva in any stage of its growth.

The length of the larval life varies quite remarkably from one to three years. Normally the larvæ complete their growth and transform to the adult in a single year, but in some cases this may be unduly lengthened by several causes. Numerous cases have been noted where blown-over balsam trees which happened to lie in locations to which the sun never has access have contained the same generation of larvæ for two and even three years. The larval period may also be unduly lengthened by other unusual conditions. On two separate occasions, once in the Adirondacks (balsam) and once at Syracuse (pine), infested wood known to contain full-grown grubs was barked and one year later still contained living larvæ or young adults. The barking of the wood created an unusual condition in several respects, but especially it rendered the wood more subject to dessication, and this abnormal dryness was doubtless the factor which retarded the development of the larvæ. It is interesting that the larvæ and young adults under these conditions were apparently normal in all respects except as regards time of emergence.

As the larva continues to grow the "retiring burrow" in the sapwood is enlarged from time to time to accommodate its larger bulk, and when the larva reaches full growth this is carried deeper into the limb or trunk to form the pupation chamber. This, in burrows in the trunk, may lie in the heartwood several inches from the bark. Always before pupation a passageway, circular in section, is extended outward toward the bark, usually ending a fraction of an inch from the inner bark. This is to act as an exit for the adult when it emerges. The larval entrance to the pupal chamber is then plugged with excelsior like frass and the larva pupates in the deeper part of the burrow. The emergence hole through the bark is nearly exactly circular in outline and from 4.6 to 6.5 mm. in diameter (Fig. 16).

Eccoptogaster piceæ and *Polygraphus rufipennis* precede *M. scutellatus* in larch and *Serropalpus barbatus* was bred from it the same season.* In balsam it is most often associated with *Pitogenes punctipennis* Lec. and with *Urocerus albicornis*. In pine *M. scutellatus* is often associated in the limbs with the sister species *M. titillator*, *Ips pini* Say, *Pitogenes hopkinsi* Swaine, and others, and in the trunks with *M. titillator*, *M. confusor*, *Ips longidens* Swaine, *Graphisurus faciatus* De G., *Rhagium lineatum* Oliv., *Pytho americanus* Kirby, etc.

* In Tree IX it was associated with *Polygraphus rufipennis*, *Neoclytus longipes* and *Xylotrchus undulatus*.

Leptura vittata Oliv.

Leng (1890, pp. 199) has recorded the habitat of this cerambycid as Canada, New York, New Hampshire, Maine, Massachusetts, Pennsylvania, Virginia, Georgia, Alabama, Louisiana, Illinois and Wisconsin. Very little is known regarding its host trees, and evidently larch is the first wood from which this insect has been bred. Blatchley (1916, pp. 1059) has taken the adult from the foliage of Virginia creeper and other shrubs. The senior author has taken it in large numbers from the blossoms of wild spiræa in the Catskill mountains during July and August.

Specimens of this insect were bred from a partly decayed piece of root that had been free of the ground for some time. The tree from which it came was still alive. The root was covered with thin bark and is about four inches in diameter. Adult specimens of *Dryocetes americanus* were taken from beneath the bark in the spring before *L. vittata* emerged. Only a small piece of root was studied, but some half dozen larvæ and adults were derived from it. Apparently the life history is not completed in one year, for wood confined in the breeding cage produced adults both in the early summer and in the following winter in the laboratory. It is very likely, however, that two years are sufficient for the completion of the various stages of its development. The larvæ burrow through the sapwood and frequently they are found deep in the heartwood. The pupal chambers, however, are found directly under the bark. The larval burrows are very similar to those of other cerambycids burrowing in the sapwood of trees. Fine dust-like frass is tightly packed in the larval burrows, while in the pupal chambers we find each end packed with the characteristic excelsior frass. Adults emerged June 15 and 28 in the outdoor breeding cages and January 10 in the laboratory the following winter.

Dryocetes americanus and *Dryophthorus americanus* and an unknown elaterid larvæ were found associated. *Phorbia fusciceps,* a fly, was also taken from the wood, but had probably emerged from decaying fungi. No associated parasites were obtained.

Leptostylus sex-guttatus Say.

Leptostylus sex-guttatus has been recorded from Canada, Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, Ohio, Michigan, Wisconsin and New Mexico (Leng and Hamilton, 1896, p. 119). Blatchley (1910, p. 1072) reports it also from Indiana. Apparently little is definitely known regarding the larval host of this cerambycid. Beutenmüller (1896, p. 79) states that it "breeds in the wood of locust." Wickham (1897, p. 152) says that it "may be taken on freshly cut pine," and Morris (1916, p. 197) records having taken a number of specimens from a fallen pine. Our record from larch is apparently the first time it has been recorded as having actually been bred from a conifer. It has also been bred from the limbs and trunk of white pine by Mr. A. J. MacNab, a former student working in our laboratory. This beetle has been found to breed only in the thin-barked parts of the larch and the female seems to show a preference for the freshly killed or weakened tops or limbs in which to deposit her eggs. However, three specimens were also obtained from the trunk of a small tree about two inches in diameter which had been killed by shading.

Upon hatching the larva begins to construct its larval gallery between the inner bark and sapwood. At first this grooves both bark and sapwood to an equal extent, but as the larva increases in size a greater per cent of the depth of the burrow is excavated from the wood and a less per cent from the thin bark, so that when the larva reaches full size about nine-tenths of the thickness of the larval mine is in the sapwood. The course of the larva is very tortuous (Fig. 18) and is sometimes unusually long for a borer of its size, even though it be a two-year form as in the present case. In one case where all parts of the larval mine could be readily traced it measured 290 mm. to the entrance of the pupal chamber.

At the end of the second season the larva reaches full growth, but before pupating it bores into the sapwood, usually not more than a half inch from the surface to construct a pupation chamber. It usually continues this burrow parallel to the surface for about 40 to 50 mm., then extends it upward to a point just beneath the bark. The pupal chamber for about half its length is solidly packed with fine frass, as was the entire larval burrow. However, the "sawdust" in the entrance to the pupal burrow is of a lighter color than that in the larval mine, because it is derived entirely from the sapwood, whereas the latter comes partly from the bark. The adult on arising gnaws through the thin layer of sapwood left by the larva, perforates the bark and emerges through an oval exit hole about 2½ by 3 mm. in diameter.

The following borers were associated with *L. sex-guttatus: Polygraphus rufipennis, Eccoptogaster piceæ, Pogonocherus mixtus, Neoclytus longipes, Phymatodes dimidiatus, Melanophila fulvoguttata, Chrysobothris blanchardi, C. sex-signata, C. dentipes,* and *Anthaxia quercata.* All of these except the two scolytids and *P. dimidiatus* are two-year forms and live in the limbs and tops during the same two seasons. *P. rufipennis* and *E. piceæ* are associated with these larger borers usually only during the first year. Occasionally, however, second broods of each of these are reared in the old host. Although this may perhaps occur more commonly in the breeding cages than in nature, examples under both conditions were found. The brood of either of these scolytids is likely to be robbed of their food or actually killed outright by the larvæ of *Leptostylus sex-guttatus* or any of the other round-headed or flat-headed borers mentioned above. This is especially true during the second year of the larval life of the large forms. In this connection it is interesting to note that two sister species of *L. sex-guttatus, L. aculipes* and *L. macula,* have been reported in similar roles in connection with two other scolytids (Schwarz, 1890, p. 165).

The inter-relations of the larger borers are variable and more or less accidental. The simultaneous presence of several specimens either of the same species or of different species in the same region may be of advantage in overcoming the resistance of the dying or weakened tree. If the tree is already so weakened as to offer no considerable danger to the developing larvæ, the presence of several is of no importance. On the other hand, so many larvæ, either of the same (Fig. 27) or different species, are sometimes present as to reduce the amount of available food to such an extent that the resulting insects are underfed and therefore undersized. It is likely that occasionally this condition becomes so acute as to result in the actual starvation of some of the larvæ.

Predators associated are *Phyllobaenus dislocatus* and *Cymatodera bicolor.* These are doubtless more dependent for food upon the associated scolytids, but it is believed that they may also feed upon the smaller flat-headed and round-headed borers, especially when these are young. The adults would experience difficulty in gaining access to the larvæ on account of the closed burrows packed with frass, so they would probably only occasionally be able to attack them. However, the larvæ of clerids are well-known inhabitants of the burrows made by other insects, and without doubt they occasionally prey upon both cerambycid and buprestid larvæ.

Three parasites were associated with *L. sex-guttatus* and the other round-headed and flat-headed borers occurring in limbs and tops. These include *Phasgonophora* sp., *Atoreutus astigmus* and *Odontaulacus bilobatus,* specimens of each of which emerged at about the same time as the two-year borers. No conclusive evidence definitely associating any of these with their host is at hand.

Neoclytus longipes Kirby.

Neoclytus longipes has been recorded from Canada, Virginia and Texas by Leng (1887, p. 8). No definite statement regarding its host was found, but Wickham (1897, p. 152) and Morris (1916, p. 198) have taken the adult from freshly cut pine.* This borer was obtained by us from larch brought both from Crittenden and from near Wanakena, showing a wide distribution in the State.

* The senior author has taken numerous specimens from the surface of the bark of freshly cut balsam and spruce.

This cerambycid requires two years for the completion of its life history. As noted above, it was bred from material from two different sources. That derived from Crittenden consisted of the limbs of Tree I. This was confined during the entire summer of 1916 and during this time gave rise to only two borers, *Polygraphus rufipennis* and *Eccoptogaster piceæ*. It was then removed to the laboratory November 2, where the temperature conditions were such as to induce the larvæ to resume work. Adults of *N. longipes* emerged January 30 and March 16.

The second lot of material derived from Wanakena consisted of tops 2–4 inches in diameter of Tree IX, which had been blown down during May, 1916, and had become infested between that date and the middle of August. This material was confined in breeding cages outdoors till early in January, 1917, when it was brought into the laboratory, but was again removed to a cold room in the latter part of February, where it remained till June. It was then placed in an outdoor breeding cage, and on July 3, 11 and 18 specimens of *N. longipes* emerged. Thus this form, which normally requires two years for the completion of its life history, was induced to emerge a season earlier by the treatment the material received. It should be noted in this connection that the specimens thus treated are slightly undersized, measuring respectively 7, 8 and 8 mm., while those from the other lots of larch were from 9 to 9.5 mm., being entirely normal in size.

N. longipes deposits its eggs in larch which is either dying or recently dead. The larvæ excavate deep, rather narrow burrows in the sapwood just under the bark. The larval mines are very long (Figs. 19, 20), in three cases where they could be accurately measured being 445 mm., 485 mm. and 568 mm. These measurements are rather too small than too large, as no attempt was made to measure the smaller curves in the course of the grooves. The entire burrow is packed full of rather fine frass by the larva, which, on becoming full grown, burrows into the wood to construct a pupation cavity (Figs. 19, 20). This chamber in the wood is also much longer than usual, varying in cases observed from 45 mm. to 120 mm. This pupation chamber is solidly packed with fine frass for the greater part of its length — only from 20–30 mm. being free of this material — and in spite of its excessive length it usually does not lie more than half an inch from the surface of the bark, although it may lie deeper. On emerging the adult gnaws through the surface and leaves the wood through a nearly circular hole slightly more than 2 mm. in diameter.

Larch is attact by *N. longipes* the same season that it is attact by *P. rufipennis* and *E. piceæ,* and thus the larvæ are often associated with the brood of these scolytids throughout their first year of life. It was also associated with the following insects emerging at about the same time: *Leptostylus sex-guttatus, Pogonocherus mixtus, Chrysobothris dentipes, C. sex-signata, C. blanchardi, Melanophila fulvoguttata* and *Anthaxia quercata.* In the material studied these forms were never so numerous that the burrows interfered with each other seriously, and therefore the interrelations were probably not at all important in an adverse way. However, in dying or sappy bark presence of a greater number of specimens, up to a number where additional ones would interfere with the available supply of food, is of a distinct advantage in overcoming the resistance of the tree. So long as these all worked in a similar region it would make no difference whether the larvæ represented a number of species or were all of one species.

Phyllobaenus dislocatus was the only predator derived from material containing *N. longipes.* It is probable that this is more usually dependent upon the associated scolytids for its food, but it is by no means improbable that it will attack the larvæ of any of these smaller round-headed and flat-headed borers whenever it can gain access to their burrows. The same three parasites were associated with *N. longipes* as with *L. sex-guttatus.*

Pogonocherus mixtus Hold.

Pogonocherus mixtus has been reported from Canada and from nearly every region of the United States except the Southeastern States. Leng and Hamilton (1896, p. 135) give the distribution as "Canada, Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Missouri, Kansas, Colorado, Montana, Idaho, California, Arizona." This species has been taken from beneath the bark of willow (Caulfield, 1881, p. 60) and "beneath the bark and on the dead limbs of pine (Blatchley, 1910, p. 1081). We have bred it both from the "shaded out" limbs of white pine and from the limbs of larch.

The eggs are deposited in recently dead thin-barked larch or pine. Cracks or other injuries in the bark were utilized by the female in ovipositing. In one case in pine the ovipositor had appearently been thrust into the entrance to the burrow of *Pityophthorus* sp. in gaining access to the inner bark. The larva on hatching works directly beneath the bark, grooving the sapwood deeply. The burrows at first are both narrow and shallow, but those made by the full-grown larva are from 4 to 7 mm. wide and slightly more than 2 mm. deep. The course of the larval gallery is only slightly winding, as shown in Fig. 21, and usually the burrow loops back upon its course so that the entrance to the pupal chamber often lies not far from the origin of the burrow. The burrow is rather short, usually from 110 to 125 mm. long. The pupal chamber is carried diagonally into the wood for a depth of 12 to 15 mm. The larva then plugs the opening loosely with medium-fine shreds of wood and pupates. Apparently before pupating the larva has arranged itself with its head directed back toward its larval burrow for the adult on emerging invariably (so far as our observations on fifteen cases go) removes the obstructing frass and emerges through a nearly circular opening in the bark covering the larval mine. The insect requires two years for the completion of their growth and the adults begin to emerge about the middle of June.

Associated borers, predators and parasites are the same as for *Leptostylus sex-guttatus* (see page 75), with the exception of *Phymatodes dimidiatus.*

Melanophila fulvoguttata Hare.

Melanophila fulvoguttata is distributed throughout eastern Canada and United States from Labrador (Sherman, 1910, pp. 193) to North Carolina (Blanchard, 1889, pp. 193) and is common as far west as the Lake Superior region (LeConte, 1859). The host trees most commonly attact are the hemlock and spruce, of both of which this species is a serious enemy. In addition Harris (1862, p. 50) records having taken the adults from the trunks of white pine during June. It was bred by us, both from the branches and the trunk of larch and has been taken by the senior author from both hemlock and red spruce in the Cranberry Lake region of New York.

M. fulvoguttata deposits its eggs in the bark of the trunk and limbs of weakened, dying or dead hemlock, spruce or larch. It may also breed in balsam fir and white pine, but no definite data is at hand to prove this. The larval mines of this flat-headed borer are rather wide, shallow and winding in their course, and where the larvæ are numerous, as is very often the case in dying hemlock or spruce, these larval burrows cross and recross each other, making it difficult or impossible to follow the course of any particular one. Two years are required for the completion of the life history. The adults emerge at any time during the summer, having been taken by the senior author in the Adirondacks at various times between June 15 and September 1.

M. fulvoguttata may occur under the bark of any part of the tree from the base of the trunk to limbs an inch in diameter. It may therefore be associated with any of the boring insects attacking the same tree. In our work it was found actually associated in the trunk region with *Dendroctonus simplex, Polygraphus rufipennis* and *Asemum moestum;* and in the limbs and tops was bred from the same material as *P. rufipennis, Eccoptogaster piceæ, Leptostylus sex-guttatus,* *Pogonocherus mixtus, Neoclytus longipes, Chrysobothris blanchardi, C. sex-signata, C. dentipes* and *Anthaxia quercata.* The associated predators and parasites were the same as for *N. longipes.*

Chrysobothris blanchardi Horn.

The distribution of *Chrysobothris blanchardi* was reported by Horn (1886, p. 94) as Massachusetts, District of Columbia and Lake Superior region. Blatchley (1910, p. 791) records specimens from two counties in Indiana. This species has been recorded as a borer in white pine in Massachusetts by Blanchard (1889, p. 31) and as occurring "on scrub pine" (Blatchley, 1910, p. 791). Blanchard's data was derived from specimens actually cut from white pine during July and August.

Chrysobothris blanchardi was obtained only from the branches and tops of larch. The eggs are laid under the bark of weakened, dying or recently dead trees. The larval burrows are rather long and flattened in cross section, but considerably narrower than in several of the sister species, including those mentioned later. Although there is much variation in the burrows, yet it is usually true that at first the larval mine is likely to be longitudinal and nearly straight, or at most only wavy in its course, while that made by the nearly full-grown larva later is likely to be very tortuous, often crossing and recrossing its own former path. (Figs. 23, 24.) The entire burrow is tightly packed with frass and that derived from the bark and from the sapwood is often so arranged as to form alternate dark and light striæ, as shown in Fig. 25. The material for this is derived by the larva alternatingly excavating from the bark and from the sapwood, and this is arranged to form the curved striæ by the abdomen of the borer, which is habitually curved, the loop being pressed against the packed frass to afford leverage while the larva is rasping off the woody fibres. Pupation takes place in a shallow chamber extending longitudinally with the wood fibre and lying just under the surface of the sapwood. The adult leaves the pupal chamber through the same opening as that through which the larva gained access, and on reaching the level of the bark, there constructs an oval emergence hole. Two years are required for the completion of the life history.

The associated insects are the same as for *Neoclytus longipes* given previously and it seems unnecessary to repeat the list here.

Chrysobothris sex-signata Say.

Chrysobothris sex-signata, according to Horn (1886, p. 112), "Occurs from New York to Virginia, westward to Nebraska and Indian Territory." Blanchard (1889, p. 31) records it as occurring in New England but as "rather scarce." Blatchley (1910, p. 791) also speaks of it as scarce in Indiana, although he lists it from five countries.

No record of this insect actually having been bred from a conifer was found, but Blanchard (1889, p. 31) has beaten it from pitch pine. Chittenden (1889, p. 219) records it as having been "cut from a beech tree in which it had bred." Smith (1909, p. 293) reports it "on beech, birch and chestnut." This species, like many others of the same genus — and indeed many other genera of buprestids — doubtless breeds indiscriminately in a large number of trees, both broad-leaved and coniferous. The authors have not only obtained a number of specimens from larch, but also have bred large numbers from hickory.

The female chooses the same sort of material in which to deposit her eggs as does *C. blanchardi.* The burrow made by the larva is quite variable. Sometimes it is only moderately coiled as in Fig. 26, while in other cases it is so tortuous that it is impossible to trace its course throughout its entire length, owing to the fact that the larva crosses and recrosses its old track. The burrows, when they can be traced, are usually readily distinguishable from those of *C. blanchardi* by their being actually broader and relatively shallower. The length of the burrows of *C. sex-signata* is more often less than those of the sister species, but this varies somewhat, dependent both upon the ultimate size of the individual making the burrow and upon the width of the burrow itself. In *C. sex-signata* the gallery leading to the pupal chamber is also noticeably wider — *i. e.*, is a flatter oval in cross section — than in the other species. The general character of the burrow of this species is well shown in Fig. 26, although it should perhaps be stated that it is rarely that the entire course of the larval mine is so readily to be seen as it is there. This species requires two years for its life history, the adults emerging in midsummer. Our record includes specimens emerging nearly daily from June 21 to July 30.

The associated insects are the same as for *Neoclytus longipes.*

Chrysobothris dentipes Germ.

Chrysobothris dentipes seems to occur throughout the greater part of southern Canada and the timbered areas of the United States. The earliest record of a host plant for this flat-head is that of Harris (1862, p. 42), who says that it "inhabits the trunks of oaks". This is confirmed by Fitch (1859, p. 793) and by Packard (1890, p. 60). Blanchard (1889, p. 31) and Crittenden (1889, p. 219) record it as common on pine and the latter concludes that "it is doubtful if it breeds in any but coniferous trees". This latter view seems to us not at all well taken, on account of the definite records from oak and in view of the well known fact that several species of this genus attack a large number of both coniferous and broad-leaved trees and even shrubs with little apparent preference. Packard (1890, p. 680) has taken dead adults of this species from beneath the bark of pine and Felt (1906, p. 657) records it from hard pine. It has been bred in our laboratory not only from larch but also from white pine.

In depositing their eggs the adults of *C. dentipes* choose much the same sort of material as do the other species already treated. They prefer the thin barked portions of larch and pine which is either weakened, dying or recently killed. Pine "slash" affords excellent conditions and they will breed in such material in immense numbers. Larvæ were also numerous in pine limbs which had been suppressed by shading and in the upper part of pines weakened by shading and killed by the attacks of other insects such as *Dendroctonus valens* and *Ips longidens*.*

The eggs were laid in larch that was not yet entirely dead, as was indicated by the fact that in some cases the early portions of the burrows are filled with frass saturated with pitch. This frass is arranged and packed by the abdomen to form the curved striæ mentioned in connection with *C. blanchardi* and evidence to indicate that the pitch was successfully manipulated by the larva is furnished by curved bands of pitchy frass alternating with other bands devoid of excessive resin. Still other cases were observed of burrows which had been made by this species several years before the death of the limb. These had been partly filled with pitchy frass and had thus been, to some extent, preserved from decay. The bark, however, had later been removed by some unknown cause and the burrows partly overgrown by the attempt at repair on the part of the tree.

The burrows made by the larvæ of *C. dentipes* are broader than those of any of the other species of flat-head borers in larch — fully twice as broad on an average as are those of *C. blanchardi*. The course varies greatly. In one case in larch the burrow is longitudinal and nearly straight throughout the greater part of its length of nearly twenty inches (495 mm.)— this doubtless being due to the larva having met no obstructions in its course. In another case a piece of pine top nine inches long and slightly more than two inches in diameter contained fifteen larvæ. The burrows in this piece are very tortuous (Fig. 27), often crossing and recrossing each other, so as to make it impossible to trace any particular one in its entirety.

This insect requires two years for the completion of its life history. The larvæ on reaching full growth burrow

* For the information relative to *C. dentipes* in white pine we are indebted to the notes of Mr. A. J. MacNab, a former graduate student in the department.

diagonally into the sapwood (either of pine or of larch), and often continue their burrows for a considerable distance through the sapwood parallel to the surface. Usually in larch the larva, after it has burrowed several centimeters, carries the mine up to the surface of the sapwood, then retreats down into it and pupates. The adult on arising emerges by continuing the burrow made by the larva up through the bark. In pine, where the sapwood is much softer and more readily worked, the larva often burrows for a considerable distance before it pupates. In one case the burrow was followed in its entirety for a distance of 13 cm. between the point of entrance and the emergence hole of the adult — the pupal chamber being 10.5 cm. from the entrance hole of the larva. All of the burrow except the pupation chamber is filled with frass. It will be apparent that the burrows of *C. dentipes* can be readily distinguished from those of other flat-headed larvæ occurring in larch by the facts just mentioned — *i. e.,* that the larva typically burrows through the sapwood for some distance before pupating, and that the adult does not follow the larval burrow back to the bark but constructs a new exit in order to reach the outside.

Insects associated with *C. dentipes* in larch are the same as those listed for *Neoclytus longipes.* Where insects are excessively numerous, as shown in Fig. 27, whether they are of the same or of different species, it is of course apparent that they are injurious to each other, to such a degree as they limit the food available for all.

Anthaxia quercata Fabr.

Anthaxia quercata is reported by Horn (1882, p. 110) as being distributed throughout the Middle, Southern and Western States and California. This includes the distribution of *A. cyanella,* which is the female of the same species. This species has been bred by Chittenden (1889, p. 219) from chestnut twigs and he has likewise taken the male from the leaves of chestnut and chestnut oak. Blanchard (1889, p. 31) reports it as common in oak shrubs; Felt

(1906, p. 578) has taken it from the leaves of scrub oak, and Smith (1909, p. 293) reports the "larva in grape and chestnut." We find no previous record of its having been obtained from a coniferous species.

The females of this small buprestid deposit their eggs in dying or recently killed larch — and other trees — choosing limbs of a diameter of from three-fourths of an inch to one and a half inches. The larval burrows, in common with those of most flatheads, are considerably broader than they are deep. They are constructed immediately under the bark, grooving both bark and sapwood, but nearly all of their depth is excavated from the sapwood. The course of their burrow is at first longitudinal and is not excessively tortuous. (Fig. 22.) The width of the burrow at the start is about one millimeter and by the end of the first year this has about doubled. The burrow made by the larva during its second season is much more variable both in diameter and in direction. The final result may be a very tortuous burrow which repeatedly crosses and recrosses its own course, or it may consist of an irregular broad area, as shown in Fig. 22. The entire larval mine is tightly packed with frass, and that derived from the bark and from the sapwood is usually so arranged as to form alternate dark and light bands or striæ just as in *C. blanchardi*.

The larva completes its growth during the second summer and then constructs a shallow pupation chamber in the outer sapwood. This extends diagonally down into the wood for a distance of from 6 to 9 mm. The larva apparently pupates with its head toward the larval burrow, egress from the pupal chamber being obtained through the larval entrance. Exit of the larva through the bark is made through a small oval (sometimes nearly semi-circular) opening, which can be readily distinguished from those of the other buprestids by its small diameter.

Insects associated with *Anthaxia quercata* form the typical limb association and comprise *Neoclytus longipes* and the species previously listed as bred from the same source.

Serropalpus barbatus* Schall (*striatus* Hell.)

According to Hamilton (1889, p. 152; 1894 a, p. 33) *Serropalpus barbatus* is distributed throughout Central and Northern Europe, Siberia and the Northern part of North America, extending through the Rocky Mountains as far as New Mexico. In the East it occurs at least as far south as West Virginia (Hopkins, 1893, p. 203).

The European hosts recorded for this melandryid by Judeich and Nitsche (2895, p. 1304) are silver fir, Scotch fir and pine. In America Hopkins has taken it from spruce (1893, p. 203) and from balsam (Felt, 1906, p. 671), and Smith (1909, p. 365) reports having taken it "at light and from dry fungus." The senior author has cut larvæ, pupæ and adults from the wood of balsam, spruce and hemlock in the vicinity of Cranberry Lake, N. Y. We bred numerous specimens from larch, which tree apparently has not previously been recorded as a host.

S. barbatus was first mentioned in forestry literature by Ratzeburg in 1863, but its work was not adequately described and illustrated until Erne gave a rather complete account of its habits in 1892. According to the latter's observations (Judeich and Nitsche, 1895, p. 1804), the adult is nocturnal in its habits and at this time all of its activities are carried on. In the daytime it conceals itself in the moss on the trees and in the ground cover. Erne believed that the life history required three years, while Wachtel (also cited by Judeich and Nitsche) states that the life cycle is completed in two years. Our own observations show that under the climatic conditions of Central New York two years is sufficient. We have, however, already pointed out the danger in making dogmatic statements regarding duration of life history, as such processes are subject to much variation even in the same general locality, being dependent upon the actual temperature and moisture conditions existing in the particular tree or other material infested.

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* Descriptions of the adult, larva and pupa of this species are given by Judeich and Nitsche (1895, p. 1303).

S. barbatus in ovipositing in larch chooses either trees which are dying or which have recently died, or living trees from which part of the bark has been peeled (this latter being in line with its common name of " blazed tree borer "). Occasionally oviposition occurs in living trees — most often in injured or dead parts of the bark. In several cases adults emerged from recently dead larch the same year as *Polygraphus* and *Eccoptogaster* — indicating that it must have entered this material a year earlier than did the scolytids, while the trees were still alive. Usually only the lower trunk is attact, but several specimens have been bred from the trunk up among the limbs as much as thirty feet from the ground.

The larval stage of *S. barbatus* is spent nearly entirely in the sapwood. As soon as they are hatched, the larvæ burrows from the bark into the sapwood and continues mining this part of the tree for two seasons. The larval burrows are very irregular in their course, winding this way and that and showing no discoverable pattern. It is noticeable, however, that a greater part of the length of the burrow is in the soft spring wood and it will often extend for several inches, either longitudinally, circumferentially or diagonally, without leaving a single ring of growth. The burrow is oval in cross section, the long diameter, which is about twice the shorter diameter, being tangential, *i. e.*, confined to one layer of "spring wood." The entire larval mine is packed full of a very fine dust-like frass.

Before transforming to the pupa the burrow is extended by the full-grown larva, which reaches a length of 25 mm. to a level not more than a half inch from the bark and a slightly enlarged chamber is here constructed parallel to the surface of the sapwood. However, before transforming, the burrow is extended to the surface of the sapwood, so that the adult may emerge without having to bore through the wood. Field notes of the senior author, dated Cranberry Lake, June 10, 1915, read as follows: " Numerous adult beetle and two larvæ taken from sapwood of a small dead hemlock. Adults were taken from chambers extending inward one-half inch and thence either downward or to the side about one inch. These chambers had been opened to the inner bark, but not through this, and the openings through the surface of the sapwood were not large enough for passage of beetle. When removed the beetles were quite lively and active." The beetle emerges through a circular hole in the bark. Our records of emergence outdoors extend from June 5 to August 3, as follows: 1916, June 6, 7, 8, 13, 15; July 1, 6; August 3; 1917, June 5, 19, and July 12. In the Adirondacks the senior author took adults from hemlock wood June 10, 1915, and balsam June 26, 1915. Pupæ were cut both from spruce and balsam June 27, 1915. Larvæ were obtained from hemlock June 10 and from spruce June 27, 1915. Individuals of *S. barbatus* differ greatly in size, specimens we have varying from 6.5 mm. to 18 mm.

Insects associated with *Serroplapus barbatus* include the scolytids — *Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Crypturgus pusillus*; the cerambycids — *Asemum moestum*, *Monohammus scutellatus* and *Phymatodes dimidiatus*; the buprestid — *Melanophila fulvoguttata*, and the two siricids — *Urocerus albicornis* and *Sirex abbotii*. None of these habitually precede *S. barbatus* in the wood, but occasionally *D. simplex* and *A. moestum* may attack the tree first. Most often, perhaps, the melandryid is the first insect to enter the living tree — entrance for the egg being gained through some mechanical injury such as a blaze or other abrasion. In weakened trees *Serropalpus* is likely to deposit its eggs at about the same time as *A. moestum* and before any of the other insects listed above. In such cases the adults of both of these two-year forms emerge at the same time as do those of *D. simplex*, *P. rufipennis*, *E. piceæ*, *P. dimidicatus*, *U. albicornis* and *S. abbotii*, all of which are one-year forms entering the tree a year later. In other cases all of the associates listed above enter the tree during the same season and the one-year forms will then have been gone an entire year before the emergence of *S. barbatus* and the other two-year forms — *A. moestum*, *M. scutellatus* and *M. fulvoguttata*.

The presence of *S. barbatus* and of other wood-boring forms in a tree serves to prepare the wood for other insects which otherwise could not utilize it, or at least would not be likely to utilize it. This was especially noticeable in Tree V, which had been partially peeled a number of years before its final death. The presence of the burrows in the wood not only affords the insects mechanical entrance to the wood, but also so promotes decay as to make it fit material for such forms as *Adelocera brevicornis, Tenebrio tenebriodes, Dryophthorus americanus* and *Stenoscelis brevis* to inhabit. After decay has started any or all of these forms may enter the exposed wood and the two latter at least may continue to breed in it for several generations.

Phyllobaenus dislocatus is the only predator bred from the same material as *S. barbatus.* On account of the character of the burrows of the latter and because of their being filled with fine sawdust it is not likely that any close relation exists between these two forms. No evidence of parasites upon *S. barbatus* was found.

Urocerus albicornis Fabr.

(Det. by S. A. Rohwer)

According to Bradley (1913, p. 19) the geographical range of *Urocerus albicornis* extends " From British Columbia, Northern Ontario, Nova Scotia and Newfoundland, south to Pennsylvania, Washington and Northern Idaho." Hopkins (1893 a, p. 215) reports it also from West Virginia. This species was recorded by Packard (1890, p. 733) as attacking pine. Later Hopkins (1893, p. 215) found the larvæ in the sapwood and heartwood of injured and dying hemlocks, while Felt (1906, p. 667) mentions spruce and fir as host trees. The senior author has taken it from the wood of spruce, fir and hemlock in the Adirondacks.

The adult female of *U. albicornis* prefers freshly killed wood in which to oviposit. This is very apparent in the Adirondacks, where females of this horntail are often seen about recently felled spruce and fir. On one occasion the senior author observed three specimens at one time hovering about spruce recently felled and stripped for pulp wood and which was at that time being piled upon a skidway.

Entomological literature contains numerous mention of this insect as a wood borer, but apparently no data is available as regards length of larval and pupal life history. Our data, while not absolutely conclusive, shows that usually the life history is completed in one year. This, however, is doubtless subject to considerable variation, dependent not only upon the general climatic conditions but also upon the exact individual conditions in each case.

The eggs are deposited by the females in the bark of dying or recently felled coniferous trees. Preference is shown for recently felled trees, but failing these, trees dying or even dead are used for ovipositing. The larvæ on hatching bore directly into the wood, in which they construct their mines throughout their entire larval existence. These burrows run in all directions through the wood and are closely packed with a very fine dust like frass. In general they are very much like the mines of *S. barbatus,* but can be distinguished by the fact that they are nearly exactly circular in cross section, while those made by the melandryid are oval.

Adults of this siricid emerged in our outdoor breeding cages during June and July. In all, twelve specimens were obtained — comprising two females and ten males. Of these one male and one female were obtained in July, 1916, from Tree II. The other female and the nine males were obtained from the lower, middle and upper trunk regions of Tree X. Mr. Rohwer of the Bureau of Entomology in identifying these specimens makes the following statement regarding the males: "At present there are no characters known which definitely separate the male of *Urocerus albicornis* Fabr. from the male of *Urocerus flavicornis* Fabr. and it is impossible to be positive as to the above determination." However, the fact that the males were bred from the same material as the known females of *U. albicornis* and emerged at about the same time would make the presumption very strong that they belong to this species. These specimens show considerable variation not only in size but in coloration. In size the five males still in our possession vary from 12 mm. to 18 mm. The differences in coloration, which are quite striking, consist in a variation in the relative amount of yellow upon the antennæ, abdomen and legs.

Borers associated with *U. albicornis* are *Polygraphus rufipennis, Eccoptogaster piceæ, Phymatodes dimidiatus, Serropalpus barbatus* and *Sirex abbotii.* As *U. albicornis,* which is typically a one-year form, attacks weakened, dying or very recently killed trees, its life history in the wood coincides with or overlaps that of each of these forms. The two scolytids usually enter the bark rather early in the same season, and are therefore likely to have been established a month or more before the eggs of the siricid are laid. *P. dimidiatus,* also a one-year form, probably enters the tree about the same time as the *Urocerus,* but as its burrows are entirely in the bark, the two forms have no direct or very definite relations. *S. barbatus* and *Sirex abbotii* are both wood-boring forms similar to *U. albicornis,* but the relations are never likely to be close. No case was observed where these various wood-eating larvæ were present in such number as seriously to interfere with each other's chances of obtaining food. The occupancy of the wood by the larvæ of *Sirex abbotii* and of *U. albicornis* coincides nearly exactly. *Serropalpus,* however, is a two-year form and its larvæ may have lived in the sapwood an entire year before the advent of the other borers and during this time may have performed a very important function in overcoming the resistance of a weakened tree.

While a number of parasites were bred from the same material as *U. albicornis,* no evidence of any close relation between them and the siricid was found, though many burrows were examined for cocoons. The predator *Phyllobaenus dislocatus* was obtained from the same material, but no reasons for believing it predaceous upon *U. albicornis* were found.

Sirex abbotii Kirby.

(Det. by S. A. Rohwer)

The distribution of *Sirex abbotii* is given by Bradley (1913, p. 13) as Georgia. No record of host trees has been found in the literature. It is very likely that this species will be found to breed in about the same trees as *S. cyaneus,* which occurs in spruce and fir, but which perhaps has a more northern range.

All our specimens of this siricid were bred from larch material derived from Tree X, the same tree from which most of the specimens of *U. albicornis* were obtained. The specimens of *S. abbotii,* however, emerged from the lower and middle trunk region only. Otherwise the habits seem to be practically identical with those of the other siricid. A total of thirteen specimens were obtained, ten of these being males and three females. Mr. S. A. Rohwer, who in identifying them has examined one of the females and a number of the males, says: "The above record for a female of *Sirex abbotii* Kirby is the first association of a female with this species. The female is very close to *S. cyaneus* Fabr. and may be under that name in collections." The specimens emerged in our cages during June and July (June 9; July 6, 12, 13, 16, 17, 18).

Sirex abbotii belongs to the same association as *U. albicornis* and bears the same relations with its associates as does the other siricid.

Tenebrio tenebriodes Beaur.

Tenebrio tenebriodes is probably distributed throughout the entire northeastern part of the country, as it has been reported from Pennsylvania (Hamilton, 1895, p. 341), New York (Felt, 1906, p. 493) New Jersey (Smith, 1909, p. 359) and Indiana (Blatchley, 1910, p. 1251). Further than the fact that this insect is usually found under decaying bark or in other similar locations very little is known regarding its habits. Felt (1906, p. 493) records it "under decaying willow, butternut and basswood bark in early spring." Smith (1909, p. 359) has taken it "Under bark of trees, among rubbish in barns and outbuildings." Blatchley (1910, p. 1251) speaks of it as "Common beneath bark."

It will be seen from the above references that no definite statements regarding the breeding habits or food habits of this beetle was found in the literature. It apparently is not known whether it breeds under bark or whether it merely hibernates there. The fact that the adults are taken constantly in the spring or early summer from under bark does not afford evidence to support either view. Nor does the fact that it has been taken from a variety of different species of tree offer any real evidence — it being a well-known fact that insect inhabitants of wood well along in decay, usually show little preference for any particular species. The evidence we have to offer is quite scant and inconclusive, but it points toward *T. tenebriodes* being a true inhabitant of decaying wood throughout its life. The material (Tree V) was confined in breeding cages late in April and the adult beetle did not appear in the cage until July 7. Had it been merely hibernating in the wood, it would likely have been found earlier.

The material from which *T. tenebriodes* was derived consisted of the decayed heartwood of Tree V which had been peeled many years ago (Figs. 29, 30). This exposed wood had at one time apparently served as the breeding place of *S. barbatus* which, however, had emerged a number of years before the material was confined in the cage. Two other insects were taken from this wood — *Adelocera brevicornis* (taken from the wood in the field April 28) and *Dryophthorus americanus* (July 3). *A. moestum, P. dimidiatus* and *S. barbatus* were bred from this same tree but emerged from the sounder more recently killed portion.

Adelocera brevicornis LeConte

Adelocera brevicornis is perhaps distributed over the greater part of eastern United States and Canada. Adams (1909, p. 196) gives the geographical range as Ottawa, Canada; Michigan; Lake Superior. Smith (1909, p. 284) reports it from The Palisades, N. J. Blatchley (1910, p. 715) records that this species "is known from Michigan and Wisconsin."

The only reference to the habits we have been able to find is the general statement regarding the genus by Smith (*loc. cit.*), that all the species occur under dead bark. We obtained but one specimen from larch and this was taken from punky wood April 28. It is believed that *A. brevicornis* breeds in decaying wood and under decaying bark, but we can offer no real evidence for this view.

The insects associated in the decayed wood are *Tenebrio tenebriodes* and *Dryophthorus americanus.* If *A. brevicornis* breeds in such surroundings it would also often be associated with *Stenoscelis brevis.* The recently killed part of the same tree contained *Phymatodes dimidiatus, Asemum moestum* and *Serropalpus barbatus.*

Phyllobænus dislocatus Say.

Phyllobænus dislocatus has been reported from various parts of the United States: Hopkins (1893, p. 187), West Virginia; Hamilton (1895, p. 335), Pennsylvania; Felt (1906, p. 503), New York; Schaffer (1908, p. 127), Arizona; Wolcott (1909), Wisconsin and Ohio; Smith (1909, p. 303), New Jersey; and Blatchley (1910, p. 859), Indiana.

This small clerid has been reported as associated — doubtless in the capacity of a predator — with a large number of bark and wood-inhabiting forms derived from a variety of different trees. Hopkins (1893, p. 187) states that it "Attacks *Polygraphus rufipennis* in Black Spruce and *Pityophthorus consimilis* in Sumach (*Rhus glabra*) and with *Scolytus regulosus* in Apple bark." According to Felt (1906, p. 449), LeConte reared it from hickory twigs containing *Chramesus hicoriæ.* Felt (1906, p. 503) reared it from hickory limbs infested with *Chrysobothris femorata,* and *Magdalis olyra.* Blackman (1915, p. 54) records having bred *P. dislocatus* from limbs of pine containing *Pityogenes hopkinsi* and no other borer, and Chapin (1917, p. 29) obtained several specimens from twigs of *Rhus glabra* associated with the cerambycids *Liopus fascicularis*, Harr. and *Psenocerus supernotatus* Say and the scolytid *Pityophthorus consimilus* Lec.

From the fact that *P. dislocatus* is constantly found in the burrow of a great variety of other insects, there can be little doubt that it is predaceous upon a large number of species. In larch it was bred from practically every lot of material placed in the breeding cages and therefore a list of probable associates in larch would include practically all of the forms bred from larch, including parasites and other predators as well as the true borers (see table on p. 38). It is indeed possible that this clerid may on occasion be predaceous upon all of these various forms. Even such forms as the larvæ of *Monohammus scutellatus*, which when well grown would conceivably be very well able to defend themselves would, when small, be comparatively helpless if attacked by an active, full-grown larva or by an adult of *P. dislocatus*. Furthermore, on account of its burrow being open from the time the larva is hatched, this round head would seem to be particularly subject to attack by predators.

Perhaps the greatest difficulty in the way of *P. dislocatus* being freely predaceous upon all of these insects, lies in the fact that typically the burrows of all of the flatheaded borers and most of the roundheaded borers in larch are entirely devoid of opening to the outside (except accidental openings) and in the further fact that the larval burrows are filled with more or less firmly packed frass. Occasionally, free access to such larval burrows may be had, however, through the egg-galleries of associated scolytids, at places where these latter passageways are crossed by the burrows of the larger larvæ.

However, we are certain that in most cases *P. dislocatus* preys principally upon scolytids. It is by no means unusual, on opening a burrow of *P. rufipennis* or other scolytid, to find the original inhabitants all dead and the burrow uncompleted. In such cases, the remains are likely to consist of the mere external shell of the scolytid, all of the soft parts having been devoured by the predator. Most usually the opening through the hard outer shell is through the posterior abdomen, this apparently being the most vulnerable point of attack. In one instance on opening the burrow a larva of *P. dislocatus* was discovered with its head thrust into the body of a recently dead *P. rufipennis* as far as the prothorax. When the clerid larva was removed the body of the scolytid showed fresh signs of having been eaten. There is also good evidence to show that both larvæ and adults feed quite readily on the dead and dried bodies of scolytids and even upon those which must be well along in decay. Thus this clerid acts as a scavenger as well as a predator.

The scolytids with which *P. dislocatus* have been found constantly associated in larch are *Polygraphus rufipennis, Dendroctonus simplex, Eccoptogaster piceæ* and *Crypturgus pusillus.* It was actually taken from under the bark among the burrows of each of these scolytids and there can be little doubt that it acts in the capacity of a predator and scavenger in the burrows of all of these forms. It is believed that as a predator *P. dislocatus* (and other clerids) most often attack the adults rather than the larvæ of scolytids. The larva or adult of the predator in order to reach the scolytid larva would either have to construct a new burrow of its own through the bark or would have to clear the larval burrow of frass and enlarge it. On the other hand the adults are quite accessible. When in the brood-burrow, the predator can reach them readily through the entrance to the nuptial chamber, while the young adults for a considerable time before emergence are readily accessible through the "ventilation openings" in their feeding galleries.

Cymatodera bicolor Say.

Cymatodera bicolor was described from a specimen from Arkansas and Horn (1888, p. 224) gives its range as "The Middle and Gulf States." It has later been reported by Wickham (1895, p. 249) from Ontario and Quebec, by Smith (1909, p. 302) from New Jersey, by Leng (1908,

p. 27) from Arizona and (1910, p. 77) from Georgia, and by Blatchley (1910, p. 850) from Indiana.

The most definite statement regarding the habits of this clerid is furnished by Hopkins (1893a, p. 185) when he lists it as predaceous and states that it occurs with *Phlœosinus dentatus* in cedar bark. In larch it was found associated with the borers *Polygraphus rufipennis, Phymatodes dimidiatus* and *Leptostylus sex-guttatus,* with the clerid *Phyllobænus dislocatus* and with the parasites *Rhyssa lineolata, Pseudorhyssa* sp., *Eurytoma* sp., and several undescribed species of *Doryctes. C. bicolor* may be predaceous upon any of these but is more likely to feed habitually upon the scolytid *P. rufipennis.* It probably also acts as a scavenger in obtaining part of its food.

Podabrus diadema Fab.

The geographical range of *Podabrus diadema* is given by Adams (1909, p. 199) as Ottawa, Canada; Mt. Washington, N. H.; Vermont; New York; New Jersey; Western Pennsylvania; Michigan; Wisconsin; Iowa. Smith (1909, p. 299) reports it from New Jersey.

Nothing regarding the habits of this lampyrid was found in the literature but we believe that it acts as a predator and as a scavenger. Regarding the sister species *P. regulosus* Blatchley (1900, p. 830) states that it "Occurs on the leaves and flowers of various shrubs and herbs. One was noted feeding on a winged plant louse."

Only one specimen of this beetle was bred from larch. It emerged on June 15, 1916, from a section of the trunk of larch about thirty feet from the ground, infested heavily with the brood of *P. rufipennis.* The only other insects bred from this lot aside from the scolytid already mentioned were *P. dislocatus* and a small undetermined chalcid. It is likely that *P. diadema* inhabits the burrows of *Polygraphus.*

Rhyssa lineolata Kirby.

(Det. by S. A. Rohwer)

According to Merrill (1915, p. 147) the geographical range of *Rhyssa* (*persuasoria*) *lineolata* is very wide, extending "Through Europe to Canada and the United States in the West, and the Himalayas in the East." Merrill (*loc. cit.*, pp. 144–147) has reviewed at some length what is known regarding the habits of this species and it seems undesirable to repeat this here. It has been reported as parasitic upon *Sirex spectrum*, *Sirex* (*Urocerus*) *cyaneus* and *Monohammus*, while other species occurring in Europe are parasitic upon several species of *Xyphydria*.

In our larch material there can be no doubt that *R. lineolata* is parasitic upon *Phymatodes dimidiatus*. The reasons for this statement have been cited on p. 32 and seem conclusive. The fact that cocoons large enough to have served the pupa of *R. lineolata* and *Pseudorhyssa* sp. occurred only in the burrows of *P. dimidatus* and that no cocoons of any sort were discoverable in the mines of *S. barbatus*, the only other insect common to the three lots of material would seem to be conclusive. Of the three lots from which this parasite was bred only one gave rise to any siricids, *U. albicornis* and *S. abbotii* being obtained from this lot, and an investigation of their burrows showed the entire absence of parasitic cocoons.

While we cannot state too strongly our certainty that *R. lineolata* in our material was parasitic upon *P. dimidiatus*, we do not in any sense wish to cast discredit upon observations which have shown it to be probably parasitic upon quite different insects. Indeed, it is nearly certain that this species is parasitic upon many wood and bark-boring forms. In fact, the senior author has removed an adult from the wood of hemlock where it was associated with adults of *Urocerus albicornis* and with larvæ and pupæ almost certainly belonging to the same species. As the adult parasite which was alive and ready to emerge was removed from a burrow similar in all respects to those from which the specimens of *U. albicornis* were taken there can be little doubt of its being parasitic upon this species also.

In larch the associated insects in addition to *Phymatodes dimidiatus* are, *Leptostylus sex-guttatus, Asemum moestum, Serropalpus barbatus, Polygraphus rufipennis, Eccoptogaster piceæ, Urocerus albicornis, Sirex abbotii, Phyllobænus dislocatus, Cymtodera bicolor, Pseudorhyssa* sp., *Doryctes,* sp., a, b, c, *Eurytoma* sp., *Spathius tomici, Spathius* sp., and an undetermined pteromalid.

Pseudorhyssa sp.

(Det. by S. A. Rohwer)

Four specimens of this new species of *Pseudorhyssa* were bred from the trunk of Tree III from five to seven feet above ground. Of these three specimens were retained by Mr. Rohwer and one is in our collection. This species also is parasitic upon *Phymatodes dimidiatus,* as was shown by a careful study of all of the burrows in the material from which it was bred. The adults emerged in the outdoor breeding cages on May 24 and 25.

Insects associated with it aside from *P. dimidiatus* already mentioned as its host, include the borers; *Leptostylus sex-guttatus, Serropalpus barbatus* and *Polygraphus rufipennis;* the predators, *Phyllobænus dislocatus* and *Cymatodera bicolor;* and the parasites *Rhyssa lineolata Eurytoma* sp., and three species of *Doryctes.*

Odontaumerus canadensis Prov.

(Det. by S. A. Rohwer)

No references to this ichneumonid were found in the literature examined by us. It was bred from Tree III and was associated with *Phymatodes dimidiatus, Leptostylus sex-guttatus, Serropalpus barbatus* and *Polygraphus rufipennis.* It is most probably parasitic on *P. dimidiatus.* This cerambycid had been very numerous in the tree trunk, and cocoons of a size which would be made by this parasite, were present in its burrow and none of a suitable size were found in any others in this lot of material.

Predators associated include *Phyllobænus dislocatus* and *Cymatodera bicolor.* The parasites present in the same material were *Rhyssa lineolata, Pseudorhyssa* sp., *Eurytoma* sp., and three species of *Doryctes.*

Odontaulacus bilobatus Prov.

(Det. by S. A. Rohwer)

According to Bradley (1908, p. 124) this ensign-fly has been taken in Quebec and West Virginia. No reference to the host of this species was found in the literature, but Hopkins (1893, p. 216) states that the sister species *O. abdominalis* was bred from hemlock infested with *Melanophila fulvoguttata.*

In larch *O. bilobatus* was associated with the buprestids, *Melanophila fulvoguttata, Chrysobothris blanchardi, C. dentipes, C. sex-signata* and *Anthaxia quercata;* the cerambycids, *Pogonocherus mixtus, Neoclytus longipes, Leptostylus sex-guttatus;* the scolytids, *Polygraphus rufipennis* and *Eccoptogaster piceæ;* the clerid *Phyllobænus dislocatus;* the hymenopterus parasites, *Atoreutus astigmus,Spathius tomici, Phasgonophora* sp., *Cheiropachus* sp., *and Heterospilus* sp., and the fly *Pollenia rudis.* Of these the two scolytids, *P. rufipennis* and *E. piceæ;* and the parasites *Spathius tomici, Heterospilus* sp. and *Cheiropachus* sp., emerged the first year while the others and *O. bilobatus* were associated throughout two years. Specimens of *P. dislocatus* were taken from these limbs of larch both seasons. Of the associated borers it is most likely that either *C. blanchardi, M. fulvoguttata* or *P. mixtus* acted as host for this parasite, although it is possible that the host may have been one of the other flat-headed or round-headed borers.

Spathius tomici Ashm.

(Det. by S. A. Rohwer)

This small bracomid has been reported as parasitic upon *Dryocoetes* [*autographus*] *americanus* Hopkins in spruce bark by Hopkins (1893, p. 145) and upon *Pityogenes* *punctipennis* Lec. [*Tomicus balsameus* Lec.] by Felt (1906, p. 379).

S. tomici was bred from several lots of larch material and was associated with the scolytids, *Dendroctonus simplex, Polygraphus rufipennis* and *Eccoptogaster piceæ.* There can be little doubt that it may be parasitic upon the larvæ of any or all of these small beetles. Cocoons which from their size probably gave rise to this small parasite were found in the larval burrows of both *P. rufipennis* and *E. piceæ,* but were especially numerous in those of the former, and specimens were bred from other lots of material containing no other scolytid than *P. rufipennis.* The clerid *Phyllobœnus dislocatus* and the parasite *Phasgonophora* sp., *Cheiropachus* sp., *Heterospilus* sp., *Atoreutus astigmus* and *Odontaulacus bilobatus* were also bred from the same materials as were a number of cerambycids and buprestids.

Spathius sp.

(Det. by S. A. Rohwer)

An unidentified species of *Spathius* was bred from the upper part of the trunk of Tree X in considerable numbers. In this material it was associated with the scolytids, *Polygraphus rufipennis* and *Eccoptogaster piceæ;* the cerambycids *Phymatodes dimidiatus;* the melandrycid, *Serropalpus barbatus;* and the siricid *Urocerus albicornis.* It is undoubtedly parasitic upon one or both of the scolytids mentioned.

The predator *Phyllobœnus dislocatus;* the parasitic hymenoptera *Spathius tomici, Rhyssa lineolata, Doryctes* sp., *Spintherus pulchripennis* and an unidentified pteromalid; and the parasitic fly *Medeterus* sp., were also bred from the same material.

Doryctes sp., a, b, c

(Det. by S. A. Rohwer)

Various species of this genus have been recorded as parasitic upon wood-boring larvæ (Riley, 1890, p. 350; Hopkins, 1893a, p. 222; Chittenden, 1893, p. 248). A number of unidentified specimens, probably representing several new species, were bred from larch material. All of them were associated with *Phymatodes dimidiatus* and probably emerged from cocoons found in the burrows of this cerambycid. Oother borers associated were *Leptostylus sexguttatus, Serropalpus barbatus, Polygraphus rufipennis, Eccoptogaster piceæ, Urocerus albicornis* and *Sirex abbotii.* Other associated insects were *Phyllobænus dislocatus, Cymatodera bicolor, Rhyssa lineolata, Pseudorhyssa* sp., *Eurytoma* sp., *Spintherus pulchripennis, Spathius* sp., and *Odontaumerus canadensis.* The adults of *Doryctes* emerged in the cage between May 25 and June 5.

Heterospilus sp.

(Det. by S. A. Rohwer)

Species of this genus have been recorded by Ashmead (1896, p. 214) as parasitic upon a coleopterous larva (from Dr. A. D. Hopkins' records) and by Viereck (1916, p. 238) from the galls of *Eurosta solidaginis.*

The species here in question came from larch June 2, 1916. It was bred from limbs of Tree I, emerging at the same time as the adults of *Polygraphus rufipennis* and *Eccoptogaster piceæ.* It is nearly certainly parasitic upon the first of these scolytids and probably upon both of them. It was bred from the same material as the various buprestids and cerambycids already recorded as characteristic of the larch limb association, but emerged a full season ahead of these and is therefore nearly certain to be parasitic upon one or both of the scolytids mentioned above, which were emerging at the same time. Other insects associated and emerging at about the same time are the clerid *Phyllobænus dislocatus* and the two hymenoptera *Spathius tomici* and *Cheiropachus* sp. Additional parasites emerging a year later are listed in the table on page 38.

Astoreutus astigmus Ashm.

(Det. by S. A. Rohwer)

No references to this insect were found in the literature at hand. We bred but one specimen and it emerged from the limbs of Tree I at about the same time as *Melanophila fulvoguttata, Chrysobothris blanchardi, C. sex-signata, C. dentipes, Anthaxia quercata, Pogonocherus mixtus, Neoclytus longipes, Leptostylus sex-guttatus* and *Phyllobænus dislocatus.* The bark-beetles *Polygraphus rufipennis* and *Eccoptogaster piceæ* emerged in some numbers the preceding summer and one specimen of the latter emerged the same season (being derived, perhaps, from the brood of a second generation started in the cages the previous summer). No definite statement regarding the exact relations of *A. astigmus* can be made but it is evident that it is more likely to have been parasitic upon one of the two-year forms — buprestids or cerambycids.

Other insects derived from the same material include *Phasgonophora* sp. and *Odontaulacus bilobatus,* two parasites emerging at about the same time, and *Cheiropacus* sp., *Heterospilus* sp., *Spathius tomici* and *Pollenia rudis* which emerged a season earlier.

Spintherus pulchripennis Cwfd.

(Det. by S. A. Rohwer)

Hopkins (1893a, p. 227) reports an unidentified species of this genus as parasitic upon *Polygraphus rufipennis* in spruce bark. Our specimens from larch were obtained from one tree only (Tree X) where they were associated with the borers — *Polygraphus rufipennis, Eccoptogaster piceæ, Phymatodes dimidiatus, Serropalpus barbatus, Urocerus albicornis* and *Sirex abbotii.* This species emerges during the early season at the same time as *P. rufipennis* and *E. piceæ,* upon one or both of which it is doubtless parasitic.

The predator *Phyllobænus dislocatus,* the hymenoptera *Spathius tomici, Spathius* sp., *Rhyssa lineolata, Doryctes* sp., an unidentified ptermalid and the fly Medeterus were also bred from the same lots of material.

Eurytoma sp.

(Det. by S. A. Rohwer)

A number of species of this genus have been found by Dr. Hopkins to be parasitic upon the larvæ of various scolytids and other wood and bark-inhabiting insects (Hopkins, 1893a, p. 324; Ashmead, 1894, pp. 323–327).

Specimens of this small eurytomid were bred from two larch trees (Tree III and Tree IX) where it was associated with the borers *Polygraphus rufipennis, Phymatodes dimidiatus* and *Leptostylus sex-guttatus*, all of which emerged at about the same time. From Tree IX, *Neoclytus longipes* was also bred but it emerged a year later than the parasite. The only insect in common between these two lots was *P. rufipennis* and its burrows were also the only ones which contained cocoons from which so small a parasite would be likely to come. It is very likely that *Eurytoma* sp. is a parasite upon this small scolytid. The adults emerged in the outdoor cages June 5 and July 28, 1916. Other insects bred from the same material are *Phyllobænus dislocatus, Cymatodera bicolor, Rhyssa lineolata, Pseudorhyssa* sp. and several species of *Doryctes*.

Phasgonophora sp.

(Det. by S. A. Rohwer)

The only reference to the host of a species of *Phasgonophora* we found is that of Smith (1909, p. 649) in which he states that *P. sulcata* has been bred from *Papilio* sp. Our specimens were bred from larch limbs which had been confined since the spring of the preceding year. They were associated with the following two-year forms and emerged at about the same time: *Melanophila fulvoguttata, Chrysobothris blanchardi, C. sex-signata, C. dentipes, Anthaxia quercata, Pogonocherus mixtus* and *Leptostylus sex-guttatus*. This species is probably parasitic upon *C. blanchardi* and possibly upon others of the associated borers as well.

Other insects bred from the same source include *Phyllobænus dislocatus, Cheiropachus* sp., *Atoreutus astigmus, Heterospilus* sp., *Spathius tomici* and *Pollenia rudis*.

Cheiropachus sp.

(Det. by S. A. Rohwer)

The only reference to a host of a member of this genus seems to be that given by Hopkins (1893, p. 148) in which he states that *C. colon* Linn is parasitic upon *Scolytus regulosus,* the fruit bark beetle.

We bred our specimens from the limbs of Tree I. The parasites emerged in the outdoor cages May 24 and 30, 1916, at about the time when the adults of *Polygraphus rufipennis* and *Eccoptogaster piceæ* were emerging from the same material. The only other insects from this material during the summer of 1916 were *Phyllobænus dislocatus, Spathius tomici* and *Heterospilus* sp., although in the following year the typical association characteristics of larch limbs and tops emerged. There can be little doubt that this small pteromalid is parasitic upon one or both of the scolytids associated, it being nearly certain that *E. piceæ* at least is so affected.

Prosopis sp.

(Det. by S. A. Rohwer)

This small black and yellow bee was bred from an outdoor cage containing part of the limbs of Tree I on June 5, 1916. Members of this genus of which the habits are known, habitually breed in the pith of various weeds and pithy shrubs. Just what the relations of this small bee was to the larch is not known, but had it been only hibernating there, it would seem as if it would have appeared in the cage considerably earlier than it did. The cage contained no punky wood in which it might have bred, but several of the sections of limbs did contain the abandoned burrows of *C. dentipes* and other borers, and these borings were filled with closely packed frass. It will be readily seen that a burrow in the wood packed with frass offers conditions somewhat similar to those in pith, and it seems possible or even probable that the specimen taken had actually bred under such conditions.

Associated insects emerging at about the same time include *Polygraphus rufipennis, Eccoptogaster piceæ, Phyllobænus* *dislocatus, Cheiropachus* sp., and *Epicallima argenticinctella,* a small moth. Insects emerging the following season comprise those borers in larch limbs and tops which require two years for their development, and the parasites upon these.

Medeterus sp.

(Det. by C. T. Greene)

A number of specimens of this small fly were bred from larch wood from a variety of different sources. However, this larch material was all similar in that it was infested with *Polygraphus rufipennis* or with both this bark beetle and *Eccoptogaster piceæ.* Small larvæ which may be the immature stage of this fly are common in the engravings of both these scolytids. Hopkins (1899, pp. 268, 450) concluded that *M. nigripes* is a primary parasite of the larvæ of *P. rufipennis.*

Associated insects in addition to the two scolytids already mentioned are *Phymatodes dimidiatus, Serropalpus barbatus, Urocerus albicornis, Sirex abbotii, Phyllobænus dislocatus, Spathius tomici, Spathius* sp., *Doryctes* sp., and *Rhyssa lineolata.*

Phorbia fusciceps Zett.

(Det. by C. T. Greene)

This small anthomyid fly is well known from the habit the larvæ have of attacking the roots of radishes, cabbages, beans, etc. It has also been said to destroy the eggs of locusts and has been suspected of being parasitic upon the beet web-worm. Howard (1894, p. 272), however, believes this latter relation is very doubtful.

Our specimens of this species were bred June 28 and July 6 from an exposed dead root of a living tree. The bark of this root was still adherent and was infested with *Dryocoetes americanus.* The wood was beginning to decay and part of it was riddled by the mines of the larvæ of *Leptura vittata. Dryophthorus americanus* and the larva of an unidentified elaterid were present. It is likely that this fly was breeding in the decaying bark and probably feeding upon the decaying inner bark or the fungi developing therein.

Pollenia rudis Fabr.

(Det. by C. T. Greene)

There can be little doubt that our specimens of this fly bred upon decaying matter in the bark. They emerged under outdoor conditions in the middle and latter part of September, 1916. The insects bred from the same lot of material are *Polygraphus rufipennis, Dendroctonus simplex, Dryophthorus americanus, Asemum moestum,* and *Melanophila fulvoguttata.* It is likely that the fly in question breeds in the decaying frass in the burrows of most any bark or wood-boring insect, and therefore we would expect in a larger number of breeding cages to obtain it from material derived from all regions of the tree and find it associated in this material with practically all of the borers.

Epicallina argenticinctella Clem.

(Det. by Carl Heinrich)

This small moth belonging to the family *Oecophoridæ* was taken from a cage containing part of the limbs of Tree I. But one specimen was obtained and it appeared in the cage July 7, 1916. It is not known whether the larva had lived in the wood or whether it had gone there to hibernate. However, the latter is rendered unlikely by the fact that the limbs confined in this breeding cage were obtained from a standing tree at a distance of from 18 to 45 feet from the ground. This, together with the fact that members of this family are known to breed in " decayed wood and other dead material " (Smith, 1909, p. 560), makes the presumption that this moth had spent its larval life in the limbs more likely. The date of emergence (July 6) still further strengthens this view.

In conclusion the authors wish to express their gratitude to several sources for assistance received. Our thanks are due to Dr. E. P. Felt, State Entomologist of New York, and his two assistants, Mr. Young and Miss Hartman, for their courtesies in placing the identified specimens in the State Museum at our disposal for comparison. We wish also to thank Dr. A. D. Hopkins for his kindness in placing his corps of specialists at our disposal in identifying specimens of *Hymenoptera, Diptera* and *Lepidoptera.* We wish also to thank these gentlemen directly: Mr. S. A. Rohwer for identifying the *Hymenoptera,* Mr. C. T. Greene for identifying the three *Diptera,* and Mr. Carl Heinrich for naming the moth. Such help is indispensible in problems such as this and we are indeed grateful for it.

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II. ON THE INSECT VISITORS TO THE BLOSSOMS OF WILD BLACKBERRY AND WILD SPIRÆA — A STUDY IN SEASONAL DISTRIBUTION.

By

M. W. Blackman, Ph. D.

ON THE INSECT VISITORS TO THE BLOSSOMS OF WILD BLACKBERRY AND WILD SPIRÆA—A STUDY IN SEASONAL DISTRIBUTION.

By M. W. BLACKMAN, Ph. D.

No one who has collected insects during July and August in localities where the wild spiræa or meadow sweet (*Spiræa latifolia* Borkh.) is abundant can have failed to have observed what an excellent bait or trap the flowers of this plant furnish for the collector. This attractive quality has been taken advantage of for several years by the author both in the Catskills and the Western Adirondacks. In both of these regions insects are attracted to the flowers in great numbers, but this is much more noticeable in the former locality than in the latter. One of the striking characteristics of the insect fauna of the Catskills is the great relative abundance of the several genera of long-horned beetles commonly known as the lepturids (*Lepturini*). These are attracted to the blossoms of wild spiræa in surprising numbers — not only as regards individuals but also as regards species — and can readily be captured while feeding there.

These beetles and also other insects have been collected by the author from spiræa in the Catskills at various times during the summer of 1913, 1914, 1915 and 1917. During the first two seasons the specimens taken from wild spiræa were not always kept separate from those taken under other circumstances, but definite data was preserved for all specimens taken in 1915 and 1917. In the former year (1915) the collections from spiræa were made on only two dates at an interval of two weeks (August 1 and August 15). When these two collections were pinned and placed side by side, the difference in the relative abundance of several species in the two lots was so striking as to suggest the desirability of a more detailed and systematic study of the insects visiting the blossoms of spiræa and other plants, with a view to obtaining data on the seasonal distribution and seasonal succession of certain insect forms. Such data was obtained during the past summer (1917) and is here presented.

These observations were made at the Catskill Forest Experiment Station of the New York State College of Forestry, near Tannersville, N. Y. The region covered is that extending north from the experiment station for about three-quarters of a mile and lying along each side of the road known locally as the County road. This varies in elevation from 2,150 feet at the experiment station to about 1,950 feet where the County road joins the main road to Elka Park. The area covered consists of about half wooded land and half clearing, and is bordered both on the east and on the west by more extensive forests which have not been lumbered for many years. The cleared land consists of irregular areas on each side of the road from which each year a sparse crop of hay is harvested. This yearly mowing keeps down young trees and also suppresses shrubs such as wild spiræa, blackberry and raspberry. Thus these shrubs are to be found only along the margins of the clearing, surrounding occasional isolated trees and large rocks, and in several swampy areas. The impression should not prevail, however, that the wild spiræa is either scanty or scattered, for such is far from being true. The area covered includes many thousands of the shrubs. Often a small clearing is bordered by a continuous fringe of wild spiræa, and in one case a solid block of this shrub covering about a half acre occurs in one semi-swampy area.

It will thus be seen that conditions here are ideal for many insects, especially such as feed upon pollen in their adult stage and live in dead or decaying wood in their larval condition. The adjacent forests, especially that towards the east, has been practically unmolested for years, and the numerous dead and decaying trees, which are always present in considerable numbers in undisturbed timber lands, serve as an excellent breeding place for the larvæ of the very forms which as adults are characteristically feeders upon pollen. Thus it happens that these insects, notably the lepturids —

existing under conditions which are favorable both to the larval and to the adult stages — are strikingly more numerous than in any other region of the State with which the author is acquainted.

In obtaining the data for this study the insects were collected from the flowers of approximately the same area at intervals of a week. Where the weather made it impossible to make the rounds at the stated day, the data was obtained the following day or the nearest favorable day succeeding. Thus a record was obtained of each seven-day period during the season. Most of the collections were made during the warmest part of the day between 1:30 and 3:30 P. M., when the insects supposedly were feeding in their maximum numbers, and all were made on bright, sunshiny days favorable to the insects. It was impracticable to take every insect seen on the blossoms on the day of collection, as some of them inevitably escaped, but it is believed that approximately the same proportion of those active at each period were taken. No insects were collected from spiræa or blackberry at times other than the stated interval except in a few cases where it was desired to record certain special data. The collections were made at intervals of a week, because there is good reason to believe that the life span of at least most of the insects which actually feed upon the honey or the pollen of flowers (which would include all but the casual visitors to spiræa blossoms) normally extends over more than that length of time.

Before tabulating and discussing the results of this study it might be well to say a few words regarding certain controlling natural factors such as climatic conditions. Both the summers of 1915 and 1917 were unusual in the lateness of the season — the former being remarkable for the cool weather as well as for the excessive rainfall during July and August in particular. Thus while in 1913 the wild spiræa was in full bloom and nearly at its maximum during the first week in July, and in the following year was at its best during the second and third weeks in July, in 1915 and 1917 the first blooms did not appear in the region studied until the middle of July (first blossom in 1917 seen on July 13), and the maximum was not reached until the first week in August.

A comparison of the data collected during these four years makes unescapable the conclusion that one can foretell the relative abundance of any one of a number of species, not in terms of the calandar date, but of the condition of the blossoms which furnish them food. Thus the blossoms of wild spiræa (and doubtless other blossoms sought by insects) act as an indicator by which we may determine the seasonal distribution of certain insects depending upon them for food. In a sense the condition of the blossoms and the relative number of certain insect visitors are co-ordinated. Perhaps a more exact statement of the real relations might be made as follows: The relative abundance of the insect in the case of many lepturids and of some others, is really determined by the relative advancement of the season, and this is indicated by the condition of the blossoms upon which the insects depend for their adult food. In other words, while this synchronism works to the advantage of the insect and doubtless also to that of the plant, we cannot assume that the relation of cause and effect exists, but must rather look upon the two as separate phenomena both of which are dependent upon the same cause, the advancement of the season. Evidence leading to this conclusion will be found later, in the notes on a number of species.

In the following tabulations all of the insects mentioned were taken from wild spiræa blossoms except those of the first two weeks and a few in the third week of July, 1917, which are from the blossoms of wild blackberry. As soon as the spiræa blossoms appeared in any numbers, the pollen-eating insects seemed to desert the berry blossoms and to feed nearly exclusively upon those of the spiræa. Thus the berry blossoms, although not the favored food supply of a number of these insects, seem to serve to tide the insects over till a better source is available. It is worthy of note in this connection that several of the lepturids had passed their maximum before the appearance of the richer supply of pollen, but the greater number of individuals, even of these species, on the appearance of the spiræa blossoms, showed a decided preference for these.

The blossoms of mountain azalea (*Rhododendron canescens* [Michx.] G. Don), which were in full bloom during the latter weeks of June, 1917, attracted quite a number of insects, but these were entirely or nearly entirely honey-feeding forms such as certain bees, moths and butterflies. Pollen-eating forms did not seem to be attracted to them.

Other flowers which coincide more or less with spiræa in their period of inflorescence include especially the "pearly everlasting" (*Anaphalis margaritacea* [L.] B. & H.) and several species of golden rod, notably the early golden rod (*Solidago juncea* Ait.), the wrinkled-leafed golden rod (*Solidago rugosa* Mill.), the white golden rod or silver rod (*Solidago bicolor* L.) and the flat-topped golden rod (*Solidago graminifolia* [L.] Salisb.). The flowers of all of these seem to exert an equal attraction to the honey-loving insects as do those of spiræa, but this is not true as regards the pollen-eating insects, although some of them, such as *Chaulignathus pennsylvanicus,* for instance, which occur in late August, must, on account of the rapid decline of the spiræa, depend upon the golden rod for most of their food. The species of golden rod most popular not only with this lamperid, but also with bees, yellow-jackets and hornets, is the flat-topped species, *Solidago graminifolia.* These began to appear in considerable numbers during the latter part of August (about August 24 in 1917) at a time when the spiræa was beginning its rapid decline.

In the following pages will be found some additional data and certain conclusions regarding a number of the species mentioned in the above table. Also notes on a few species not taken in 1917 but found on spiræa during some previous summer are added. It will be readily seen, both from the table and from these notes, that most of the abundant and interesting beetles on spiræa belong either to the subdivision of *Cerambycidæ* known as the *Lepturini* or to the family *Mordellidæ.* Both of these groups are well known flower frequenters and there can be no doubt that they depend upon the pollen of flowers for their food. The richness of spiræa blossoms in this material is doubtless the reason for its popularity with these insects.

Number of Specimens of Coleoptera Taken Each Week, July 1–September 1, 1917.

Species	July 1–7	July 8–14	July 15–21	July 22–28	July 29–Aug. 4	Aug. 5–11	Aug. 12–18	Aug. 19–25	Aug. 26–Sept. 1
Leptura mutabilis Newn.	8	3	1	....	....	....	....	....	....
Leptura pubera Say	11	8	5	7	....	....	....	....	....
Leptura sphaericollis Say	2	....	....	....	....	....	....	....	....
Pachyta monticola Rand	1	....	....	....	....	....	....	....	....
Leptura lineola Say	1	1	4	1	....	....	....	....	....
Leptura vittata Oliv	....	4	6	13	4	8	3	....	....
Leptura nana Newn	....	....	1	....	....	....	....	....	....
Leptura proxima Say	....	....	2	9	16	15	15	3	....
Leptura vagans Oliv	....	....	1	....	1	....	2	1	1
Strangalia luteicornis *Fabr.*	....	....	1	1	....	1	....	....	....
Leptura rubrica Say	....	....	....	7	13	1	4	1	1
Leptura plebeja Rand	....	....	....	1	....	....	....	....	....
Typocerus velutinus Oliv	....	....	....	5	14	17	12	5	3
Leptura cordifera Oliv	....	....	....	2	1	5	3	4	1
Leptura canadensis Oliv	....	....	....	....	....	1	17	9	3
Oberia tripunctata Swed	1	1	....	....	....	....	....	....	....
Oberia bimaculata Oliv	....	2	....	....	....	....	....	....	....
Clythanthus ruricola Oliv	....	....	1	1	4	....	2	....	....
Orsodachna atra Ahrens	....	....	1	....	....	....	....	....	....
Gallerucella decora Say	....	....	1	1	....	....	....	....	....
Nodonta puncticollis Say	....	....	....	1	....	....	....	....	....
Trihabda virgata Lec	....	....	....	....	....	....	2	....	....
Diabrotica 12-punctata Oliv	....	....	....	....	....	....	1	....	....
Diachus auratus Fabr	....	....	....	....	....	....	....	1	....
Anthrenus castaneae Melsh	....	....	1	....	....	....	2	2	....
Dolopius lateralis Esch	....	1	....	....	....	....	1	....	....
Asaphes decoloratus Say	....	....	....	....	....	....	1	....	....
Agrilus ruficollis Fabr	....	1	....	....	....	....	....	....	....
Podabrus tomentosus Say	1	....	....	....	....	....	....	....	....
Podabrus rugulosus Lec.	....	1	....	....	....	....	....	....	....
Pyropyga decipiens Harr	....	....	....	....	....	1	....	....	....
Chaulignathus pennsylvanicus DeC	....	....	....	....	....	....	1	4	7
Ditemnus sp	....	....	....	....	....	....	....	1	....
Trichodes nuttalli Kirby	....	....	2	....	....	....	....	1	....
Trichius affinus Gory	....	9	4	5	1	....	2	1	1
Macrodactylus subspinosus Fabr.	....	....	....	1	....	....	....	....	....
Isomira similis Blatch	1	....	....	....	....	....	....	....	....
Arthromacra aenea Say	....	1	....	....	....	....	1	....	....
Anaspis rufa Say	....	2	11	9	+	+	16	+	....
Mordellistena morula Lec	....	1	....	....	....	....	....	....	....
Mordellistena biplagiata Helm	....	....	2	3	2	1	1	....	....
Mordellistena ambusta Lec	....	....	....	....	....	....	2	....	....
Mordella marginata Melsh	....	....	3	2	1	3	2	1	1
Epicauta pennsylvanica DeC	....	....	....	....	....	....	....	....	1
Odontocorynus scutellum-album Say	....	....	1	3	2	....	4	2	....

Leptura mutabilis Newn. As will be seen from the table, this species was at its maximum in 1917 during the first half of July. All but two specimens were taken from wild blackberry blossoms. Of these two, one was from a spiræa blossom, while the other was taken June 22 from the surface of a beech log felled three years before. Of the twelve specimens taken in 1917, eleven of which were from flowers, eight are of the testaceous variety known as variety *luridipennis*. *L. mutabilis* has been bred from a small branch of a dying alder obtained near Syracuse, and Mr. Carl Wright, a student in the college, has taken a specimen of the testaceous form from the wood of hemlock at Cranberry Lake, N. Y. Apparently it has a variety of hosts.

Leptura pubera Say. The seasonal distribution of this species nearly coincides with that of *L. mutabilis*, but extends slightly later. Specimens were numerous upon blackberry blossoms until the appearance of the spiræa blooms, when they showed a very marked preference for the latter. During the first three weeks in July this species was decidedly the most common lepturid. In 1914 several specimens were taken from daisy heads.

Leptura sphæricollis Say. But three specimens of this species were taken in 1917, two from wild blackberry in the first week in July and one from mountain azalea on June 20. These all are of the typical form with the black prothorax. Three specimens were also taken in July, 1914, of which two are of the typical coloration and one has the red prothorax characteristic of the variety *ruficollis*.

Pachyta monticola Rand. But one specimen of this lepturid was taken during the last season and it was obtained from a blackberry blossom on July 3. The only other specimen taken by the author from this same general region was from the bark of recently felled balsam tree, July 8, 1914. No breeding data is available, but it is believed the specimen captured on balsam was preparing to oviposit. Wickham (1897, p. 171) records the adult from the blossoms of wild rose.

Leptura lineola Say. This species, which in the region studied is never one of the most abundant lepturids, has a seasonal distribution extending over July, the maximum number in 1917 having been taken during the third week. One specimen was also taken in July, 1914, and two on August 1, 1915. It has reached its maximum numbers about the time the wild spiræa begins to bloom.

Leptura vittata Oliv. This very abundant species begins to appear in some numbers before the wild spiræa blossoms, but does not reach its maximum until these flowers are nearly at their best. In both 1915 and 1917 they had practically disappeared by the middle of August. Copulating pairs were seen July 17 and 27 (numerous) and August 17. The specimens show a considerable range of variation in the coloration of the elytra but this variation is within much narrower limits than in *L. mutabilis L. vagans,* etc. *L. vittata* has been bred from dead larch wood but doubtless breeds in spruce and balsam in the Elka Park region as little or no larch is present there.

Leptura nana Newn. Only two specimens of this small species have been taken from Elka Park. Of these, the one taken July 20, 1917, is entirely black, while the other specimen taken July 23, 1914, is of the variety *hæmatites* characterized by the red prothorax. Nothing is known regarding its breeding habits.

Leptura proxima Say is perhaps the most abundant lepturid in the Elka Park region, its only rival in this respect being *Typocerus velutinus.* In all, some 60 specimens were taken in 1917, all but one of which were on the blossoms of spiræa. This single exception was on elderberry blossoms (*Sambucus canadensis* L.), but apparently had merely alighted there as it was not feeding. The seasonal occurrence of this species may be said to correspond nearly exactly with that of the wild spiræa blossoms. It begins to appear with the first blossoms of the spiræa, is at its maximum during the greatest abundance of these, and decreases in numbers with the waning of the flowers. The data from other years agrees entirely in this respect. Copulating pairs were common throughout the last week in July and the first three weeks in August. Wickham (1897, p. 192) reports this species as having been bred from maple. No additional data is at hand.

Leptura vagans Oliv., while never as numerous as several other species, has about the same seasonal distribution as *L. proxina.* Six specimens were taken in 1917 — three of the typical variety having black elytra with a reddish brown marginal stripe and three having the elytra entirely testaceous. In 1915 eight specimens showing about the same seasonal distribution were taken — two on August 1 and six on August 15. Of these, three are of the testaceous variety and five are typical. The larvæ have been reported (Wickham, 1897, p. 192) as boring in yellow birch and hickory and it is likely that the former of these two trees acts as host in the Elka Park region.

Strangalia luteicornis Fabr. Only three of these were taken in the region studied — not a sufficient number for me to venture any statement regarding the period of greatest abundance. Nothing is known regarding its larval host.

Leptura rubrica Say begins to appear in numbers during the second week of the blooming season of spiræa and continues in considerable numbers for nearly a month. In 1914 thirteen specimens were taken on July 23 and this species was doubtless at its maximum at that time, this being entirely in accord with the data on other forms which show that the season of 1914 was about two weeks earlier in its advancement than in 1915 and 1917. My field notes record copulating couples as common on July 27 and August 3. *L. rubrica* has been bred from hickory at Syracuse.

Leptura plebeja Rand. Only one specimen has been taken by me in the Elka Park region and this gives no basis for a conclusion regarding seasonal distribution. However, from the fact that I have specimens from Cranberry Lake taken on July 12 and September 16 it is believed this species may occur at any time in late summer. It is apparently not very common in either of the regions mentioned. An adult of this species has been obtained from spruce wood in the Cranberry Lake region of the Adirondacks.

Typocerus velutinus Oliv. is one of the extremely common and numerous forms upon spiræa blossoms. It begins to appear soon after these flowers and occurs in maximum numbers when they are at their best. In general its seasonal distribution is similar to that of *L. proxima,* but appears to be about one week later both in its beginning and its decline. The data for the various years check very closely when judged in terms of the advancement of the season or of the condition of the blossoms upon which the adults depend for food. Copulating pairs were observed on July 27, August 3 (common) 9 and 17 respectively. *T. velutinus* shows a very considerable degree of variation in its color pattern. The light bands are nearly obsolete in some cases while in others they are so enlarged as to show a tendency to fuse more or less. Several adults have been bred from much decayed hickory at Syracuse and it is likely that it breeds in decayed wood of a variety of species of trees.

Leptura cordifera Oliv. has the same seasonal distribution as *T. velutinus* but in the region studied is not so extremely common as this other lepturid. There is much variation here as regards relative amount of black and yellow on the elytra. It has been bred from chestnut (Lugger, 1884, p. 204).

Leptura canadensis Oliv. The seasonal distribution of this form is interesting from the fact that it appears later in the summer than any of the other lepturids taken on wild spiræa. Another interesting fact is that up until August 13, but a single specimen had been seen and yet in this week seventeen specimens were taken — it being the most numerous lepturid at that time and remaining so for the rest of the season. Of the 30 specimens taken in 1917, six are of the variety *erythroptera* and the rest, which are of the more typical coloration show considerable variation in the amount of red upon the elytra. There is considerable disproportion in the number of males and females taken from the flowers, for of the thirty specimens twenty-four are males. Of the red-winged variety three were males and three females.

One sexual difference in this species is that in the male the antennæ are strongly serrate and are entirely or nearly entirely black while in the female they are quite feebly serrate and according to Leng (1890, p. 189) joints 4–11 are annulate with yellow. As a matter of fact, the antennæ in both sexes are subject to considerable variation as regards color. The following data on the variation in the antennæ of the males of *Leptura canadensis* is based on a study of fifty-two antennæ from thirty-one individuals, some of the specimens having lost on antennæ:

Antennæ entirely black	33 from 19 individuals.
Antennæ with joint 8 with more or less yellow at base	18 from 11 individuals.
Antennæ with joint 6 with more or less yellow at base	1 from 1 individual.
Antennæ with joints 6 and 8 more or less yellow at base	1 from 1 individual.

Except in one case, the two antennæ on the same individual were similar.

The variation in the female antennæ is more striking. The thirteen females studied agree in having joints 1, 2 and 3 and 11 entirely black and joints 5, 6 and 8 with more or less yellow. The following tabulated data on variation in the antennæ of the female of *Leptura canadensis* is based on a study of twenty-two antennæ from thirteen individuals.

With joints 4–10 all more or less yellow	7 from 4 individuals.
With joint 4 entirely black	3 from 2 individuals.
With joint 7 entirely black	11 from 7 individuals.
With joint 9 entirely black	14 from 8 individuals.
With joint 10 entirely black	4 from 3 individuals.
With joints 7, 9 and 10 entirely black	3 from 2 individuals.
With joints 7 and 9 entirely black	10 from 6 individuals.
With joints 8 entirely or nearly entirely yellow	19 from 11 individuals.
With joints 6 entirely or nearly entirely yellow	14 from 9 individuals.
With joints 6 and 8 entirely or nearly entirely yellow	13 from 9 individuals.

It will be seen from the above that in the specimens from the Elka Park region taken in 1915 and 1917 there is a tendency toward joints 4, 7, 9 and 10 to be entirely black, and this is especially noticeable in joints 7 and 9. There is a still more decided tendency for joints 6 and 8 to become entirely yellow, this condition being especially true as regards joint 8.

Dr. Felt (1906, p. 670) reports this lepturid as breeding in spruce and hemlock and the author has taken it from spruce.

Other Lepturids. In addition to the Lepturids listed above, all of which were collected in 1917, there are a number of other species taken other years which should be mentioned.

Acmeops directa Newn. Four specimens of this lepturid were taken from the flowers of wild spiræa and other blossoms during the third week in July, 1914. Considerable variation in color is noticeable in these specimens.

Bellamira scalaris Say. But one specimen of this striking insect has been taken by me in the vicinity of Elka Park and this was obtained from spiræa bloom during the third week in July, 1914. This insect habitually breeds in yellow birch (Packard, 1890, p. 486). Large numbers of the larvæ, pupæ and newly transformed adults were found in a birch log in the region of Cranberry Lake, N. Y., in July, 1917, by Prof. C. J. Drake of this Department.

Leptura subhamata Rand. Two males of this species were collected July 23, 1914, from wild spiræa near Elka Park. Wickham (1897, p. 192) reports it as having been taken in a beech log.

Leptura subargentata Kirby. Seven specimens of this species were taken in July, 1914, four from flowers (probably spiræa, but notes do not specify) and three taken on the wing and upon felled balsam near the top of Twin Mountain.

Leptura circumdata Oliv. Four specimens of this species were obtained from spiræa blossoms July 23, 1914. Prof. C. J. Drake reports having cut an adult of this species from a spruce log near Cranberry Lake in July, 1917.

Leptura biforis Newn. One specimen of this beetle was taken July 23, 1914, from spiræa bloom. Nothing is known regarding its breeding habits.

Leptura vibex Newn. A single example of this species was taken July 10, 1914, from leaves about half way up Spruce Top Mountain. It is not known that this species ever visits wild spiræa but from the great uniformity in habits shown by the adults of this genus it seems probable.

Leptura aurata Horn. Two specimens were taken from spiræa July 23, 1914. Nothing further is known regarding its habits.

Only a few species of Coleoptera other than the lepturids already treated were taken in sufficient numbers for any conclusions to be drawn regarding their seasonal distribution. A few of these are briefly mentioned below.

Oberea tripunctata Swed. and *Oberea bimaculata* Oliv. may be mentioned together. Two specimens of each were taken during the first two weeks of July, 1917, from blossoms of wild blackberry in the stems of which they are said to breed.

Clytanthus ruricola Oliv. This cerambycid occurs at its maximum numbers in late July and early August at the heighth of the wild spiræa season. While it frequents these flowers by preference it is also occasionally seen on the flowers of the daisy, golden-rod and others. A number of specimens of this form have been bred from hickory at Syracuse but no hickory occurs in the Elka Park region and it must depend upon some other wood. In one case a specimen was observed which was apparently preparing to oviposit in beach and it is probable this serves as a larval host.

Chaulignathus pennsylvanicus DeG. is well known to be a late season form. It appears about the middle of August and does not occur in great numbers until the spiræa blossoms are decidedly on the wane and the golden rods are at their maximum. For that reason much larger numbers are to be seen on golden rod than upon spiræa, Yet in spite of this it will be seen from the table that the specimens actually taken from spiræa were continually on the increase up to September 1, although the numbers of these blossoms were rapidly decreasing.

Trichius affinus Gory. Although this beetle occurs in some numbers throughout the entire summer, it is more numerous in July. It is found in the early season most frequently on the blossoms of raspberry, blackberry and daisy but with the appearance of the spiræa bloom it shows a decided preference for this.

Five species of *Mordellidæ* were taken from the blossoms studied and three were very common. The most common form is *Anaspis rufa* Say, which is present in considerable numbers from the third week in July until the close of the season. No effort was made to collect these consistently after the third week in July and on several of the weeks the specimens were so numerous that they were not saved. The general assertion, however, may be safely made that the seasonal distribution is timed to that of the spiræa blooming period. *Mordellistena biplagiata* Helm. seems to reach its maximum before the spiræa bloom is at its best and no specimens were taken after August 17. *Mordella marginata* Melsh. has about the same seasonal distribution as *Anaspis rufa.*

Odontocorynus scutellum-album Say. This small curculionid was taken on no other flower than that of wild spiræa where it appeared to be feeding upon pollen. Its occurrence coincides very closely with that of this blossom. A pair in copulation was observed July 25, 1917.

It is probable that most of the remaining beetles which are included in the table, but are not mentioned in the notes, are more or less casual or accidental visitors and are not on the flowers in search of food. Probable exceptions to this statement are furnished by *Anthrenus castaneæ* Melsh. and *Epicauta pennsylvanica* DeG., both of which are probably pollen eaters.

NUMBER OF SPECIMENS OF HYMENOPTERA TAKEN EACH WEEK, JULY 1–SEPTEMBER 1, 1917.

Species	July 1–7	July 8–14	July 15–21	July 22–28	July 29–Aug. 4	Aug. 5–11	Aug. 12–18	Aug. 19–25	Aug. 26–Sept. 1
Allantus dubius Norton			7 ♂	2 ♂	5 ♂				
			11 ♀	7 ♀	1 ♀	2 ♀	3 ♀		
Allantus basilaris Say						2 ♂	1 ♂		
				1 ♀	3 ♀	2 ♀	6 ♀	3 ♀	
Tenthredo rufipes Say				1					
Hylotoma clavicornis Fabr					5				1
Hylotoma dulciaria Say					4				
Polysphincta rubricapensis Prov						1	1	1	
Amblyteles unifasciatorius Say								1	
Campsomeris plumipes Drury								1	
Psammochares luctuosus Cresson					1	3		2	2
Psammochares ethiops Cresson									1
Pompiloides marginatus Say								1	
Odynerus catskilli De Saussure		1				2	1		
Odynerus walshianus De Saussure							1		
Odynerus tigris De Saussure								1	
Odynerus collega De Saussure								1	
Odynerus albomarginatus De Saussure								2	
Eumenes fraterna Say	2								
Vespula (Vespa) diabolica De Saussure		1		1	1	3	10	+	+
Vespula (Vespa) maculata Linneus						1	+	+	+
Vespula (Vespa) marginata Kirby							6	+	+
Vespula (Vespa) arctica Rohwer							1		
Polistes pallipes Lepel						4	2		
Solenius (Crabro) singularis Smith								1	
Cerceris fulvipediculata Schlett						1	1	1	1
Halictus sp	1								
Halictus provancheri Dalla Torre	1	2		3		5	1		
Halictus confusus Robertson								1	
Andrena sp	2		4				1	1	
Hylaeus (Prosopis) modestus Say		1	2	2		3		2	2
Hylaeus (Prosopis) sp			3	1					
Osmia lignaria Say	1								
Megachile sp		1							
Bremus (Bombus) vagans Smith				1	1		1	+	+
Bremus (Bombus) terricola Kirby				1	1	2	5	+	+
Bremus (Bombus) ternarius Say						1	1	+	+
Formica fusca fusca Linn var. *subaenescens* Emery	+					+			
Formica fusca fusca Linn						+			+
Formica neogagates neogagates Emery								+	+
Camponotus herculaneus Linn var. *noveboracensis* Fitch									+
Camponotus fallax Nyl var. *nearcticus* Emery									+

The preceding table of hymenopterous visitors to the blossoms of wild spiræa perhaps needs little explanation or comment. It should, however, be remembered that these insects represent forms having rather diverse habits and modes of life. Thus the objects gained by the insects in visiting the flowers varies considerably. Some of them doubtless obtain only honey; others — a more numerous class, including the various bees and social wasps — seek both honey and pollen; others, perhaps, are in search of pollen only; while still others are in search of their prey. A few should be classed as casual visitors only — having alighted upon the blossoms by accident.

The number of specimens of most of the species listed in the table is not sufficiently great to warrant any deductions regarding seasonal distribution. Some few species, however, occurred in sufficient numbers to make a tentative conclusion desirable. Some of these are briefly discussed below.

Allantus dubius Nort. This saw-fly begins to frequent the flowers of spiræa in considerable numbers during the first week of the blossoming season. Indeed they seem to be at their maximum at this time and in succeeding weeks are gradually on the decrease. It is not known upon what this insect fed before the appearance of the spiræa, as there were none taken from wild blackberry or other blossoms. Nothing was found regarding the breeding habits.

Allantus basilaris Say begins to appear upon the spiræa during the fourth week of July, reaches its maximum at the middle of August and no specimens were taken after August 25. This species is not quite so numerous as the sister species, only eighteen specimens being taken, and of these only three are males.

Vespula (*Vespa*) *diabolica* De Saussure, one of the commonest of the colonial wasps, may be taken as a good example of insects of this genus and general mode of life. This insect is a frequent visitor to wild spiræa in search both of honey and pollen. It, however, does not visit the blossoms of this plant to the exclusion of other flowers, but during the height of the blooming season seems to prefer these flowers to all others. Later when *Solidago graminifolia* is in full bloom and is very abundant these blossoms are sought by the yellow jackets in great numbers. Even at this time, however, a proportional number apparently visit the few spiræa blossoms remaining. Regarding the seasonal distribution of the yellow jacket and of other species of the same genus, as would be expected of a colonial form, there is a rather gradual numerical increase during early and midsummer and a very rapid increase later in the season. This rapid increase in 1917 commenced during the first week in August and by the middle of this month this species was so common that specimens were no longer retained. However, it was apparent that they were rapidly increasing in numbers up to the time observation ceased, September 2, at which time individuals of the various species of *Vespula* far outnumbered all other flower visitors combined.

Bremus (*Bombus*) *terricola* Kirby. This bumble-bee, which apparently is the most common one frequenting spiræa blossoms in the Elka Park region, may be used as an example of the genus. Its seasonal distribution as shown by its relative abundance upon spiræa is similar to that of the yellow jacket although it is never quite so numerous. This is to be expected from the similarity in habit between these forms both of which are colonial forms and visit the blossoms in search of honey and pollen.

The data regarding most of the remaining Hymenoptera is not complete enough to warrant important conclusions. In the case of such forms as the various species of *Psammochares, Odynerus, Eumenes, Solenius* and *Cerceris*, the visits of which to spiræa blossoms are probably as likely to be in search of prey as for obtaining honey or pollen, we would not expect much uniformity of occurrence. Therefore a curve showing the numbers occurring at stated periods on one particular species of flower would not be so likely to represent the true seasonal distribution of the species because prey could likely be obtained from many other sources.

The ants listed above, the species of which were kindly determined by Mr. M. R. Smith of the Bureau of Entomology represent only specimens collected accidentally except those taken in the last week in August. It might be said, however, that ants are constant visitors to the blossoms of spiræa and blackberry throughout the entire season. They are perhaps the most consistently numerous insect visitors as they are to be found working among the blossoms in almost every kind of weather except during heavy rain storms and even then some are stranded there. It is likely that their primary object is to obtain nectar but it is by no means improbable that they eat pollen as well.

NUMBER OF SPECIMENS OF HEMIPTERA TAKEN EACH WEEK, JULY 1–SEPTEMBER 1, 1917.

Species	July 1–7	July 8–14	July 15–21	July 22–28	July 29–Aug. 4	Aug. 5–11	Aug. 12–18	Aug. 19–25	Aug. 26–Sept. 1
Euschistus euschistoides Voll.	2								
Euschistus tristigmus Say						1*			
Euschistus variolarius P. B.					–1–	1a–	1n–		
Acrosternum hilaris Say						1n–			
Meadorus lateralis Say								1	
Alydus eruinus Say					–1–				
Corizus crassicornis Linn.								2a–1n	1n
Phlegyas abbreviatus Uhl.							1		
Sinea diadema Fabr.						1n		2a	
Neurocolpus nubilus Say					1				
Adelphocoris rapidus Say				1	2	1	2	4	3
Lygus vanduzeii Knight	1		1	1				1	
Lygus pratensis Linn.						4			
Lygus sp. a		2							
Lygus sp. b								1	
Lopidia instabile						2	5	3	1
Plagiognathus sp			2	7	1		4	1	1
Aphrophora quadrinotata Say							1		
Graphocephala teliformis Walk.					1		1		

* The letter "a" signifies adult, the letter "n" signifies nymph.

Probably little comment is necessary regarding the *Hemiptera* listed above. It is likely that most of these should be looked upon as casual visitors, and not as forms which visit the flowers to obtain some portion or product of these for use as food. Where such a casual or accidental relation exists, it is apparent that quantitative data of the insect on the flower would not be likely to furnish a reliable foundation upon which to base conclusions regarding its seasonal abundance. It is possible that a few of these bugs actually were obtaining food from the flowers, and if it should prove that the spiræa is the favorite source of food, the data for such forms should lend itself to the formation of a reliable curve showing seasonal distribution. In the case of *Lopidia instabile,* one of the most consistent hemipterous visitors to spiræa blossoms, the curve is at least not unbelievable.

I am indebted to Prof. C. J. Drake, my colleague, in the department for his kindness in identifying the Hemiptera, listed in the table.

Number of Specimens of Diptera Taken Each Week, July 1–September 1, 1917.

Species	July 1–7	July 8–14	July 15–21	July 22–28	July 29–Aug. 4	Aug. 5–11	Aug. 12–18	Aug. 19–25	Aug. 26–Sept. 1
Asilus orphne Wk	1	1	....	....	....	....	....	....	....
Criorhina analis Macq	....	1	....	....	....	....	....	....	....
Chilosia similis Shannon	....	1	....	....	....	....	....	....	....
Tephritis albiceps Lw	....	...	1	....	....	....	....	....	....
Hammerschmidtia ferruginea Fallen	....	....	....	1	....	....	....	....	....
Chrysogaster nigripes Lw	....	....	....	1	....	....	....	....	....
Pangonia tranquilla O. S.	....	....	....	....	....	8	2	....	....
Ceraturgus cruciatus Say	....	....	....	....	....	1	....	....	....
Peleteria robusta Wd	....	....	....	....	....	1	....	....	....
Hemyda aurata Dew	....	....	....	....	....	1	....	....	....
Chrysogaster pulchella Will	....	....	....	....	....	1	....	....	....
Criorhina intersisteus Wk	....	....	....	....	....	1	....	....	....
Spilomyia fusca Lw	....	....	....	....	....	1	2	3	....
Syritta pipiens L	....	....	....	....	....	....	1	....	....
Eristalis tenax L	....	....	....	....	....	....	2	....	1
Tabanus trispilus Wd	....	....	....	....	....	....	1	....	....
Gymnosoma fuliginosa Dew	....	....	....	....	....	....	1	....	....
Eristalis bastardi Macq	....	....	....	....	....	....	....	1	1
Anthrax alternata Say	....	....	....	....	....	....	....	....	1
Eurosta coma Wd	....	....	....	....	....	....	....	....	2

Of the *Diptera* listed in the accompanying table only a few should probably be classified as other than casual visitors to the blossoms of spiræa. It seems certain that some at least of the *Syrphidæ* obtain nectar from these flowers, and if these insects were present in any considerable numbers, they should furnish reliable data regarding the season of greatest abundance. However, the numbers in all cases were so limited as to make it unwise to deduce more than rather general conclusions. Thus we can say that *Pangonia tranquilla* is most abundant in the Elka Park region when the blossoms of wild spiræa are at their maximum, which in 1917 was during the first half of August. Similarly we may say that *Spilomyria fusca* begins to appear at about the same time but does not reach its maximum numbers until the spiræa blossoms are decidedly on the wane. This species then, does not appear until *Vespula marginata* and other similar black and white hornets of which it is a mimic, are becoming quite numerous, and does not reach its maximum numbers until these hornets are the most abundant flower visitors. The very striking resemblance of the fly and hornet can but be admitted by anyone who has collected both from the same flowers.

I am under obligations to Prof. A. S. Hine of Ohio State University for his kindness in identifying the flies in the above table.

In addition to the various *Coleoptera, Hymenoptera, Hemiptera* and *Diptera* which are listed in the accompanying table a considerable number of insects belonging to other orders were observed on spiræa blooms. Doubtless the majority of these were casual visitors which would be no more likely to be found on blossoms than on any other structure occurring in the same location. This is certainly true of several species of dragon flies, grasshoppers, katydids, caddisflies, etc. In addition to these, several moths and a number of butterflies were seen upon spiræa blossoms, but no effort was made to obtain quantitative data of any of these. The following butterflies were observed upon the blossoms of spiræa: *Papilio turnus* Linn, *P. polyxenes* Fabr., *Feniseca tarquinius* Fabr., *Basilarchia arthemis* Drury, *B. astyanax* Fabr., *B. archippis* Cram., *Grapta progne* Cram., *Argynnis cybele* Fabr., and *Erynnis* sp. The moths taken are fewer in number of species and include *Hæmorrhagia diffinis* Boisd., *Lycomorpha pholus* Drury, *Ctenucha virginica* Charp., *Synanthedon bassiformis* Walk., *S. acerni* Clem., and *Oxyptilis* sp. These moths apparently were on the flowers in search of food as some of them when taken were observed to have their probosces uncoiled and searching about among the flowers for the nectaries.

In arriving at conclusions regarding seasonal distribution and seasonal succession of insects from data such as here presented, it is wise to scrutinize such data with the greatest of care. It has already been shown that the collections were made as nearly as possible at intervals of seven days. But it was considered to be more important that the climatic conditions — temperature, moisture, light and wind — should be as nearly uniform as possible, than that the interval should be exactly one week. Of course, some variation of these conditions were inevitable and unavoidable but the collection days were as uniform as possible and the results are believed to be entirely trustworthy in this respect.

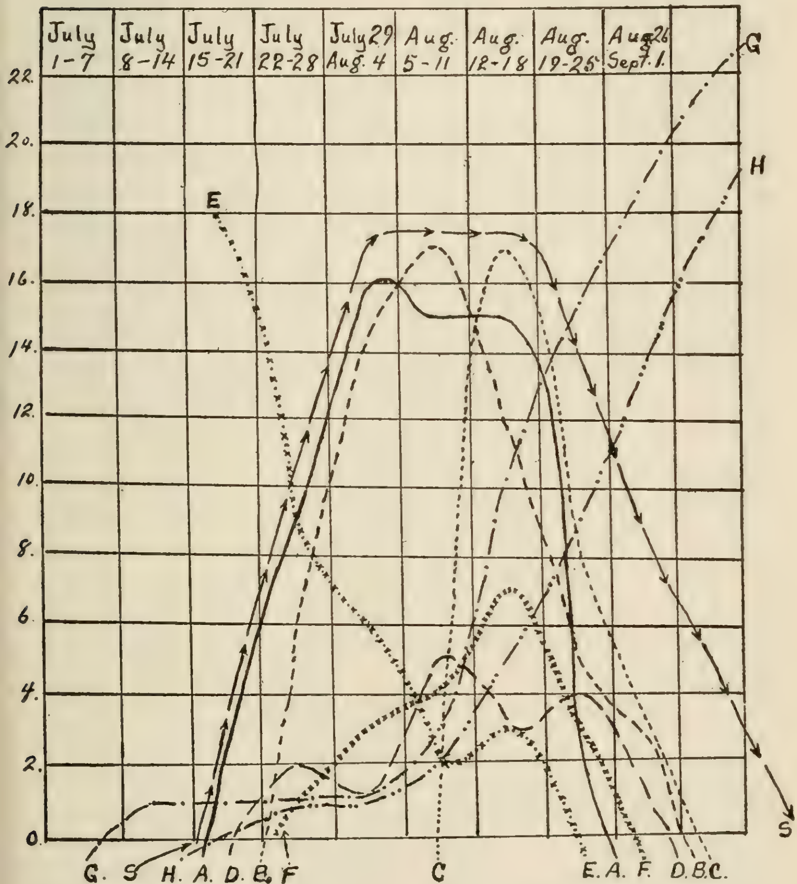
The validity of conclusions from such data is also dependent upon the uniformity with which each species of insect seeks the blossoms from which the collections are made. Thus in the case of some of the insects from spiræa blossoms, it is believed that the number taken on any date represents a fairly definite per cent of those actually in the adult condition at that time. In other cases it is believed that the numbers taken have not even an approximately definite relation to the numbers actually out. The object of the insect's visit to the blossom has much to do with the reliability of the data for the purpose mentioned. Thus, if the insect is in search of honey or of pollen or of both of these, and if observations have shown that the blossoms in question are the favorite source of this material, the data should be reliable. If the insect visitor is in search of insect prey, the data is not so valid unless it is established that the predaceous or parasitic form is in search of some particular species which is usually to be found only on the flower in question. If the insect is an accidental or casual visitor which has happened to alight upon the flower the data is valueless, as the number taken from flowers would bear no fixed relation to the actual numbers at the time.

It would seem then, that in the case of an insect feeding upon pollen or honey, or both, which has shown a preference for that derived from the spiræa blossom, a curve showing its numerical abundance upon this flower at fixed intervals, should represent its seasonal distribution. The accuracy of this curve would depend upon the factors already mentioned. The larger the number of insects taken at each period and the larger per cent collected of those actually out, the more reliable will be the curve. It is apparent that when the number of specimens of a consistent visitor to spiræa is great enough, quantitative data furnishes material for the construction of a reliable curve showing seasonal numerical distribution.

A number of curves from such data are shown in the accompanying figure. It will be seen that typically they fall into two general classes dependent upon the habits and mode of life of the insect. In cases of species which live as individuals (*i. e.,* not in colonies), the curve typically shows an even rise, which may be either gradual — such as *Allantus basilaris* — or sudden — such as *Leptura canadensis* — until a maximum is reached. This maximum may be held for several weeks followed by regular decline, as in *Leptura proxina,* or a more or less gradual drop may follow the maximum immediately, as in the curves of *Typocerus velutinus* and *Leptura canadensis.* The irregularity in the curve of *Leptura cordifera* is due to the small number of specimens of this species taken as it is apparent that in a small number, a variation of one or two individuals causes a relatively great irregularity in the curve.

The curve showing the seasonal distribution of colonial insects such as the yellow-jackets, hornets and bumble-bees, is of quite a different character as will be seen by studying G and H of the accompanying figure. Here the insects (fertile females) appear in small numbers with the beginning of the flowers in early summer. These little more than hold their own until the season has advanced to such a degree that the spiræa blossoms have about reached their maximum, when with the appearance of an ever-increasing number of workers,

CURVES SHOWING THE SEASONAL DISTRIBUTION OF CERTAIN INSECTS TYPICAL OF THOSE VISITING THE BLOSSOMS OF WILD SPIRÆA.



A — *Leptura proxima*
B — *Typocerus velutinus*
C — *Leptura canadensis*
D — *Leptura cordifera*
E — *Allantus dubius*
F — *Allantus basilaris*
G — *Vespula (Vespa) diabolica*
H — *Bremus (Bombus) terricola*
S — Blossoms of *Spiræa latifolia.*

the curve showing numerical abundance soars upward and continues rising until the onset of cold weather. It is not known exactly what would be the course of the curve following the first heavy frost, but there would doubtless be a very rapid drop as the wasps and bees sought hibernation quarters.

One interesting observation regarding the seasonal distribution of several of the lepturids especially, is apparent both in the table and in the curve. This is the fact that all of the late summer lepturids showed a rapid decrease in numbers after August 17, 1917. At this date the spiræa blossoms were only just beginning to wane and several of the lepturids as *Leptura proxima* and *L. canadensis* were still at their maximum and *L. cordifera* and *Typocerus velutinus* were but little below their highest numbers. Yet by the following week *L. proxima* had nearly disappeared and there was a very striking decrease in all of the lepturids. This rapid drop in numbers then occurred in 1917 before any frost and was out of all proportion to the decrease in spiræa blossoms. A careful search was made upon the blossoms of other plants, and while the various *Vespidæ* and *Bombidæ* and beetles such as *Chaulignathus pennsylvanicus* were present there in ever-increasing numbers no specimen of lepturids were found. It apparently is a case where insects cease feeding on the approach of cold weather but a considerable time before killing frosts occur. In the cases of insects which hibernate either as adults or as immature forms such cessation of feeding before the fall frosts might be spoken of as an adaptive response, as it seems to be generally understood that insects are better able to hibernate at low temperature when the digestive processes have ceased some time and the alimentary canal has been entirely emptied of food and waste materials. The species in question, however, doubtless never hibernates in the adult condition, and it is believed that the response to the cool nights which herald the approaching frosts results in cessation of feeding and more prompt ovipositing on the part of the adults already out. It is likely also that the cool nights react upon the larvæ and pupæ which are about ready to transform, in such a manner as to postpone the completion of their life cycle until the following summer. This latter is in line with numerous observations of the author which show that the duration of the life history of many species of boring insects is subject to considerable variation, due often to apparently only small differences in the environmental conditions.

My thanks are due to several men for the assistance they have given by identifying specimens. I wish to thank Dr. Harry P. Brown of the Department of Dendrology of this college, for identifying the several plants mentioned; Prof. C. J. Drake, my colleague in the Department of Entomology of this college for naming the Hemiptera; Prof. J. S. Hine of the Department of Zoology and Entomology, Ohio State University, for naming the flies, and Mr. M. R. Smith of the Bureau of Entomology, U. S. Department of Agriculture, Baton Rouge, La., for identifying the ants.

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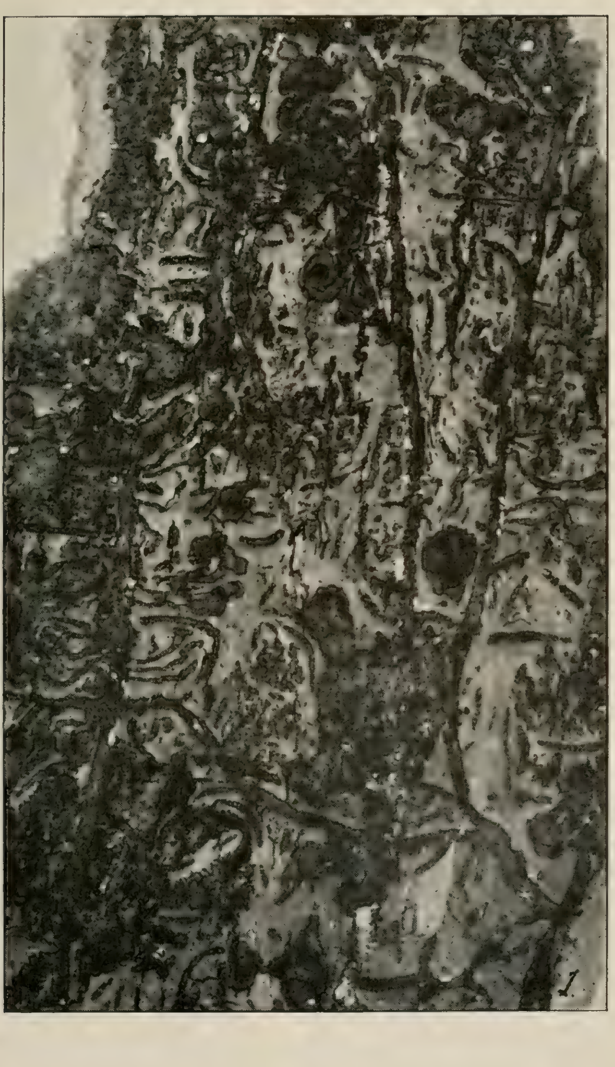
EXPLANATION OF PLATES.

All photographs were made by the senior author.

Plate 1.

Fig. 1. View of the inner bark of American larch, showing the burrows of *Dendroctonus simplex.* The wider passages are the egg-galleries made by the adults, while the shorter burrows at right angles to them are the larval mines. Note the arrangement of the larval mines in alternate groups of from three to six on opposite sides of the egg-gallery. This is best shown in connection with the egg-gallery at the right-hand side of the picture. About four-fifths natural size.

PLATE I.



1.

Plate II.

Fig. 2. Top of American larch with the outer bark removed, showing the burrows of *Polygraphus rufipennis*. Note the engravings with one, two and four egg-galleries. It will be seen that the egg-galleries are typically and nearly invariably transverse, while the larval mines are longitudinal. Reduced to seven-tenths natural size.

Fig. 3. Burrows of *P. rufipennis* in the inner bark of the trunk of the American larch. Note the direction of the egg-galleries and the variation in the number of these in the different engravings. The bark even on the trunk of larch is relatively thin, and therefore the nuptial chamber is here at the juncture of inner bark and sapwood. Slightly less than one-half natural size.

Fig. 4. Burrows of *P. rufipennis* in the inner bark of red spruce. The bark here is thicker than in larch and the nuptial chambers of the burrows are therefore in the outer part of the inner bark and not visible. Reduced to about three-fourths natural size.

Fig. 5. Section of the trunk of larch from which the greater part of the outer bark has been removed by woodpeckers, exposing numerous burrows of *P. rufipennis* and one burrow of *Monohammus scutellatus*. These birds have acted as a partial check upon the borers, as a large per cent of the latter had been eaten by them; yet in spite of their work the number of borers which remained alive was considerably larger than the number originally entering the bark. Thus, while woodpeckers render efficient assistance in keeping down the numbers of boring insects, they cannot be depended upon to restore the balance of nature unless aided by artificial or by other natural factors. Reduced to about two-fifths natural size.

PLATE II.

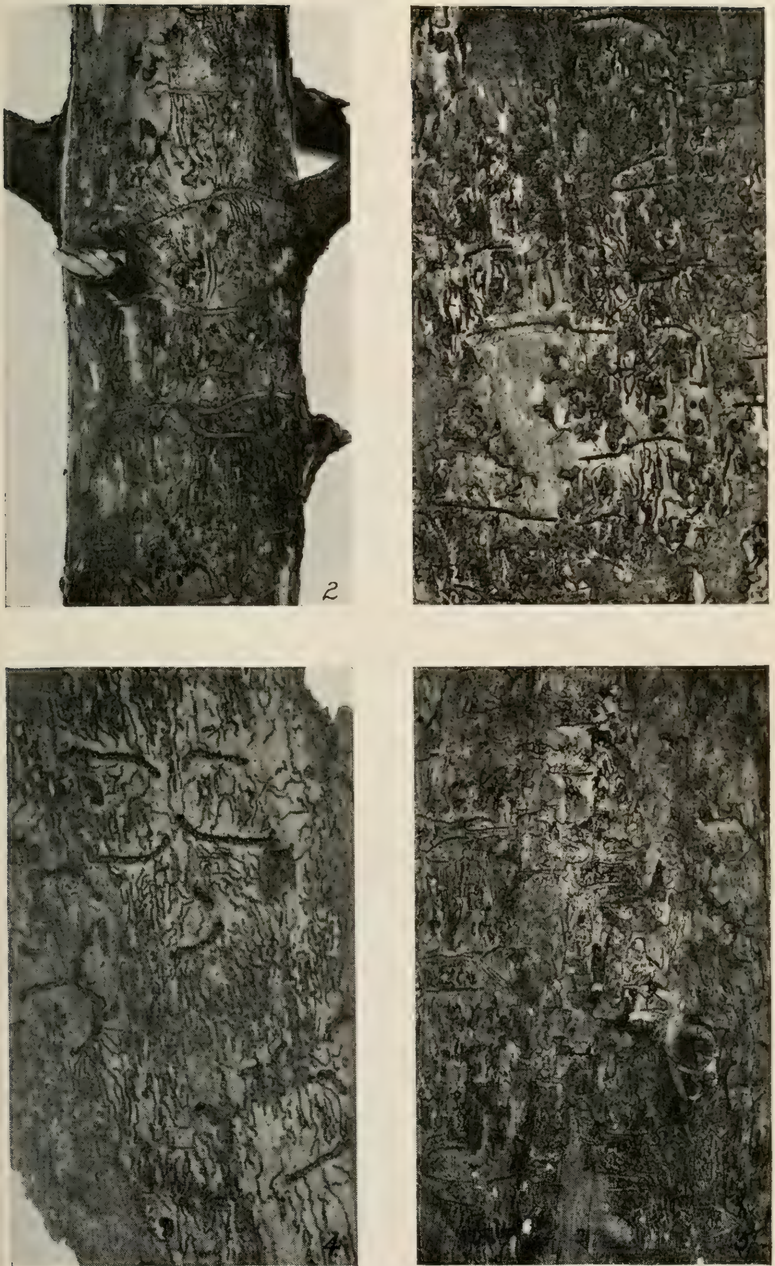


Plate III.

Fig. 6. Another section of trunk of larch tree showing the work of woodpeckers in removing the outer bark in order to feed upon the borers therein. In this case the work has not been quite so thorough as in Fig. 5. Reduced to about two-fifths natural size.

Fig. 7. General view of the engravings of *Eccoptogaster piceæ* upon the surface of the wood of larch tops, showing the general appearance of larch wood one year after it has been attacked. This section of the tree contained nearly a pure culture of *E. piceæ*, but one engraving of *P. rufipennis* may be seen near the lower left-hand corner of the photograph. Note the different types of burrows. Reduced to slightly less than two-fifths natural size.

Fig. 8. Engraving of *E. piceæ* in larch, showing the burrow with two egg-galleries, which is the most common type. Note that there is a much larger number of egg niches in the upper egg-gallery, although in this case the two are about the same length. Typically the upper egg-gallery, which is the first one begun, is both longer and contains more egg niches. The larval mines at first are nearly parallel to each other and at nearly right angles to the egg-gallery, but later they become very tortuous. The wider, deeper, more tortuous burrows (as those in the upper left-hand region of the picture), which appear whiter on account of their grooving the sapwood so deeply, are made by the young adults, which feed in the old host for a time before emerging. About four-fifths natural size.

Fig. 9. Engraving of *E. piceæ* with three egg-galleries. About four-fifths natural size.

Plate III.

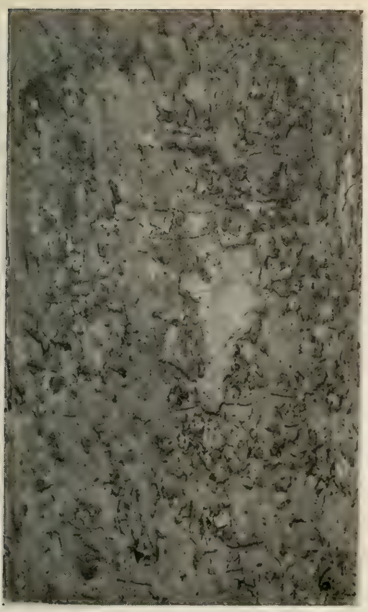


Plate IV.

Fig. 10. Burrow of *Eccoptogaster piceæ* in larch, having only one egg-gallery. The length of this one is remarkable even for uniramous burrows, as is also the number of egg-niches. Slightly more than three-fourths natural size.

Fig. 11. View of the inner bark of larch, showing the burrows of *Crypturgus pusillus* arising from the engravings of *P. rufipennis.* This shows the usual confused appearance after the larvæ have developed and destroyed the egg-galleries. The flocculent white material is due to fungi. Reduced to about four-fifths natural size.

Fig. 12. Engraving of *Crypturgus pusillus* in the inner bark of red spruce. In this case twenty-two egg-galleries arise from the nuptial chamber of an abandoned burrow of *P. rufipennis* and several more from the egg-gallery. The egg-galleries here are not so much destroyed by the larvæ as usual because most of these have burrowed at another level, in the outer part of the inner bark. About three-fourths natural size.

Fig. 13. Engraving of *C. pusillus* in inner bark of larch. Here also the egg-galleries originate from the nuptial chamber of *P. rufipennis.* About four-fifths natural size.

Plate IV.

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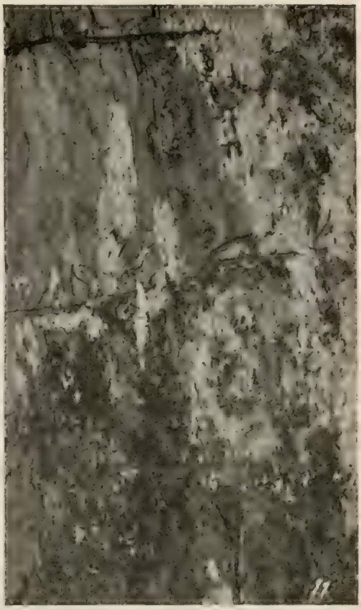

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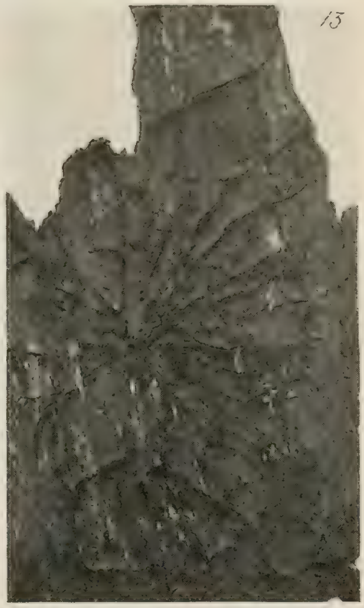


Plate V.

Fig. 14. Segment of the trunk of larch with bark removed, showing the burrows of *Polygraphus rufipennis* and *Phymatodes dimidiatus.* The wider grooves in the wood, many of which end in oval openings leading down into pupation chambers, are made by *P. dimidiatus.* About two-thirds natural size.

Plate V.

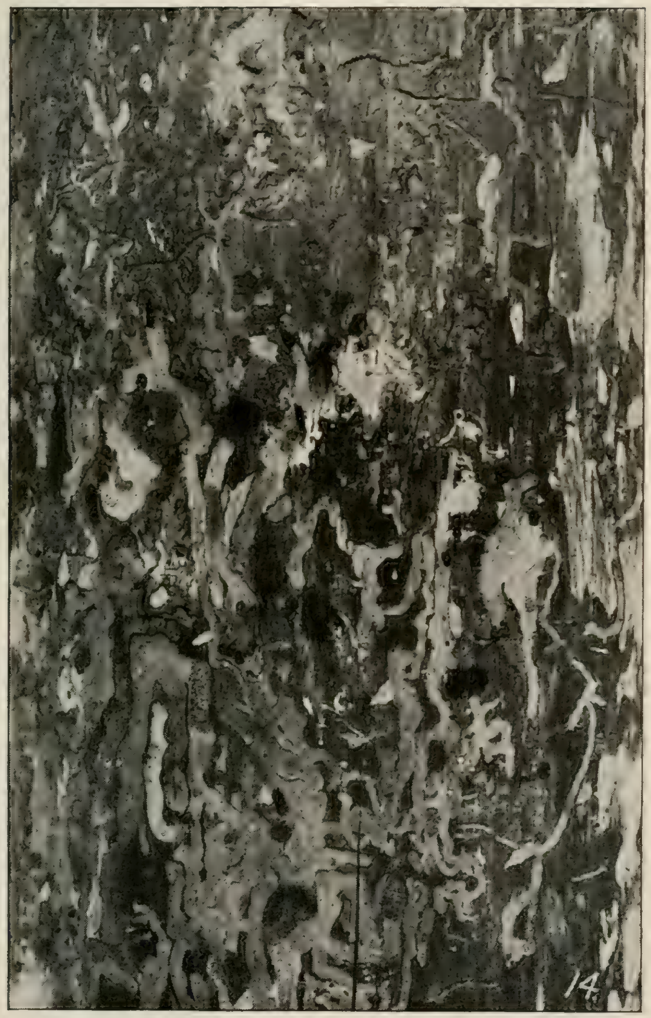


Plate VI.

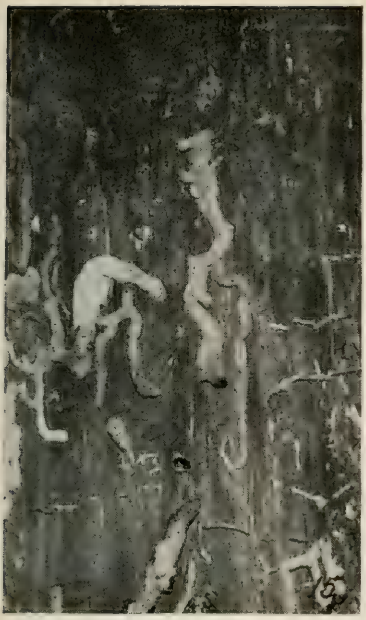
Fig. 15. Burrows of *Phymatodes dimidiatus* in trunk of larch. Near the center can be seen the complete larval burrow, the entrance to the pupation chamber and the exit hole. The entire burrow is relatively short, as would be expected of a one-year form. Reduced to about two-thirds natural size.

Fig. 16. Burrow made by the larva of *Monohammus scutellatus* in white pine. All of the larval work cannot be seen, but characteristic points are shown. Note that the part of the burrow adjacent to the chamber in the wood used for retiring, hibernation and pupation has been kept free of frass, while much of the rest is packed full of the characteristic "sawdust" like detritus. Note also the oval opening leading to the pupation chamber (below) and the nearly exactly circular exit opening (above). Reduced to slightly less than one-half natural size.

Fig. 17. Thin-barked limb of white pine showing where the adults of *M. scutellatus* have fed upon the thin smooth bark. At various places in the smoother areas of the bark can be seen the work of the mandibles of the beetles. The females oviposit in such areas and the several small white spots in these areas indicate "ventilation openings" through which the newly hatched larvæ have extruded the white frass. These "ventilation openings" of the very young larvæ are the openings made by the ovipositor of the female, which have been enlarged and utilized by the newly hatched larva. Reduced to about one-half natural size.

Fig. 18. Portion of the trunk of a small larch sapling, showing the burrow of *Leptostylus sex-guttatus*. The entire burrow, including larval mine, entrance to pupation chamber and exit hole, is shown. This being a two-year form, the burrow is relatively quite long. Slightly more than one-half natural size.

Plate VI.



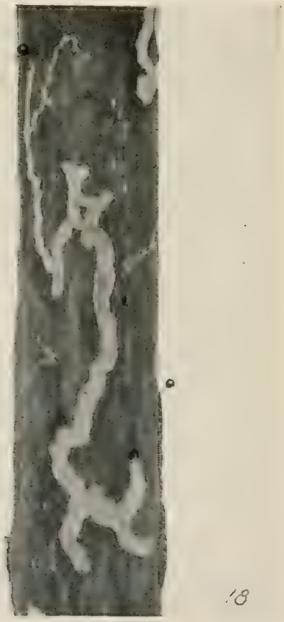


Plate VII.

Fig. 19. Burrow of *Neoclytus longipes* in limb of larch. This cerambycid is a two-year form and the larval burrow here is narrow, deep and extraordinarily long. After grooving the sapwood just beneath the bark for most of its life, the larva bores through the sapwood for some distance before pupating. Thus the exit hole may be on the opposite side of the limb from the point of entrance to the chamber in the wood. Slightly more than one-half natural size.

Fig. 20. Another burrow of *N. longipes* in a larch limb. This burrow is perhaps more typical from the fact that the larva tunneled the wood for a distance of 10½ cm. before it pupated. Reduced to slightly less than one-half natural size.

Fig. 21. Burrows of *Pogonocherus mixtus* in larch. The burrow is here rather short but quite wide for so small a form. Entrance to and exit from the pupal chamber is through the same opening. This is not so common among cerambycids as it is with the buprestids. About one-half natural size.

Fig. 22. Burrow of *Anthaxia quercata* in limb of larch. The burrow made by this small flat-headed borer during its first year is shallow and rather narrow, but during the second year the larva is likely to excavate a broad area rather than continue it as a linear mine. The adult emerges from the pupal chamber through the same opening by which the larva entered. About five-eighths natural size.

PLATE VII.

Plate VIII.

Figs. 23, 24. Burrows of *Chrysobothris blanchardi* in larch limb. The larval mine during the first year is likely to be linear and is usually not very tortuous while that made during the second year is very tortuous. The adult in emerging from the pupal chamber uses the entrance burrow made by the larva. The two burrows shown in Fig. 24 are quite typical. Fig. 23 reduced to about one-half natural size. Fig. 24 reduced to about two-fifths natural size.

Fig. 25. Burrow of *C. blanchardi* in larch from which the frass has not been removed. Note that this material forms alternate bands of light and dark. This is produced by the habit of the larva in excavating from the bark and from the sapwood alternately. This material is arranged to form curved striæ by the abdomen of the flat-headed larva, which is habitually bent to form a loop and pressed against the frass in order that the borer may obtain leverage in rasping off the fibres. Reduced to about two-fifths natural size.

Fig. 26. Burrow of *Chrysobothris sex-signata* in small larch sapling. The burrow here is relatively shallower and wider than those made by the foregoing buprestids. That made during the second year is especially wide. The larval entrance to the pupal chamber is used by the adult in emerging. Reduced to about five-ninths natural size.

PLATE VIII.

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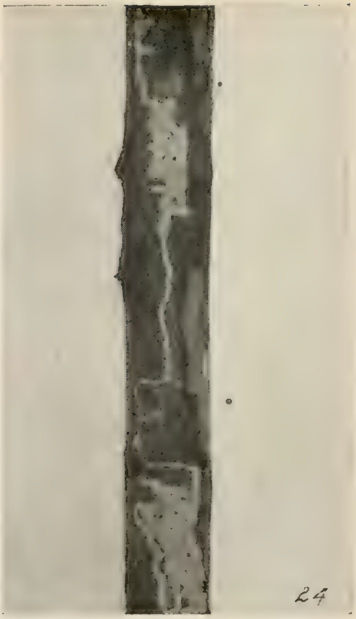

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Plate IX.

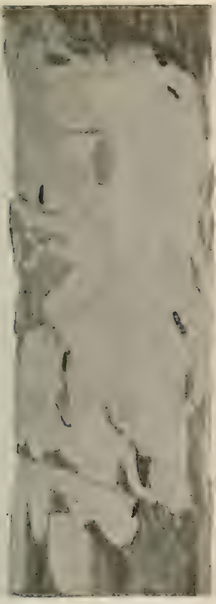
Fig. 27. Burrows of *Chrysobothris dentipes* in white pine. The greater part of the larval burrow of this species is in the sapwood immediately under the bark. When nearly full grown the larva tunnels into the wood and often bores through this for a distance of several inches before pupating. In emerging the adult makes an opening of its own which is often at some distance from the point at which the larva entered the wood. Reduced to slightly less than three-fifths natural size.

Fig. 28. Section of the trunk of larch showing the burrows of *Polygraphus rufipennis* (upper left) and of *Eccoptogaster piceæ* (right) and the exit holes of *Urocerus albicornis.* Reduced to about two-thirds natural size.

Fig. 29. View of a segment of the trunk of Tree V. The exposed decaying wood was killed a number of years ago, probably by peeling. At that time it had been tunneled by the larvæ of *Serropalpus barbatus* and perhaps other forms, and decay had for this reason been more rapid. A specimen of *Adelocera brevicornis* was taken from this wood in the field, and *Tenebrio tenebriodes* and *Dryophthorus americanus* were bred from it in the breeding cages. The more recently killed wood at the sides shows the engravings of *P. rufipennis.* Reduced to one-third natural size.

Fig. 30. Portion of the heart wood from Tree V, showing the larval burrows made by *Serropalpus barbatus* many years before. The burrows of *Dryophthorus americanus* may be seen at various places. This insect bores in the soft "spring wood," leaving the harder "summer wood" nearly intact. Reduced to about two-thirds natural size.

Plate IX.



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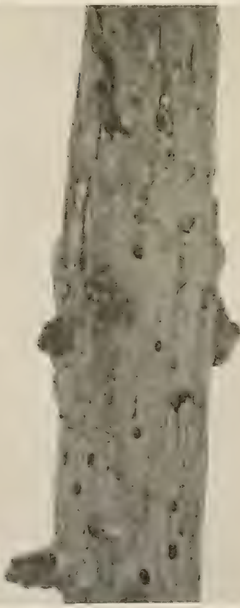
29



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Volume XVIII June, 1918 Number 5

TECHNICAL PUBLICATION NO. 11

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AT

SYRACUSE UNIVERSITY

HUGH P. BAKER, Dean

The Biology of Polyporus Pargamenus Fries

BY

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Director of Forest Investigations.

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Professor of Forest Pathology.

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Professor of Silviculture.

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Professor of Forest Zoology.

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Professor of Landscape Extension.

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Professor of Dendrological Chemistry.

ROBERT CRAIG, Jr., M. S. F., 1910 (Michigan),
Professor of Forestry at New York State Ranger School.

*REUBEN PARKER PRICHARD, B. S., 1907 (Dartmouth); M. F., 1909 (Yale),
Assistant Professor of Dendrology.

LAURIE D. COX, A. B., 1903 (Arcadia College); S. B. in Landscape Architecture, 1908 (Harvard),
Assistant Professor of Landscape Engineering.

HOWARD BLAINE WAHA, B. S., 1909; C. E., 1918 (Pennsylvania State College),
Assistant Professor of Forest Engineering.

*HENRY HARRINGTON TRYON, A. B., 1912; M. F., 1913 (Harvard),
Assistant Professor of Forest Utilization.

ERNEST G. DUDLEY, A. B., 1908 (Leland Stanford Jr. University); 1908–09 (Yale Forest School),
Assistant Professor of Forest Extension.

ALFRED HUBERT WILLIAM POVAH, A. B., 1912; Ph. D., 1916 (Michigan),
Assistant Professor of Forest Botany.

CARL JOHN DRAKE, B. S., B. Ped., 1912 (Baldwin-Wallace); A. M., 1914 (Ohio State University),
Assistant Professor of Forest Entomology.

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* On leave of absence.

HIRAM LEROY HENDERSON, B. S., 1915 (Michigan),
Assistant Professor of Forest Utilization.

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Instructor in Landscape Engineering.

CARL CHESWELL FORSAITH, A. B., 1913 (Dartmouth); A. M., 1914, Ph. D., 1917 (Harvard),
Instructor in Forest Technology.

HAROLD CAHILL BELYEA, A. B., 1908 (Mt. Allison Univ.); M. F., 1916 (Yale),
Instructor in Forest Engineering.

EDGAR C. PEDDIE, B. S., 1917 (New York State College of Forestry),
Instructor in Landscape Engineering.

RAYMOND F. HOYLE, B. S., 1917 (New York State College of Forestry),
Instructor in Forest Utilization.

MERLE R. MEACHAM, B. S., 1913 (Hiram College); B. S. in Ch. E., 1914; Ch. E., 1916 (Purdue University),
Research Assistant in Dendrological Chemistry.
(Fuller Fund)

ALVIN G. SMITH, B. S., 1915 (New York State College of Forestry),
Field Assistant in Forest Investigations; in charge of Syracuse Forest Experiment Station at Syracuse.

*WILFORD E. SANDERSON, B. S., 1917 (New York State College of Forestry),
Field Assistant in Forest Investigations.

DON M. BENEDICT, B. S., 1917 (Michigan),
Laboratory Assistant in Botany.

C. F. CURTIS RILEY, A. B., 1901 (Doane College); B. S., 1905 (Michigan); A. M., 1911 (Doane College); M. S., 1913 (University of Illinois),
Special Lecturer in Animal Behavior.

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THE BIOLOGY OF POLYPORUS PARGAMENUS Fries.

A THESIS

Submitted to the Faculty of the New York State College of Forestry at Syracuse University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, May 1, 1917.

BY

Arthur S. Rhoads, M. S.

CONTENTS.

THE BIOLOGY OF POLYPORUS PARGAMENUS Fries.[1]

Arthur S. Rhoads.

Introduction.

Polyporus[2] *pargamenus* Fries is one of the numerous fungi which cause the rotting of wood. Its small sporophores are to be found during all months of the year on living trees, dead trees, and fallen woody parts in moist situations. Even in winter its sporophores begin to grow with every warm spell of weather. Under the climatic conditions of the eastern United States, however, it is especially during the autumn months that the sporophores appear in great abundance. This fungus is one of the familiar objects to the field mycologist, but its life history, morphology, and ecology seem hitherto to have been neglected.

Deciduous forest trees are effected with an unusually large number of different fungous diseases, some of which are assuming more and more importance daily. In dealing with our timber tracts, whether they be wood-lots or larger areas, it is becoming of increasing importance to take cognizance of those factors which entail a marked depreciation in the

[1] A thesis submitted to the faculty of The New York State College of Forestry at Syracuse University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, May 1, 1917.

[2] The writer has deemed it advisable to drop the generic name *Polystictus* as a designation of a section of *Polyporus* for two reasons: First, because it is a synonym of *Coltricia* Gray, which was proposed several years earlier, and second, because it is not a well-defined genus, there being too many intermediate species to permit of its being longer used. This digression should cause no confusion since the names *Polyporus* and *Polystictus* have been used almost interchangeably with reference to the thin coriaceous plants once segregrated under the latter name.

value of the timber produced, either by diminishing the value of the wood cut or by retarding or preventing the growth of the trees themselves.

Polyporus pargamenus, while of rare occurrence on coniferous woods, grows on all or nearly all of the dicotyledonous woods occurring within its range, especially on the sapwood, and exhibits no perceptible preference for any particular species. On account of its wide geographic distribution and its ability to grow on and destroy so many different kinds of wood it should be regarded, in the United States at least, as second probably only to its near relative, *Polyporus versicolor* (L.) Fr., in being the most common of the wood-destroying fungi which attack the dead wood of dicotyledonous trees. As a usual rule *Polyporus pargamenus* is confined to dead trees and fallen woody parts, although frequently it may become a wound parasite and thus attack living trees whenever they become injured. The decay is at first restricted to the sapwood, but, under favorable conditions, after the destruction of the sapwood the fungus may advance and gradually decay the heartwood also. Thus the whole tree may be rendered valueless for lumber and of but little value for fuel. To the living forest trees, therefore, this class of fungi is a constant menace, and to the dead trees and fallen trunks, almost a certain evil.

These saprophytes are of great importance in two ways. From the standpoint of man's narrower economy they are directly injurious by virtue of the enormous losses sustained as a result of the decay of wood and timbers. From the standpoint of the broader economy of nature they are the scavengers which retard the accumulation of plant débris. As such their ability vastly outweighs those effects detrimental to man's interest.

It was not until 1833 that we had the first attempt, by Theodor Hartig, at a scientific investigation of the decay of wood. Of course the earlier explanations of the causes of disease were bound to be defective in accordance with the condition of botanical science at that time, but with the advent of time the basic principles became established effectually. As a result of the increasing favor with which this phase of plant pathology has met, an extensive literature on the subject has been assembled gradually. Despite our rapid progress in certain fields, we as yet know but little concerning the life histories of our wood-destroying fungi, supplemented by detailed and accurate information as to the way in which they bring about decay in wood, together with the chemistry involved in the process of decay. The prevention of the destruction of wood by any particular fungus presupposes a definite knowledge of its biologic and physiologic relations. Since we still are lacking this knowledge for the species here selected for investigation, detailed studies have been undertaken, placing foremost the interests of dendropathology and technical science.

Geographic Distribution and Host Woods of Polyporus Pargamenus.

Polyporus pargamenus is of wide geographic distribution, occurring on most any of the dicotyledonous, although rarely the coniferous, trees in many parts of the world. In the United States this fungus is of especially common occurrence in the great deciduous forests east of the Mississippi River, but of only scattered occurrence throughout the states west of the Mississippi River. Even here its occurrence in most all the states would lead one to expect that it will be reported eventually from every state, since *Populus tremuloides* Michx., which occurs in all of the western states, serves as a host to bridge the prairie states, *Polyporus pargamenus* having been collected on this species from points as far west as North Dakota, Colorado, and New Mexico. Collections of this fungus have been recorded from all states of the United States but Nebraska, Wyoming, Nevada, California, and Arizona. From the United States *Polyporus pargamenus* extends northward into southern Canada, authentic collections being recorded from British Columbia, Ontario, Quebec, Nova Scotia, and Newfoundland. The fungus likewise extends southward through Mexico and Central America.

Murrill (1915, p. 17) states that *Polyporus pargamenus* is frequent to common on dead wood throughout most of tropical North America, including Mexico, Central America, southern Florida, the Bermudas, the West Indies, and all other islands between North America and South America with the exception of Trinidad. Hans and Paul Sydow (1907) record it from South America as being among the collections of F. Noak made in Brazil. According to Murrill (1906, p. 655), Bresadola reports it as being common on poplar, oak, and basswood in Hungary and considers it cosmopolitan in one or more of its multiplied forms.

Authentic collections of *Polyporus pargamenus* have been recorded from Spain, France, Germany, Austria-Hungary, and Russia in Europe; from Japan, Malay Peninsula, and the Philippine Islands in Asia; and from Queensland and Victoria in Australia.

From the foregoing facts it is evident that the distribution of *Polyporus pargamenus*, even though still known but very imperfectly, embraces five of the six continents. A detailed tabulation of all the more important authentic collections of *Polyporus pargamenus* that the writer has been able to compile is given in the following pages. In connection with this work the specimens in the herbaria of the New York Botanical Garden, The Pennsylvania State College, the Office of Pathological Collections of the U. S. Bureau of Plant Industry, and the collections of the Office of Investigations in Forest Pathology having been examined personally.

Distribution in North America.

CANADA.

British Columbia:

On ——————. Kamloops, J. Macoun, in June, 1889 (Herb. N. Y. Bot. Gard.); New Westminster (Herb. N. Y. Bot. Gard.); Sidney, J. Macoun (Herb. C. G. Lloyd, No. 13089).

Ontario:

On *Populus* sp. London, J. Dearness, in August, 1887 (Herb. N. Y. Bot. Gard.).

On *Quercus rubra*. Ontario (Herb. N. Y. Bot. Gard.).

ONTARIO — *Continued:*

On *Acer* sp. Crystal Beach, E. Bartholomew, in July, 1913 (Fungi Columbiani, No. 4913).

On ————————. Shannonville, in 1882 (Herb. N. Y. Bot. Gard.); London, J. Dearness (Herb. C. G. Lloyd, No. 11172); Simcoe, P. L. Ricker (Herb. C. G. Lloyd, No. 05065½; Temagami, C. G. Lloyd (Herb. C. G. Lloyd, No. 07616); Toronto, Thos. Langton (Herb. C. G. Lloyd, Nos. 08 + 302, and 05260); Locality unknown, Mrs. I. M. Walker (Herb. C. G. Lloyd, No. 05577).

QUEBEC:

On ————————. Little Metis, J. Fowler (Herb. C. G. Lloyd, No. 08 + 133); Montreal, H. Dupret (Herb. C. G. Lloyd, No. 05479).

NOVA SCOTIA:

On *Populus balsamifera.* Pictou, Robinson, in August, 1905 (Herb. N. Y. Bot. Gard.).

On ————————. Halifax, A. H. Mackay, in November, 1906 (Herb. N. Y. Bot. Gard.).

NEWFOUNDLAND:

On *Betula* sp. Locality unknown, A. C. Waghorne, in August, 1897 (Herb. N. Y. Bot. Gard.).

On ————————. Locality unknown, A. C. Waghorne, in 1887 (Herb. Mo. Bot. Gard., No. 4558).

UNITED STATES.

ALABAMA:

On *Quercus nigra.* Auburn, in January, 1897 (Herb. Mo. Bot. Gard., No. 4437).

On *Liquidambar styraciflua.* Dothan, G. G. Hedgcock, in March, 1915 (F. P.[3] 17580).

On *Ilex opaca.* Auburn, Peters (Herb. N. Y. Bot. Gard.).

On *Rhododendron maximum.* Goldbranch, J. R. Weir, in 1904 (Herb. J. R. Weir, No. 9593).

On ————————. Auburn, F. S. Earle, in December, 1896 (Herb. N. Y. Bot. Gard.); Auburn, in February, 1897 (Herb. Mo. Bot. Gard., No. 4436); Montgomery, J. D. Burke (Herb. C. G. Lloyd, No. 7).

ARKANSAS:

On *Quercus alba.* Rogers, E. Bartholomew, in October, 1908 (Fungi Columbiani, No. 2825).

On *Quercus marilandica.* Nordyce, C. J. Humphrey, in September, 1909 (F. P. 5601).

[3] "F. P." = Forest Pathology Investigations number.

ARKANSAS — *Continued:*

On *Liquidambar styraciflua.* Camden, C. J. Humphrey, in September, 1909 (F. P. 6180); El Dorado, T. C. Abbott, in December, 1914 (F. P. 2879).

On ——————. Wynne, Wm. Trelease, in March, 1899 (Herb. Mo. Bot. Gard., No. 4431).

COLORADO:

On *Populus tremuloides.* Montezuma National Forest, G. G. Hedgcock, in July, 1911 (F. P. 9268); San Juan National Forest, G. G. Hedgcock, in July, 1911 (F. P. 9224).

On *Alnus tenuifolia.* Golden, L. O. Overholts, in 1914 (Herb. L. O. Overholts, No. 1743).

On ——————. Denver, E. Knaebel (Herb. C. G. Lloyd, No. 07663).

CONNECTICUT:

On *Betula alba.* Central Village, J. L. Sheldon, in September, 1910 (F. P. 9104).

On *Betula lutea.* North Bloomfield, P. Spaulding, in September, 1910 (F. P. 2295).

On *Quercus* sp. J. L. Sheldon, in August, 1908 (F. P. 9105).

On *Acer saccharinum.* Junction of Moosup and Quinnebaug Rivers, J. L. Sheldon, in September, 1908 (F. P. 9103).

DELAWARE:

On *Acer rubrum.* Wilmington (Herb. N. Y. Bot. Gard.).

DISTRICT OF COLUMBIA:

On *Castanea dentata.* Washington, S. C. Bruner, in February, 1914 (F. P. 8269).

On *Quercus prinus.* Takoma Park, R. G. Pierce, in November, 1913 (F. P. 18003).

On *Tilia platyphyllos.* Washington, G. G. Hedgcock (?), (F. P. 462 a).

On ——————. Washington, H. R. Ramsey, in October, 1915 (Herb. Path. Coll.).

FLORIDA:

On *Hicoria* sp. Jacksonville, G. G. Hedgcock, in March, 1918 (F. P. 23674).

On *Liquidambar styraciflua.* Gainesville, G. G. Hedgcock, in March, 1915 (F. P. 17303); Jacksonville, G. G. Hedgcock, in March 1918.

On ——————. Eustis, G. V. Nash, in July, 1895 (Herb. Mo. Bot. Gard., No. 4557); Gainesville, N. L. T. Nelson (Herb. C. G. Lloyd, Nos. 13, 37, 176, and 191); H. S. Fawcett (Herb. C. G. Lloyd, No. 08089).

Georgia:

On *Fagus atropunicea.* Atlanta, E. Bartholomew, in November, 1914 (Fungi Columbiani, No. 4522).

On *Liquidambar styraciflua.* Darien, H. W. Ravenel, in March, 1881 (Ellis' N. A. Flora, No. 312 d); Savannah, C. J. Humphrey, in July, 1909 (F. P. 5074).

On *Nyssa aquatica.* Near Macon, R. M. Harper, in 1902 (Georgia Plants, No. 1805 b).

On ————————. Bullock Co., R. M. Harper, in June, 1901 (Ellis' N. A. Flora, No. 884 d); Locality unknown, H. H. Bartlet (Herb. C. G. Lloyd, Nos. 08 + 210, and 08 + 211); Cornelia, G. C. Fitch (Herb. C. G. Lloyd, No. 12814); Vienna, C. J. Humphrey, in July, 1909 (F. P. 5153).

Idaho:

On *Populus tremuloides.* Salmon National Forest, G. G. Hedgcock, in August, 1910 (F. P. 4483); Priest River, J. R. Weir, in September, 1915 (Herb. J. R. Weir, No. 700).

On *Populus acuminata.* Salmon National Forest, G. G. Hedgcock, in August, 1910 (F. P. 4480).

On *Populus trichocarpa.* Priest River, J. R. Weir, in September, 1914 (Herb. J. R. Weir, No. 702).

On *Betula occidentalis.* Priest River, J. R. Weir, in September, 1914 (Herb. J. R. Weir, No. 697).

Illinois:

On *Quercus alba.* Jacksonville, E. Bartholomew, in September, 1907 (Fungi Columbiani, No. 2513).

On *Quercus prinus.* Cobden (Herb. N. Y. Bot. Gard.).

On *Quercus* sp. Cobden, F. S. Earle, in March, 1887 (Herb. Path. Coll.); Edgemont, L. O. Overholts, in 1912 (Herb. L. O. Overholts, No. 594); Cerro Gordo, L. O. Overholts, in 1915 (Herb. L. O. Overholts, No. 3213).

On ————————. Grand Pass, Trelease, in March, 1899 (Herb. Mo. Bot. Gard., No. 4433); Joliet (Herb. C. G. Lloyd, No. 05298); Chicago, L. H. Watson (Herb. C. G. Lloyd, No. 05333).

Indiana:

On *Salix nigra.* Scottsburg, J. R. Weir, in May, 1912 (Herb. J. R. Weir, No. 693).

On *Hicoria glabra.* Scottsburg, J. R. Weir, in May, 1912 (Herb. J. R. Weir, No. 703).

On *Fagus atropunicea.* Weirtown, J. R. Weir, in 1912 (Herb. L. O. Overholts, No. 3529).

On *Quercus rubra.* Weirtown, J. R. Weir, in May, 1912 (Herb. J. R. Weir, No. 696).

On *Toxylon pomiferum.* Little York, J. R. Weir, in November, 1917 (Herb. J. R. Weir, No. 5211).

INDIANA — *Continued:*

On *Prunus serotina*. Brownstown, J. R. Weir, in April, 1912 (Herb. J. R. Weir, No. 692).

On *Cercis canadensis*. Weirtown, J. R. Weir, in November, 1906 (Herb. J. R. Weir, No. 5215).

On *Gleditsia triacanthos*. Scottsburg, J. R. Weir, in November, 1917 (Herb. J. R. Weir, No. 9556).

IOWA:

On ————————. Decorah, E. M. Holway (?), in June, 1882 (Herb. N. Y. Bot. Gard.); Ft. Dodge, O. M. Oleson (Herb. C. G. Lloyd, Nos. 383, 561 a, 12174, and 12720).

KANSAS:

On *Quercus* sp. Bourbon Co., A. O. Garret, in August, 1902 (Herb. E. A. Burt).

On *Ulmus americana*. Strong City, G. G. Hedgcock, in November, 1910 (F. P. 4947).

On ————————. Manhattan, Kellerman and Swingle, in August, 1897 (Kansas Fungi, No. 1091); Rockport, E. Bartholomew (Herb. C. G. Lloyd, No. 6038).

KENTUCKY:

On *Quercus alba*. Ft. Thomas, J. R. Weir, in April, 1912 (Herb. J. R. Weir, No. 699).

On *Quercus* sp. Berea, L. O. Overholts, in 1915 (Herb. L. O. Overholts, No. 2767).

On *Tilia americana*. Louisville, J. R. Weir, in April, 1912 (Herb. J. R. Weir, No. 685).

On ————————. Mammoth Cave, C. G. Lloyd, in June, 1896 (Herb. Mo. Bot. Gard., No. 4439); Crittenden, C. G. Lloyd (Herb. C. G. Lloyd, Nos. 001, 0014, 07079, 1222, and 07355).

LOUISIANA:

On *Pinus* sp. East Louisiana, March, 1886 (Herb. Path. Coll.).

On *Salix* sp. Baton Rouge, C. J. Humphrey, in August, 1909 (F. P. 5428).

On *Quercus virginiana*. New Orleans, G. G. Hedgcock, in March, 1909 (F. P. 343).

On *Quercus palustris*. Bogalusa, G. G. Hedgcock, in March, 1909 (F. P. 367, 392, and 409).

On *Quercus nigra*. Baton Rouge, C. J. Humphrey, in August, 1909 (F. P. 5393).

On *Ulmus* sp. Locality and collector unknown, in November, 1889 (Herb. Path. Coll.).

On *Nyssa sylvatica*. Locality unknown, G. G. Hedgcock, in March, 1909 (F. P. 709).

LOUISIANA — *Continued:*

On ——————. Ville Platte, A. B. Langlois, in May, 1886 (Herb. Path. Coll.); Slidell, C. J. Humphrey, in July, 1909 (F. P. 5376).

MAINE:

On *Salix* sp. Kittery Point, A. S. Rhoads, in April, 1918.

On *Populus tremuloides.* Kittery Point, A. S. Rhoads, in June, 1918.

On *Betula populifolia.* Kittery Point, A. S. Rhoads, in April, 1918; in July, 1918 (F. P. 23681).

On *Betula lutea.* Hastings, G. G. Hedgcock, in July, 1913 (F. P.).

On ——————. Orono (Fungi of N. A., No. 140 a).

MARYLAND:

On *Pinus virginiana.* Takoma Park, A. S. Rhoads, in November, 1917 (F. P. 23651).

On *Betula nigra.* Takoma Park, G. G. Hedgcock, in September, 1908 (F. P. 4020); Great Falls, A. S. Rhoads, in October, 1917 (F. P. 23650); Cabin John Creek, A. S. Rhoads, in November, 1917 (F. P. 23656).

On *Carpinus caroliniana.* Takoma Park, A. S. Rhoads, in November, 1917 (F. P. 23649); Cabin John Creek, A. S. Rhoads, in November, 1917.

On *Fagus atropunicea.* Cabin John Creek, A. S. Rhoads, in November, 1917.

On *Castanea dentata.* Takoma Park. G. G. Hedgcock, in September, 1908 (F. P. 253 and 411); in 1909 (F. P. 467).

On *Quercus alba.* Takoma Park, G. G. Hedgcock, in April, 1911 (F. P. 9006).

On *Quercus prinus.* Cabin John Creek, A. S. Rhoads, in November, 1917.

On *Quercus rubra.* Glen Echo, A. S. Rhoads, in August, 1917; Great Falls, A. S. Rhoads, in October, 1917.

On *Quercus palustris.* Cabin John Creek, A. S. Rhoads, in October, 1917.

On *Liriodendron tulipifera.* Takoma Park, G. G. Hedgcock, in June, 1910 (F. P. 4001 and 4006); Glen Echo, A. S. Rhoads, in August, 1917.

On *Prunus serotina.* Chain Bridge, A. S. Rhoads, in October, 1917.

On *Acer rubrum.* Great Falls, A. S. Rhoads, in October, 1917; Cabin John Creek, A. S. Rhoads, in November, 1917.

MASSACHUSETTS:

On *Salix* sp. Mt. Auburn, E. A. Burt, in November, 1893 (Herb. E. A. Burt).

MASSACHUSETTS — *Continued:*

On *Hicoria* sp. Mt. Holyoke, P. Spaulding, in September, 1912 (F. P. 2746).

On *Betula lutea.* Mt. Holyoke, P. Spaulding, in September, 1912 (F. P. 2743).

MICHIGAN:

On *Populus* sp. Houghton, L. H. Pennington, in July, 1906 (Herb. L. H. Pennington).

On *Betula papyrifera.* Marquette, L. H. Pennington, in August, 1906 (Herb. L. H. Pennington).

On *Betula lenta.* Locality and collector unknown (Herb. N. Y. Bot. Gard.).

On *Platanus occidentalis.* Reported by C. H. Kauffman (1917, p. 156).

On ————————. Ann Arbor, C. H. Kauffman (Herb. C. G. Lloyd, Nos. 45 and 10590); Detroit, O. E. Fischer (Herb. C. G. Lloyd, No. 10328).

MINNESOTA:

On *Populus tremuloides.* Cass Lake, G. G. Hedgcock, in July, 1910 (F. P. 4171); Park Rapids, G. G. Hedgcock, in July, 1910 (F. P. 4161); Itasca Lake, G. G. Hedgcock, in July, 1910 (F. P. 4095); Minnetonka Lake, G. G. Hedgcock, in July, 1910 (F. P. 4064 and 4066).

On *Populus grandidentata.* Cass Lake, R. G. Pierce, in June, 1915 (F. P. 18068).

On *Populus balsamifera.* Cass Lake, J. R. Weir, in June, 1912 (Herb. J. R. Weir, No. 701).

On *Betula papyrifera.* Lake Itasca, G. G. Hedgcock, in July, 1910 (F. P. 4091 and 4125); Cass Lake, G. G. Hedgcock, in July, 1910 (F. P. 4201); J. R. Weir, in June, 1912 (F. P.).

On *Quercus coccinea.* Lake Minnetonka, G. G. Hedgcock, in July, 1910 (F. P. 4070).

On *Tilia americana.* Cass Lake, J. R. Weir, in June, 1912 (Herb. J. R. Weir, No. 694).

MISSISSIPPI:

On *Persea pubescens.* Sandy Hook, G. G. Hedgcock, in March, 1909 (F. P.).

On ————————. Biloxi, O. M. Oleson (Herb. C. G. Lloyd, No. 579).

MISSOURI:

On *Hicoria* sp. Creve Coeur, P. Spaulding, in December, 1905 (Herb. Mo. Bot. Gard.).

On *Betula nigra.* Williamsville, B. M. Duggar, in October, 1902 (Herb. E. A. Burt).

Missouri — *Continued:*

On *Quercus velutina.* Perryville, C. H. Demetrio, in April, 1883 (Rabenhorst-Winter's Fungi Europaei, No. 3331).

On *Quercus* sp. Jefferson Barracks, L. O. Overholts, in 1913 (Herb. L. O. Overholts, No. 529); Bismark, L. O. Overholts, in December, 1913 (Herb. Mo. Bot. Gard., Nos. 1780 and 21994).

On *Prunus* sp. Perryville, L. O. Overholts, in 1915 (Herb. L. O. Overholts, No. 2704).

On ————————. O'Fallon, Wm. Trelease, in November, 1895 (Herb. Mo. Bot. Gard., No. 4714); Valley Park, H. von Schrenk, in October, 1896 (Herb. Mo. Bot. Gard., No. 42838); Cliff Cave, J. B. S. Norton, in April, 1898 (Herb. Mo. Bot. Gard. No. 3864); Meramec, P. Spaulding, in April, 1906 (Herb. Mo. Bot. Gard., No. 4186); Poplar Bluff, F. W. Dewart(?), in August, 1892 (Herb. Mo. Bot. Gard., No. 4086); Creve Coeur Lake, L. O. Overholts, in 1912 (Herb. L. O. Overholts, No. 482).

Montana:

On *Salix lasiandra.* Belton, J. R. Weir, in September, 1912 (Herb. J. R. Weir, No. 691).

On *Populus trichocarpa.* Ashland, J. R. Weir, in September, 1913 (Herb. J. R. Weir, No. 690); Wisdom, J. R. Weir, in September, 1914 (Herb. J. R. Weir, No. 688).

On *Alnus tenuifolia.* Missoula, J. R. Weir, in May, 1914 (Herb. J. R. Weir, No. 689).

New Hampshire:

On *Juglans cinerea.* North Conway, A. S. Rhoads, in August, 1918 (Herb. A. S. Rhoads).

On *Salix discolor.* North Conway, A. S. Rhoads, in August, 1918 (Herb. A. S. Rhoads and F. P. 23684).

On *Populus tremuloides.* Willey House, A. S. Rhoads, in August, 1918 (Herb. A. S. Rhoads); North Conway, A. S. Rhoads, in September, 1918 (Herb. A. S. Rhoads).

On *Betula lutea.* Gorham, G. G. Hedgcock, in July, 1913 (F. P. 8608).

On *Betula papyrifera.* Gorham, P. Spaulding, in September, 1910 (F. P. 2319); North Conway, A. S. Rhoads, in September, 1918.

On *Fagus atropunicea.* Willey House, A. S. Rhoads, in August, 1918; North Conway, A. S. Rhoads, in August, 1918.

On *Prunus pennsylvanica.* Gorham, G. G. Hedgcock, in July, 1913 (F. P. 8645).

On *Acer saccharum.* White Mountains, G. G. Hedgcock, in July, 1913 (F. P. 8628).

On *Acer pennsylvanicum.* Gorham, P. Spaulding, in September, 1910 (F. P. 2342).

On *Acer rubrum.* North Conway, A. S. Rhoads, in September, 1918 (Herb. A. S. Rhoads).

NEW JERSEY:

On ——————. Newfield, J. B. Ellis, in November, 1876 (Mycotheca Universalis, No. 1304); Ellis and Everhart (Fungi Columbiani, No. 302); Trenton, E. B. Sterling (Herb. C. G. Lloyd, Nos. 08 + 452, 08 + 492, 08 + 459, 08 + 499, 05844, and 07656).

NEW MEXICO:

On *Populus tremuloides.* Manzano National Forest, G. G. Hedgcock, in June, 1908 (F. P.); Mogollen, G. G. Hedgcock and W. H. Long, in October, 1911 (F. P. 9888); Sandia Mts., G. G. Hedgcock, in June, 1908 (F. P. 456 and 462).

NEW YORK:

On *Tsuga canandensis.*. Ithaca, B. B. Higgins, in October, 1911 (Fungi Columbiani, No. 3616); Jamesville, A. S. Rhoads, in November, 1915 (Herb. A. S. Rhoads).

On *Hicoria glabra.* Syracuse, A. S. Rhoads, in November, 1916.

On *Hicoria minima.* Jamesville, A. S. Rhoads, in October, 1916.

On *Populus tremuloides.* Center, C. H. Peck, in September, 1879 (Ellis' N. A. Fungi, No. 312 a); Saranac, P. Spaulding, in May, 1909 (F. P. 2041); Glenn Falls, G. G. Hedgcock, in August, 1913 (F. P. 8660); Dobson's Camp, A. S. Rhoads, in June, 1916 (Herb. A. S. Rhoads).

On *Populus grandidentata.* Jamesville, A. S. Rhoads, in October, 1916.

On *Betula lutea.* Copake, C. H. Peck, in October, 1877 (Mycotheca Universalis, No. 1102); Cranberry Lake, A. S. Rhoads, in July, 1916; Fayetteville and Jamesville, A. S. Rhoads, in October, 1916.

On *Betula papyrifera.* Glenn Falls, G. G. Hedgcock, in August, 1913 (F. P. 8666).

On *Fagus atropunicea.* Alcove, C. L. Shear, in August, 1893 (Shear's New York Fungi, No. 38); Apulia, A. S. Rhoads, in September, 1916.

On *Castanea dentata.* Verona, C. H. Peck, in August, 1879 (Ellis' N. A. Fungi, No. 312 b).

On *Quercus alba.* Glenn Falls, G. G. Hedgcock, in August, 1913 (F. P. 8663).

On *Quercus rubra.* Glenn Falls, G. G. Hedgcock, in August, 1913 (F. P. 8662).

On *Prunus serotina.* Apulia, A. S. Rhoads, in October, 1916.

On *Prunus pennsylvanica.* Phoenix, A. S. Rhoads, in September, 1916.

On *Acer saccharum.* Cranberry Lake and Jamesville, A. S. Rhoads, in August, 1916.

On *Acer pennsylvanicum.* Cranberry Lake, A. S. Rhoads, in July, 1916.

On ——————. Long Island, G. C. Fisher (Herb. C. G. Lloyd, No. 08 + 238).

NORTH CAROLINA:

On *Hicoria glabra*. Bald Rock, A. H. Graves, in August, 1910 (F. P. 3687); Fairfield Lake, in August, 1910 (F. P.).

NORTH CAROLINA — *Continued:*

On *Fagus atropunicea*. Salem, R. K. Beattie, in February, 1913 (F. P. 8233).

On *Acer rubrum*. Marion, A. Ames, in October, 19— (F. P.).

On *Quercus* sp. Leicester, B. B. Higgins, in July, 1909 (Fungi Columbiani, No. 2924).

NORTH DAKOTA:

On *Populus tremuloides*. Near Fargo, J. F. Brenckle and O. A. Stevens, in June 1915 (Fungi Dakotensis, No. 412).

OHIO:

On *Betula* sp. East Cleveland, E. Claassen, in 1911 (Herb. L. O. Overholts, No. 269).

On *Quercus* sp. West Elkton, L. O. Overholts, in 1912 (Herb. L. O. Overholts, No. 476).

On *Prunus* sp. Lorain Co., E. C. Mosely, in 1911 (Herb. L. O. Overholts, No. 318).

On *Acer* sp. Oxford, L. O. Overholts, in 1909 (Herb. L. O. Overholts, No. 6).

On ——————. Cincinnati, D. L. James, in October, 1879 (Ellis' N. A. Fungi, No. 312 c); Oxford, L. O. Overholts, in 1910 (Herb. L. O. Overholts, No. 7); Sugar Grove, W. G. Stover, in 1911 (Herb. L. O. Overholts, No. 166).

OKLAHOMA:

On ——————. Poteau, I. T., Wm. Trelease, in February, 1901 (Herb. Mo. Bot. Gard., No. 4732).

OREGON:

On *Quercus californica*. Grants Pass, J. R. Weir, in September, 1916 (Herb. J. R. Weir, No. 686).

On *Quercus garryana*. Portland, J. R. Weir, in August, 1913 (Herb. J. R. Weir, No. 698).

PENNSYLVANIA:

On *Tsuga canandensis*. Philadelphia, A. S. Rhoads, in September, 1916 (Herb. Penna. State College).

On *Hicoria alba*. Near State College, A. S. Rhoads, in 1913 (Herb. Penna. State College); A. S. Rhoads, in September, 1916.

On *Hicoria ovata*. Lemont, C. R. Orton and A. S. Rhoads, in 1915 (Herb. Penna. State College).

On *Betula lenta*. Near State College, A. R. Bechtel, in 1913 (Herb. Penna. State College); Philadelphia, A. S. Rhoads, in September, 1916.

On *Betula lutea*. Carbondale, E. A. Burt, in December, 1898 (Herb. E. A. Burt); near State College, A. S. Rhoads, in 1915 (Herb. Penna. State College).

PENNSYLVANIA — *Continued:*

On *Castanea dentata.* Near State College and Ephrata, A. S. Rhoads, in September, 1916.

On *Quercus alba.* Near State College, A. S. Rhoads, in 1914 (Herb. Penna. State College) ; A. S. Rhoads, in September, 1916.

On *Quercus phellos.* Philadelphia, A. S. Rhoads, in September, 1916.

On *Quercus prinus.* Ephrata and Philadelphia, A. S. Rhoads, in September, 1916 (Herb. A. S. Rhoads).

On *Quercus coccinea.* Near State College, A. S. Rhoads, in September, 1916.

On *Quercus velutina.* Philadelphia, A. S. Rhoads, in 1915 (Herb. Penna. State College).

On *Prunus* sp. Petersburg, G. G. Hedgcock, in June, 1914 (F. P. 15478).

On *Gleditsia triacanthos.* State College, C. R. Orton and L. O. Overholts, in 1916 (Herb. Penna. State College).

On *Acer rubrum.* Mont Alto, J. S. Illick, in May, 1913 (F. P. 8346) ; Hammersley Forks, M. E. Muller, in January, 1914 (F. P. 15248) ; near Boalsburg, A. S. Rhoads, in 1915 (Herb. Penna. State College) ; State College and Philadelphia, A. S. Rhoads, in September, 1916.

RHODE ISLAND:

Locality and other data unknown. Several collections in herbarium of Brown University.

SOUTH CAROLINA:

On *Hicoria* sp. Aiken, H. W. Ravenel (Fungi Americani Exicatti, No. 423).

On *Nyssa* sp. Lanes, C. J. Humphrey, in July, 1909 (F. P. 5040).

On ——————. Locality unknown, H. W. Ravenel, in 1852 (Fungi Caroliniani, Fasc. I, No. 13).

SOUTH DAKOTA:

On *Populus tremuloides.* Custer, G. G. Hedgcock, in September, 1914 (F. P. 15818).

TENNESSEE:

On *Quercus* sp. Jonesboro (Herb. N. Y. Bot. Gard.).

On ——————. Rugby, M. S. Percival (Herb. C. G. Lloyd, Nos. 7142 and 10831).

TEXAS:

On *Quercus nigra.* Quitman, W. H. Long, in November, 1911 (F. P. 12089).

On *Quercus texana.* Houston, G. G. Hedgcock, in March, 1909 (F. P. 722).

On *Liquidambar styraciflua.* Joaquin, E. Bartholomew, in October, 1913 (Fungi Columbiani, No. 4620) ; Quitman, W. H. Long, in November, 1911 (F. P. 12051).

TEXAS — *Continued:*

On *Nyssa sylvatica.* Houston, G. G. Hedgcock, in March, 1909 (F. P. 701).

UTAH:

On ——————. Locality unknown (as *Coriolus subchartaceus* Murrill *in* North Am. Fl. 9:24, 1907.

VERMONT:

On *Populus tremuloides.* Bethel, P. Spaulding, in May, 1908 (F. P. 2067).

On *Populus grandidentata.* Bethel, P. Spaulding, in May, 1909 (F. P. 2186).

On *Betula lutea.* Middlebury, E. A. Burt, in October, 1895 (Herb. E. A. Burt); Bethel; P. Spaulding, in November, 1912 (F. P. 2561); Walden, C. R. Orton, in 1913 (Herb. Penna. State College).

On *Prunus* sp. Bethel, P. Spaulding, in January, 1912 (F. P. 2573).

On *Acer saccharum.* Bethel, P. Spaulding, in October, 1910 (F. P. 2423).

On *Acer saccharinum.* Bethel, P. Spaulding, in November, 1912 (F. P. 2711).

VIRGINIA:

On *Betula nigra.* Great Falls, P. Spaulding, in January, 1911 (F. P. 2395).

On *Quercus prinus.* Rosslyn, R. G. Pierce, in December, 1914 (F. P.).

On *Quercus velutina.* Rio, G. F. Gravatt, in February, 1915 (F. P. 17281).

On *Quercus rubra.* Chain Bridge, A. S. Rhoads, in October, 1917.

On *Quercus marilandica.* Chain Bridge, A. S. Rhoads, in October, 1917.

On *Sassafras sassafras.* Chain Bridge, A. S. Rhoads, in October, 1917 (F. P. 23643).

On *Prunus americana.* Chain Bridge, A. S. Rhoads, in October, 1917 (F. P. 23642).

On *Prunus serotina.* Chain Bridge, A. S. Rhoads, in October, 1917.

On *Rhus vernix.* Vienna, A. S. Rhoads, in January, 1918 (Herb. A. S. Rhoads).

On *Acer rubrum.* Chain Bridge, A. S. Rhoads, in October, 1917.

On *Fraxinus americana.* Great Falls, P. Spaulding, in January, 1911 (F. P. 2461).

WASHINGTON:

On *Quercus garryana.* Near Bellingham, J. R. Weir, in September, 1916 (Herb. J. R. Weir, No. 687).

WEST VIRGINIA:

On *Betula* sp. Cranberry Glades, Pocahontas Co., J. L. Sheldon, in August, 1909 (Fungi Columbiani, No. 3655).

West Virginia — *Continued:*

On *Fagus atropunicea.* Albright, J. L. Sheldon, in August, 1908 (F. P. 9102).

On *Quercus* sp. Cranberry Glades, Pocahontas Co., J. L. Sheldon. in August, 1909 (Fungi Columbiani, No. 3621).

Wisconsin:

On *Salix* sp. Madison, M. C. Jensen, in October, 1910 (F. P. 6711).

On *Populus* sp. Oneida Co., J. J. Neuman, in 1904 (Herb. Mo. Bot. Gard., No. 42712).

On *Betula papyrifera.* Trout Lake, P. Spaulding, in June, 1915 (F. P. 2691).

On *Quercus* sp. Madison, C. J. Humphrey and E. Bartholomew, in October, 1911 (Fungi Columbiani, No. 3907).

On *Alnus incana.* Elmside, R. A. Harper, in September, 1902 (Herb. Univ. Wisc.).

MEXICO.

On *Pinus* sp. Locality unknown (Herb. N. Y. Bot. Gard.).

On ————————. Locality unknown (as *Polyporus Xalapensis* Berk, *in* Jour. Bot. & Kew Misc. **I**:103, 1849); Jalapa, Chas. L. Smith, January–June, 1894 (Central American Fungi, No. 122); W. A. Murrill, in December, 1909 (Herb. N. Y. Bot. Gard.).

CUBA.

On ————————. Locality unknown (as *Polyporus Flabellum* Mont. *in* Pl. Cell. Cuba, p. 388, pl. 15, f. 2, 1842); (as *Polyporus laceratus* Berk. *in* Ann. Mag. Nat. Hist. **3**:392, 1839, according to Saccardo, Syll. Fung., **6**:231, 1888).

Distribution in South America.

Brazil:

On ————————. Sao Francisco dos Compos, in Province of Sao Paulo, F. Noack, in 1896–1898 (No. 292), according to Hans and Paul Sydow (1907).

Distribution in Europe.

Spain:

On ————————. Northern Spain (Herb. N. Y. Bot. Gard.).

France:

On ————————. Carqueiranne, E. Jahandiez (Herb. C. G. Lloyd, Nos. 09227, 08 + 48, and 11282; New Caledonia (Herb. C. G. Lloyd, No. 0608); locality unknown, N. Patouillard (Herb. C. G. Lloyd, No. 3931).

Germany:

On ————————. Dresden, O. Pazschke (Herb. C. G. Lloyd, No. 13101).

AUSTRIA-HUNGARY:

AUSTRIA:

On ———————. Tirolo. Rev. Bresadola (Herb. C. G. Lloyd, No. 3903); Wien, von Höhnel (Herb. C. G. Lloyd, No. 08725).

HUNGARY:

On ———————. Travnik, E. Brandis (Herb. C. G. Lloyd, Nos. 08846, 08847 and 08862).

On *Populus tremula*, *Quercus* sp., and *Tilia* sp. Kmet, in 1891 (Herb. N. Y. Bot. Gard.).

RUSSIA:

On *Betula alba*. Viro B. Eichler (according to Bresadola, Ann. Myc., **1**:76, 1903).

On *Betula* sp. Bialowiezan Lithuania (as *Polyporus simulans* Blonski *in* Hedw., 1888, p. 280, according to Saccardo, Syll. Fung., **9**:185, 1891).

On ———————. Majkop, N. Schustenow (Herb. C. G. Lloyd, No. 1703).

DISTRIBUTION IN ASIA.

JAPAN:

On *Pinus* sp. Settsu, Ch. Tanaka, in August, 1908 (Polyporaceae of Japan, No. 62).

MALAY PENINSULA:

On ———————. Perak (Herb. N. Y. Bot. Gard.).

PHILIPPINE ISLANDS:

LUZON:

On ———————. Lamao Forest Reserve, Bataan Province, H. M. Curran, in July, 1907 (Flora of Philippines, Herb. Bureau of Science).

DISTRIBUTION IN OCEANICA.

AUSTRALIA:

On ———————. Victoria, De Müller (as *Polyporus dispar* Kalchbr. *in* Symb. Myc. Austral., II, n. 82, according to Saccardo, Syll. Fung., **6**:262, 1888); Queensland (according to D. C. McAlpine, Syst. Arr. Austral. Fungi, 1895, pp. 48–49).

Von Schrenk and Spaulding (1909, p. 57) state that they have collected *Polystictus pergamenus* on *Quercus imbricaria* Michx., a species not included among the host species cited in the above list of exsiccati. Furthermore, Kauffman (1918) reports the sycamore (*Platanus occidentalis* Linn.) as a host for this fungus. From the foregoing data it is evident that the following woods[1] are attacked by *Polyporus pargamenus:*

Pinus virginiana
Tsuga canadensis
Juglans cinerea
Hicoria minima
Hicoria ovata
Hicoria alba
Hicoria glabra
Salix nigra
Salix discolor
Salix lasiandra
Populus tremula
Populus tremuloides
Populus grandidentata
Populus balsamifera
Populus acuminata
Populus trichocarpa
Betula alba
Betula papyrifera
Betula populifolia
Betula occidentalis
Betula lutea
Betula nigra
Alnus incana
Alnus tenuifolia
Carpinus caroliniana
Fagus atropunicea
Castanea dentata
Quercus alba
Quercus garryana
Quercus prinus
Quercus virginiana
Quercus rubra
Quercus texana
Quercus coccinea
Quercus velutina
Quercus californica
Quercus palustris
Quercus marilandica
Quercus nigra
Quercus imbricaria
Quercus phellos
Ulmus americana
Toxylon pomiferum
Liriodendron tulipifera
Persea pubescens
Sassafras sassafras
Liquidambar styraciflua
Platanus occidentalis
Prunus americana
Prunus pennsylvanica
Prunus serotina
Cercis canadensis
Gleditsia triacanthos
Rhus vernix
Ilex opaca
Acer pennsylvanicum
Acer saccharum
Acer saccharinum
Acer rubrum
Tilia americana
Tilia platyphyllos
Nyssa sylvatica
Nyssa aquatica
Rhododendron maximum
Fraxinus americana

The above list of host species is but a meager indication of the commonly known ones. Unfortunately in most of the available collections the host species are either incompletely, or more often not at all, given. A detailed reconnaissance in this and foreign countries should more than double the size of the present list.

[1] The nomenclature used for the trees mentioned in this list is that of George B. Sudworth. (Check list of the forest trees of the United States, their names and ranges. U. S. Dept. Agr., Div. Forestry Bul. **17**:144 pp., 1898).

History and Synonomy.

Since its description in 1838, the identity of *Polyporus pargamenus* has been obscured repeatedly owing to the fact that various forms or collections of it have been described as distinct species. Without due regard for the fact that the various morphological characters of one and the same species of fungus are subject to considerable variation, especially when grown under widely different environments in various parts of the world, mycologists often have been misled and have described aberrant or imperfectly developed forms of this plant as new species. Moreover, the various ecological forms of this plant have been published independently as "new species" in former years from three or four European centers of research, each ignoring the existence of the rest. In many cases these brief early descriptions are entirely inadequate and the poorly preserved type plants, when they exist at all, often fail to supplement them sufficiently. Add to this the host of incorrect determinations found in the literature then current, the wholesale assignment of foreign names to plants exclusively American, and the glittering array of species combined under one name in important herbaria, and the reason for the confusion over the status of this plant becomes clear. *Polyporus pargamenus* is generally believed to have been described first by Fries (1838, p. 480) from specimens collected from trunks of pine in arctic North America by the Franklin Expedition. Dr. W. A. Murrill of the New York Botanical Garden, however, who has recently examined the type specimens, has decided that they are a form of *Polyporus abietinus* Fries [*Coriolus*[5] *abietinus* (Dicks.) Quél.].[6] According to Mur-

[5] In keeping with the present day tendency of a few authors to break up the old cumbersome genera, containing a large aggregation of often heterogeneous species, and to regroup the species into smaller groups containing only closely related species, Murrill (1903, p. 93) states that the name "*Polystictus*" is not valid since it is a synonym of *Coltricia* Gray, proposed in 1821. According to Murrill, this removes "*Polystictus*" since it was not used until several years later by Fries (1851). As a result of this discrepancy Murrill (1903, p. 95) has adopted *Coriolus* Quél. as the generic name for the thin coriaceous species of the

rill (1907, p. 27) the true type specimen of this plant came from Mexico and was described by Fries (1838, p. 443) as *Polyporus prolificans* Fr.

In response to the writer's request for enlightenment upon the obscure early history of *Polyporus pargamenus*, Mr. C. G. Lloyd of the Lloyd Library, who has made a careful study of European polyporoid exsiccati, very kindly wrote the following account:

> Fries, who in his early day was limited in his knowledge of foreign species to a scanty few that had drifted into Europe, got a deformed specimen from Mexico which he named *Polyporus prolificans*. It was not proliferous, however, but a malformation — a monstrosity.
>
> Some years afterwards Klotzsch (who was a German working in Hooker's herbarium) sent Fries some foreign plants numbered, which Fries named for Klotzsch by number. Among others was one supposed to be the plant in question (*Polyporus pargamenus*), which Klotzsch published, but through some transformation of the numbers, either on the part of Fries or Klotzsch, this plant (or a form of *Polyporus abietinus*) was published by Klotzsch, at least as to part. The specimen is not clearly indicated in Hooker's herbarium today, but is indicated from Klotzsch's description. Perhaps, however, it was *Polyporus abietinus*.
>
> Afterwards, when Fries summarized the subject, he proposed *Polyporus pargamenus* on a plant received from Klotzsch, and applied the name to the plant that you have in question. He received the plant from a number of correspondents since, and he always named it as *Polyporus pargamenus*, as evidenced in his herbarium today. *Polyporus pargamenus* came into use not only at Upsala, but throughout the mycological world, for Fries in those days was supposed to know his own species, and those who were in correspondence with Fries, such as Berekeley and Montagne, engaged in naming plants, used Fries' name. There are several hundred specimens in the various museums in Europe and the United States, practically all of them labelled as above. To attempt to change the name at this late date would be absolutely futile, even if it were based on any merit. To take the position that a plant, always called *Polyporus pargamenus* by Fries and every other leading mycologist, be changed to another name and claimed to be on the authority of Fries is absurd on the face of it, and places Fries in a false position.

Polyporaceæ, this name being founded on *Polyporus zonatus* Fr. and seven other species by Quélet (1886), according to Murrill (1906, p. 640).

[6] The close resemblance of these two species, namely *Polyporus pargamenus* Fr. and *Polyporus abietinus* Fr. had lead to considerable confusion in the examination of very old herbarium specimens.

Some years ago Bresadola got a clue to the Klotzschian history, and in one of his papers called the plant "*Polyporus biformis*". It was really based on probable fact but Bresadola only followed it for a short time, for, as every one else who attempts to change established nomenclature for some trivial reason, he has since receded from his position.

In the meantime, however, the plant was found in southern France, where it is an extremely rare plant, and a specimen drifted in to Boudier. The latter submitted it to Patouillard, and he being in touch with Bresadola, gave it the name Bresadola was using at that time. This is the reason why the plant was illustrated in Boudier's "Icones" as *Polyporus biformis*. . . .

There is a strong probability that the Mexican plant which came originally to Fries was but a malformation of this same plant. Fries made two mistakes regarding it: First, in considering that it was a species when it was simply an abortion and should not have been named; and second, in naming it "prolificans" when it was not proliferous, but malformed. Although the plant, through some unfortunate chance, still remains in Fries' herbarium, being one of the very few that have persisted, Fries never recognized it as being the same plant that he got normal specimens of from several correspondents and always called *Polyporus pargamenus*. It seems to me that anyone that substitutes this plant for *Polyporus prolificans* is putting Fries in a ridiculous position if he writes Fries after it, for he is virtually claiming that Fries' blunder should take precedence over his intelligent work. I believe, if Fries were alive today, he would resent it as vigorously as I do. It is unfortunate enough when a man makes a blunder of this kind, but doubly so if it is brought up and paraded years after his death.

As to the question whether the particular specimen sent by Klotzsch to Fries is the plant that you have in question (*Polyporus pargamenus*) or a form of *Polyporus abietinus*, my impression is that the particular specimen from Klotzsch is not preserved in Fries' herbarium. I am sure, however, that there are several specimens that were named *Polyporus pargamenus* and that they are the same plant that you are considering, and if you virtually make the charge that Fries, in addition to not recognizing the old abortion, did not distinguish between *Polyporus pargamenus* and *P. abietinus*, I hardly feel that you will be able to maintain it. . . .

You ask "what will become of Fries' *Polyporus prolificans?*" I think it will remain in a state of "*innocuous desuetude*" as it has remained for nearly one hundred years, and would have remained forever if it had not been dug up as a juggle. . . .

The following list of names may be taken as a partial index to the synonomy of *Polyporus pargamenus:*

Polyporus pargamenus Fries, Epicr. Myc., 480, 1838. (Type from arctic North America.)

Polyporus laceratus Berk., Ann. Mag. Nat. Hist., **3**:392, 1839. (Type from Louisiana.)

Polyporus Flabellum Mont., Pl. Cell. Cuba, 388, pl. 15, f. 2, 1842. (Type from Cuba.)

Polyporus Menandianus Mont., Ann. Sci. Nat., II, **20**:362, 1843. (Type from New York.)

Polyporus subflavus Lév., Ann. Sci. Nat., III, **5**:300, 1846. (Type from New York.)

Polyporus Xalapensis Berk., Jour. Bot. & Kew Misc., **I**:103, 1849. (Type from Mexico.)

Polyporus Sartwellii Berk. & Curt., Grevillea **I**:51, 1872. (Type from New York.)

Polyporus ilicincola Berk. & Curt., Grevillea **I**:52, 1872. (Type from Alabama.)

Polyporus pseudopargamenus Thuem., Myc. Univ., no. 1102, 1878. (Type from New York.)

Coriolus pargamenus (Fr.) Pat., Tax. Hymen., 94, 1900.[7]

Coriolus subchartaceus Murrill, North Am. Fl., **9**:24, 1907. (Type from Colorado.)

Coriolus prolificans (Fr.) Murrill, North Am. Fl., **9**:27, 1907.[8]

Polystictus[9] *pargamenus* (*pergamenus*[10]) of most American authors.

As can be surmised readily from the list of the more important synonyms given above, *Polyporus pargamenus* has had rather a chaotic past history. If we discredit the monstrosity named "*Polyporus prolificans*" by Fries we may consider that Fries' *Polyporus pargamenus*, described originally, under the name in current use, from specimens collected by the Franklin Expedition on trunks of pine in arctic North America, is the type of the species made the subject

[7] Inaccurately cited by Patouillard as "*Coriolus pergamenus* Berk.", and correctly given by Murrill (1906, p. 654).

[8] Based on the monstrosity named "*Polyporus prolificans*" by Fries from specimen from dead deciduous trunk in Mexico.

[9] As stated earlier, the name "Polystictus" is invalid since S. F. Gray in 1821 used "Coltricia" for the plant which Fries made the type of Polystictus in 1851.

[10] This perverted spelling was inaugurated at least as early as 1860. Since its use by Saccardo it has been widely followed by American writers.

of this study. A year later Berkeley described it from New Orleans, La., under the name of *Polyporus laceratus*. Three years after this Montagne described and figured collections of this plant on dead branches and trunks in Cuba as *Polyporus Flabellum*. Types at Paris are well preserved. Then Montagne found it among Menand's New York collections and gave it the name of the collector. Later Léveillé briefly described a form of *Polyporus pargamenus*, collected on trunks in New York by Sallé, as *Polyporus subflavus*. In 1849 Berkeley described collections from Mexico and South Carolina as *Polyporus Xalapensis*. In 1851 Fries erected Polystictus for a section of *Polyporus* as an experiment, changing *Polyporus pargamenus* to *Polystictus pargamenus*. Fries' name is based on *Polystictus parvulus* Kl., a close ally of *P. perennis*, and must therefore stand as a synonym of Coltricia proposed by S. F. Gray in 1821 for *P. perennis* and two other species. Several years afterward Berkeley and Curtis described a poroid form of the plant, collected on trunks in New York by Sartwell, as *Polyporus Sartwellii*, the types now being preserved at Kew. During the same year the same authors described other collections, made by Peters on bark of *Ilex opaca* in Alabama, as *Polyporus ilicincola*, the types at Kew not being well preserved. Later Thümen named a poroid form of the plant in question *Polyporus pseudopargamenus* in contradistinction to the hydnoid form which he considered the real *Polyporus pargamenus*. In 1900 Patouillard adopted the generic name Coriolus, proposed earlier by Quélet, thus making the name *Coriolus pargamenus*. In the case of the splitting of the old cumbersome genus Polyporus and the regrouping of the species into a number of smaller groups containing only closely related species the writer regards "*Coriolus pargamenus*" as the correct name. In 1907 Murrill described a thick poroid form of the plant from the western United States as *Coriolus subchartaceus*. The last name given to this plant is "*Coriolus prolificans*," based on Murrill's belief that Fries' *Polyporus pargamenus* is synonymous with his *P. abietinus*, and that the monstrosity named *Polyporus* *prolificans* by Fries is therefore the type of the plant in question.

The synonomy of this variable plant might be extended considerably. Murrill (1906, p. 655) states that, according to Bresadola, *Polyporus dispar* Kalchbr. and *Polyporus simulans* Blonski should be added for the European forms and that there are probably half a dozen or more from other regions. According to Murrill (l. c.), specimens from North America have been variously determined as *Polyporus elongatus* Berk., described from Manila, *Polyporus nilgheriensis* Mont., described from India, and *Daedalea ferruginea* Schum., described from Denmark.

The Fungus.

Description of the Sporophore.

Technical Description.—*Pileus* exhibiting great ecological variation, ranging from thin to comparatively thick, tough, corky-leathery, sessile or affixed by a short tubercle, effused-reflexed, imbricate, dimidiate, or flabelliform, frequently becoming laterally confluent, broadly or narrowly attached, often with cuneate base, 1-7 by 1-7 by 0.1–0.8 cm.; *surface* finely villose tomentose, whitish, cremeous, gray, or sometimes brownish-gray with age, usually but not always marked by a few narrow, more or less shining and distinct buff to dark brown zones, frequently becoming more or less concentrically sulcate; *margin* usually very thin, acute, and sterile, sometimes becoming fertile with extreme age, entire to lobed, often splitting radially when thin specimens are dried, fuscous, violaceous, or whitish; *context* white or whitish, fibrous, usually very thin, rarely more than 1 mm. thick; *tubes* 1-5 mm. long, white to discolored within, the mouths whitish to cremeous or often violaceous, especially toward the margin, becoming yellowish to yellowish-brown with age or upon drying, small, angular, irregular, seriate, averaging 3-4 to a mm. in poroid forms, the dissepiments thin and usually becoming irpiciform at an early age, frequently, however, produced at length in the form of very thin dentate, but becoming lacerate, more or less concentric lamellæ; *spores* smooth, hyaline, cylindric (rod-like in dorsiventral view but allantoid and obliquely apiculate in lateral view), curved, 5-6.5 by 2-2.25 μ; *cystidia* of variable occurrence; when present, conspicuous, hyaline, blunt, and capitate with an incrustation of mineral matter, 15-25 by 4-5 μ; projecting 0-10 μ; *hyphae* of the context hyaline, 3-4 μ in diameter.

Variation Exhibited by the Sporophores of Polyporus Pargamenus.—In the above technical description an attempt has been made to make the descriptive terms somewhat broad and far-reaching — an absolute necessity when describing a species comprising half a dozen more or less distinct forms. The following account of Peck (1880, pp. 36–37) is cited here since it accurately portrays the range of variation assumed by this plant in the eastern United States.

> "*Polyporus pergamenus*, Fr. The typical form of this species, according to the description, has the pileus coriaceo-membranaceous, rigid, tomentose, concentrically sulcate, white; the pores seriately placed, pallescent and produced into very thin dentate plates. Its habitat is said to be pine, and its locality Arctic America. The species, as now understood, proves to be a very common and very variable one and includes several synonyms. In Ravenel's Fungi Car. Exsicc., Fasc. 1, No. 13, *Polyporus laceratus*, Berk., is represented to be a synonym of this species. Dr. Berkeley himself does not give it as a distinct species in his Notices of North America Fungi, though it was founded on specimens from New Orleans, from which we infer that he does not regard it as a good species. According to the description it scarcely differs from *Polyporus elongatus*, Berk., except in its shape and its larger pores. The former difference is of little value for *P. elongatus* is known to vary very much in shape and size. But *P. elongatus*, according to authentic specimens received from Dr. Michener, can scarcely be regarded as anything more than a mere form, or perhaps variety, of *P. pergamenus*. For of this species we have in this State (New York) two prevailing forms. One form has the pileus tomentose, concentrically sulcate and white, and its pores become paler with age and are at length produced or lacerated into thin dentate plates precisely as required by the description. But it differs from the type in general, though not always, having the pileus too thick to be called membranaceous, and in the pores not being seriately placed. These slight differences, however, are of but little account in such a variable plant as ours is known to be, and there can be no doubt that it should be referred to *P. pergamenus*. The other

form, which is more abundant even than the first, is generally thinner and less distinctly tomentose. Indeed, it is sometimes nearly or quite smooth, and it often appears to become smoother with age. Instead of being concentrically sulcate it is generally more or less marked with narrow delicate zones. There are also fine radiating lines or striations which are more perceptible in the smoother specimens. The color is generally grayish pallid or subochraceous. The pores are usually seriately placed, especially toward the margin, and though variable in color they are commonly tinged with purple when fresh and young, as in the preceding form. As in that form also they become paler with age. This is the form recently published under the name *Polyporus pseudopargamenus*, Thum. When the pileus is narrowed toward its base so that its length is greater than its breadth it is *Polyporus elongatus*, Berk. It occurs on a great variety of deciduous trees, but is most frequent on birch, maple, oak and chestnut. The first form is most common on poplar though not limited to it. I have not found either growing on pine. These two forms run into each other by such insensible graduations that it is not possible to draw any satisfactory line of distinction between them, and therefore, the conclusion must be that both are forms of one species, *Polyporus pergamenus*."

Relation of Environmental Factors to the Morphologic Variation of the Sporophores.—All plants, especially fungi, manifest fluctuating variation in all their characters. Such variations are largely, if not entirely dependent upon the environment. Differences in the kind of food elements supplied, due to the occurrence of fungi on a great variety of hosts in different stages of decay will give rise often to sporophores of variable appearance. Changes in the amount of water available and the length of time that an optimum supply remains available are manifested in the resulting form of the sporophores. Variations in the degree of humidity as determined by the growth site or environment, climatic conditions, temperature, etc., are reflected in the variation of size, shape, and other morphological characters of the sporophores. Probably the greatest factor of all, however, is that of the growth position of the sporophores on the substratum. This factor alone is probably responsible for greater variation in the appearance of the sporophores of fungi than all the others combined. Only when we fully realize the importance of environmental factors in influencing the morphology of the sporophores can we appreciate the value of a broader conception of our species of fungi.

Polyporus Pargamenus Fries Versus Polyporus Abietinus Fries.

Unfortunately *Polyporus pargamenus* frequently has been, and still is, confused with its near relative, *Polyporus abietinus.* Many authors state that the former plant is confined entirely to the wood of dicotyledonous trees, while the latter plant is confined entirely to the wood of coniferous trees, and are of the opinion that this fact affords the only constant character by which they can be separated. The writer wishes to make clear that such an impartially drawn distinction may generally, but will not always, separate these two closely related species, since *Polyporus abietinus* sometimes occurs on dicotyledonous woods and *P. pargamenus* sometimes occurs on coniferous species. Weir (1917) mentions the occurrence of small but typical specimens of *Polyporus abietinus* on *Populus trichocarpa* in the Northwest.[11] The writer (1917[1]) has made collections of *Polyporus pargamenus* from dead trunks of hemlock (*Tsuga canadensis*) upon several occasions both in New York and Pennsylvania. On one occasion he observed both plants growing side by side on the same dead hemlock trunk (Plate II). Upon another occasion a dead hemlock was literally covered with sporophores of *Polyporus pargamenus* alone, up to about eight feet above the base (Plate III). In every case where *Polyporus pargamenus* was observed growing on hemlock trunks the macroscopic appearance of the rot produced was indistinguishable from that produced in this wood by *Polyporus abietinus.* Recently the writer (1918) collected specimens of both plants on a dead scrub pine (*Pinus virginiana*) trunk

[11] Freeman (1905, p. 258) states that *Polyporus pargamenus* occurs abundantly on living larch (*Larix laricina*) trees in Minnesota, and gives an illustration (p. 81, fig. 36) of a larch trunk bearing numerous sporophores of what he takes to be this fungus. He states further that there is strong evidence of it having been the cause of the death of numerous larch trees in Minnesota. A careful perusal of Freeman's work, however, shows that he does not distinguish between *Polyporus pargamenus* and *P. abietinus*, so that the case cited undoubtedly refers to *P. abietinus.*

in Maryland. In this case two groups of typical sporophores of *Polyporus pargamenus* had formed from the mycelium developing out of two insect tunnels about two inches apart in the bark. On adjacent portions of the bark were numerous typical sporophores of *Polyporus abietinus*.

Probably one reason for the confusion of these two species may be that while the specimens collected from trunks of pine by the Franklin Expedition in arctic North America have generally been regarded as the type of our present-day *Polyporus pargamenus*, the plant that has gone under this name in the United States is practically always found on the wood of dicotyledonous trees. As Overholts (1915) states, this has led some authors to regard the original *Polyporus pargamenus* as probably a synonym for *P. abietinus*.

As stated earlier, some authors state that *Polyporus pargamenus* and *P. abietinus* can be distinguished only on the basis of knowing whether they occur on coniferous or dicotyledonous hosts. Since the writer's observations, as well as those of others, show that the determination as afforded by knowledge of the host cannot always be relied upon for the separation of these two species, it would seem advisable to consider them as biologic forms of the same species if they cannot be distinguished on the basis of their appearance and structure. To my mind, however, it is easily possible to distinguish, at least arbitrarily, between these two closely related plants by their appearance and structure alone.

Overholts (1915) states that *Polyporus pargamenus* and *Polyporus abietinus* are very closely related and that they are connected by intermediate forms to such an extent that it is difficult to refer some collections to their proper species. However, he finds the usual form of the fructification to be distinct enough. It is his experience that *P. abietinus* is usually much the smaller, is frequently effused-reflexed with a narrow and often laterally continuous pileus, rarely more than two cm. in length, and that the tubes often break up into lamellæ-like plates — a condition which, so far as the writer's knowledge extends, has never been observed in *Polyporus pargamenus*. According to the same author that species often grows much larger than *P. abietinus*, sometimes attaining a length of 6–7 cm., and is often fan-shaped or cuneate in outline and attached by a narrow, attenuate, sometimes stem-like base, so that the form and size of the sporophore will usually separate it from *P. abietinus*. Other differences may be pointed out as follows: *P. abietinus* lacks the more or less shining, indistinct, buff, to dark-brown zones which are so characteristic of *P. pargamenus*. The sporophores of the latter plant are sometimes concentrically sulcate but rarely prominently so; those of *P. abietinus*, however, are almost invariably concentrically sulcate and frequently very conspicuously so (Plate IV). The pubescence of the pileus of *P. pargamenus* varies from silky to velvety, while that of *P. abietinus* varies from silky-villous to strigose. The pores of *P. abietinus* are larger, more delicate and shallow than those of *P. pargamenus*. In the latter the mouths of the pores almost always become irpiciform at a very early age — in fact almost as soon as they are formed (Plate I); in the former, however, the poroid configuration of the hymenium usually is retained until maturity (Plate IV). Even then they practically never become irpiciform to the same extent that occurs in *P. pargamenus*. The pores of *P. abietinus* are very thin-walled, usually becoming somewhat radiately-lacerate with age. Both species often have a violaceous or lavender tint to the margin of the hymenium, especially on the margins of young pilei. This peculiar coloration is almost always present in *P. abietinus*, occasionally becoming so pronounced in young specimens that the hymenium is indigo. This coloration may or may not be present in *P. pargamenus*, but when present it is rarely so pronounced as that which commonly occurs in *P. abietinus*. The hymenium of the former plant usually is marked by a prominent sterile margin, except in very old specimens; that of the latter rarely has any sterile margin to speak of. In *P. pargamenus* the freshly growing margin of the pileus is silky at first, while in pilei of *P. abietinus* it is usually more or less strigose from the beginning. The microscopic examination of the two species fails to furnish additional characters for their separation, other than on the occurrence of cystidia. In general it may be stated that in the usual hydnoid form of *P. pargamenus* cystidia are of infrequent occurrence, whereas *P. abietinus* apparently always is characterized by abundant prominent cystidia that are distinctly capitate with minute crystals. The poroid forms of *P. pargamenus*, however, likewise have the same type of cystidia that commonly occur in *P. abietinus*. The spores of both species agree as to their size and shape.

These two species then are to be distinguished definitely only by the combined use of such characters as the form of the pores and the size, shape, and general appearance of the pileus. In most cases they can be separated by their habitat alone. The writer's collecting experience, however, has shown that the latter character is not always enough to separate them. When once the two plants are learned the matter of form and surface characters will usually be sufficient for the identification of the specimens, even if the habitat be unknown.

Morphology of the Sporophore.

Form of the Sporophore.— The sporophores of *Polyporus pargamenus* vary greatly in size and shape, the resupinate forms often covering the whole under side of a log (Plate V). The sporophores, however, usually are pileate. Neuman (1914) states that his largest specimen is about ten cm. wide, five cm. long, and from 2–4 mm. thick. Although the pileus invariably is sessile, the form of the sporophore is variable, depending upon its habitat. When the pilei develop from the base of a tree they usually are narrowly attached by cuneate bases. When the substratum is well above the ground they are more broadly attached. When the sporophores develop from a standing tree or from the upper half of fallen stems they usually become shelving However, upon one occasion entirely resupinate sporophores were found on the standing dead trunk of a black oak (*Quercus velutina* Lam.), while a few pileate sporophores were found on adjacent parts of the same trunk. When the sporophores grow out from the lower sides of fallen stems they invariably are more or less resupinate. Those forming on the under sides of fallen stems become effused over the surface of them and develop into resupinate sporophores when the stems lie immediately upon the ground. If the lower surface of the stem is supported just off the ground the sporophores tend to become more or less pileate in time. Those sporophores which develop between the immediate lower surface and the central peripheral portion of fallen stems are effused at first but the subsequent growth assumes a pileate form.

Development of the Sporophore.—In trees having thin bark with numerous lenticels, such as the yellow birch, the mycelium invariably grows out of the lenticels. The mycelium, after growing out of the lenticels as little white tufts, quickly develops into small nodular masses which, when no larger than 1/16 of an inch broad, begin to differentiate into little pilei each with its hymenial surface developing downward. The development of the pores and production of spores begins at this point and continues until the sporophore has attained maturity.

In other trees having a thicker and fissured bark, such as the oaks or maples, the mycelium develops out of the fissures in the bark, frequently filling them first with a white, felty mass. Certain portions of this felty layer of mycelium develop into small nodular masses which quickly elongate into pilei as previously described. On trees and fallen trunks from which large numbers of sphorophores are developing the whole surface frequently becomes covered with a felty layer of mycelium out of which new sporophores develop from time to time. The young sporophores are shallowly poroid at first but normally the pores become lacerate early. Occasionally mature sporophores are found in which the hymenium has a perfectly poroid configuration even at maturity but such cases are of comparatively rare occurrence.

The poroid form of *Polyporus pargamenus* apparently is confined to species of *Populus* and *Salix*. The writer has made collections of this poroid form on *Populus grandidentata* and *P. tremuloides* in Pennsylvania and New York, and has examined numerous specimens of this form on western species of *Populus*. Recently a specimen of the poroid form on *Salix,* collected at Madison, Wisconsin, came to the writer's attention. Since he had never observed this form of the plant on wood of any other genus than *Populus* he was skeptical of the determination since, from the appearance of the accompanying bark and wood, it may have been either *Populus* or *Salix*. Since the wood of these genera can not be distinguished macroscopically the writer made radial microtome sections to study the structure of the medullary rays which afford the chief distinguishing character, the rays of *Salix* being heterogeneous, whereas those of *Populus* are homogeneous. A microscopic examination of the prepared sections showed that the marginal cells of the rays were upright in contrast to the radially elongated or procumbent cells composing the interior of the rays, thus proving the wood to be *Salix* rather than *Populus*. It is evident, therefore, that the poroid form of *Polyporus pargamenus* occurs on both *Populus* and *Salix,* but apparently is confined to these two genera of the family *Salicaceæ*. The writer wishes to have it distinctly understood, however, that, in addition to the poroid form apparently confined to wood of the genera *Populus* and *Salix*, the typical hydnoid form of *Polyporus pargamenus* is also found occasionally on these hosts.

The poroid forms of *Polyporus pargamenus* found in the eastern and middle western United States depart markedly from the typical form of the plant. The upper surface of the sporophores of these forms varies from light to dark gray, depending on the age of the sporophores. It is zonate but lacks the more or less conspicuous multicolored zones which commonly occur in most specimens of *Polyporus pargamenus,* and is more rigid and hirtose than the usual form of the plant. Like the latter, however, it frequently has violaceous pores, thus indicating the close relationship of these forms. The point of attachment of the poroid forms usually is much broader than that usually seen in *P. pargamenus* and the sporophores frequently spread out over the bark to a considerable extent before shelving out. The sporophores of these poroid forms are also much thicker than those of the usual form of *P. pargamenus*, often being triquetrous in sectional outline. Specimens of the eastern poroid form submitted to Dr. W. A. Murrill were declared to correspond closely with the type of *Polyporus Sartwellii* Berk. and Curt. described from New York, which he studied carefully while at Kew.

In one collection made in Pennsylvania from a dead sapling of *Populus grandidentata* Michx., the majority of the sporophores were exceptionally thick. A close examination showed that the growth of the sporophores had been checked by dessication early in their life, and that they had revived and developed a new hymenial layer which overspread the old one. In most of the sporophores the new growth apparently commenced at the margin of the old pileus and spread over it in all directions, often completely enveloping the old gray pileus in a new mycelial growth (Plate VI). The sections made through these revived pilei presented two definite layers of growth (Plate XII, Fig. 2). The appearance of this section, in view of the two distinct layers of pores, would seem to indicate that this was a perennial sporophore. The two hymenial layers occurred not only in the larger pilei but also in many of the smaller ones, some of which measured less than a quarter of an inch across. While the sectional view of any one of these pilei would seem to indicate that they were perennial, the macroscopic observations on their size, form, color, and rate of growth do not uphold this inference but testify that the occurrence of two hymenial layers in the pilei were merely the result of periodic or seasonal growth. It is therefore evident that the presence of more than one hymenial layer within a pileus does not necessarily indicate that the pileus is perennial, since the two hymenial layers may have been caused by a revival and continuance of the growth of the pileus. In this particular case it does indicate that the pileus is ecologically adapted to living and developing under xerophytic conditions which often are such as to temporarily arrest all growth of the pileus.

Lloyd (1917) recently has commented on a specimen of this poroid form on *Populus* sent him by Dr. J. R. Weir, as follows:

> "NOTE 536.—*Trametes pergamena*, from James R. Weir, Montana. A thick, trametoid form of *Polystictus pergamenus*. The Fresian system of genera for the large fungi is probably the best, but it is embarrassing when species assume forms that place them in two genera. The common *Polystictus pergamenus* of our Eastern States is our only polyporoid (excepting *P. abietinus*) that has violaceous pores. The Western form found on *Populus trichocarpa* by Mr. Weir, is a thick, rigid plant, but in other features context, large violaceous pores, etc., is that same species. It was recently named *Polystictus subchartaceus*."

The poroid form on species of *Populus* throughout the West is extremely variable and at times looks quite distinct from the poroid form on species of this same genus in the East. As a general rule the western specimens are much thicker than the eastern, often becoming a centimeter or more in thickness. The upper surface usually is hirtose-tomentose and is marked by more or less distinct, often heterogeneously colored, sulcations which are indicative of the periodic increment made by the pileus during its development. The pores, which are at first thick-walled, become thinner-walled and more or less lacerate with age. A part of the western material examined agrees closely in its macroscopic characters with *Coriolus subchartaceus* Murrill, as evidenced by its comparison with a portion of the type collection of this plant which was kindly furnished the writer by Dr. Murrill. The most striking disagreement was in the absence, in the writer's material, of the shrunken blackish margin present in the authentic material. As a matter of fact this shrunken, blackish margin present in the type specimen was undoubtedly caused by the collection of the specimen before the marginal portion had fully matured. The writer therefore considers that, since the blackening of the margin when bruised is not a constant character, its mention as a general occurrence does not fortify the description but is misleading. With this character thrown out of consideration a portion of the material at the writer's disposal agreed fully with the portion of the type specimen of *Coriolus subchartaceus*. Still other specimens at the writer's disposal, however, departed markedly from the type material of *C. subchartaceus* in that the pilei were laterally elongated and effused, and almost equilaterally triquetrous in sectional outline. At the rear of these pilei the tubes were more or less thin-walled and lacerate, and attained a length of five mm., becoming progressively shorter toward the margin where they remained thick-walled and entire.

The writer has collected similar laterally elongate, triquetrous, thick-walled, poroid forms of *Lenzites sepiaria* on fallen trunks of lodgepole pine in Montana, and has come to regard such extreme forms as the ecological growth form of these plants in response to xerophytic conditions.

While the poroid form, including its many varieties departs markedly in many respects from the typical hydnoid *Polyporus pargamenus*, it still bears considerable resemblance to it. The hymenial elements are very similar in both forms. In the various poroid forms studied, however, cystidia predominatingly capitate with minute crystals (Fig. 1, p. 50) as described by Overholts (1915), were invariably present; similar cystidia also occur in the typical hydnoid forms of *Polyporus pargamenus*, but usually less abundantly than in the poroid forms.

The usual type of the poroid form of *Polyporus pargamenus* has sufficient morphological characters in common with the well-established hydnoid form of *P. pargamenus* that it has been included with it by practically all mycologists who have worked with it. Moreover the macroscopic characters of the decayed wood are the same in both cases. On the other hand, the differences between these two forms are vastly more pronounced than those between a number of our other closely related accepted species and the poroid form could rightfully be set aside as a distinct species as has been done in the past, although it seems useless to multiply species. In fact Murrill (1907, p. 24) has described one of the more aberrant western varieties of the poroid form as a distinct species, *Coriolus subchartaceus*. It should not be correct, however, to refer one extreme type of a particular plant to a distinct species and at the same time not have it include all other closely related types of what obviously is the same plant, namely the thinner poroid forms

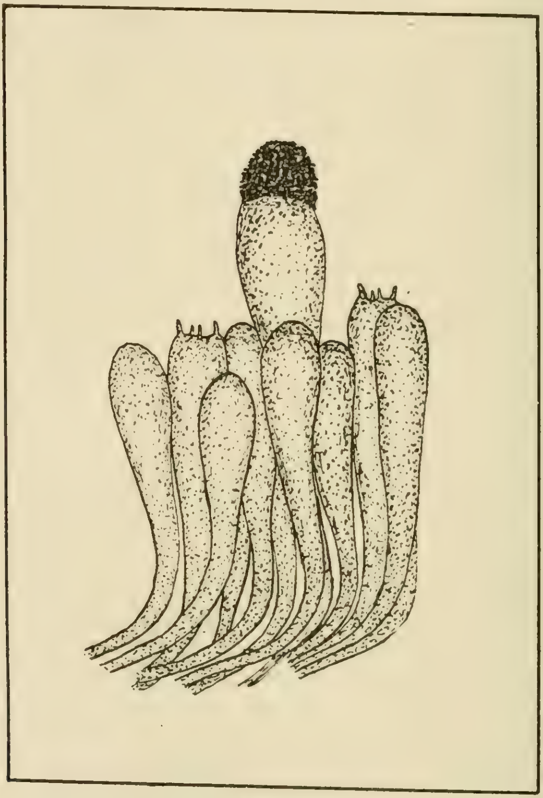

FIG. 1.

Capitate cystidium and basidia of poroid form of *Polyporus pargamenus*, X 2,500.

occurring in the eastern and western United States. In view of the great array of intergrading varieties of this poroid form, the exact status of this form was doubtful in the mind of the writer.[12] Accordingly a number of specimens of the above-mentioned forms were submitted to Mr. C. G. Lloyd, who regards them all as forms of the one species. In Mr. Lloyd's opinion there is nothing in the more obvious variations of the plant nor in the microscopic structure to justify trying to maintain different species where there are so many connecting forms.

Just whether the extremely variable poroid form of *Polyporus pargamenus* is an ecological adaptation, a racial form, or a distinct species, the writer would not like to state in the complete absence of any cross inoculation data. At any rate, among the hundreds of specimens examined by him during the course of this study, few intergradations occur between the poroid form on species of *Populus* and *Salix*, and the typical hydnoid form on the woods of these and other genera. In his opinion the ultimate criterion for making the poroid form a distinct species would be afforded only by the making of cross inoculations. Pure cultures of the poroid form on species of *Populus* and *Salix* should be obtained and inoculated on other species of dicotyledonous woods. At the same time the typical hydnoid form of *Polyporus pargamenus* occurring on these and other species of trees should be inoculated on species of *Populus* and *Salix* and the resulting sporophores compared. The results obtained should show whether this poroid form is a distinct species that may be inoculated and reisolated from various species of trees other than species of *Populus* and *Salix*, or whether it is a biological form aberrant from the type of *Polyporus pargamenus* and arising as a result of some peculiarity of the wood of the species of these two genera that serve as hosts. Furthermore, such an experiment, when conducted under controlled conditions, should determine the

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[12] In some of the herbaria examined many of the specimens classified under *Polyporus* (*Coriolus*) *subchartaceus* are merely imperfectly developed or old weathered specimens of *Polyporus hirsutus* on *Populus*.

susceptibility of the sporophores to variation induced by various ecological factors.[13]

In the absence of any cross inoculation data, it has been regarded best for the present to include the poroid forms, including both the thick western plant with long tubes on species of *Populus* that has been called *Polyporus* (*Coriolus*) *subchartaceus* by Murrill (1907, p. 24) and the thinner plant with shorter tubes occurring on the wood of *Populus* and *Salix* both in the eastern and western United States under *Polyporus pargamenus.*

The sporophores of *Polyporus pargamenus* grow through only a limited period. When drought or cold weather intervenes, growth is interrupted. However, this and similar tough forms of leathery consistency are able to withstand severe conditions and continue growth after such interruptions so that they are perennial in the sense that they grow from year to year. Growth of the sporophore in this and similar thin, leathery forms is limited mainly to the marginal hyphae and ordinarily the pileus does not increase in thickness. The areas representing the increase in the width of the pileus during the different periods of growth usually are demarked by more or less distinct sulcations. Upon a plentiful supply of moisture, after periods of long drought, the pilei frequently renew growth for a time. The result is that one frequently finds specimens that are concentrically sulcate with a broad, bright-colored margin which is in strong contrast to the dark-gray color of the older growth. Each portion of growth does not represent annual growth, but does represent periodic growth which took place between periods of drought. This and similar species are said to be annuals in that they do not form more than one layer of pores although exceptions occur occasionally. Growth, however, may begin at any month of the year so long as conditions favorable to growth occur, and continues even during the winter months at intervals when the sporophores are not frozen.

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[13] Such an experiment would take at least two, and probably more, years' work to complete. For this reason it has not been attempted in the present investigation.

Consistency of the Sporophore.— In the growing margin of the pileus the hyphæ, whatever may have been their earlier arrangement, usually are parallel to one another, little interwoven, and extend in the direction of growth. As the pileus matures they become variously interwoven and modified. In this as well as other coriaceous species the pileus is quite thin and usually fibrous and flexible. Microscopic examination of a pileus of *Polyporus pargamenus* showed that it consists of a mass of branching, sparingly septate hyphæ extending singly or in loose strands parallel to the surface. These hyphæ or strands of hyphæ are but little interwoven and form a tissue homogeneous throughout the pileus. At the upper horizontal surface many hyphæ grow upward and terminate as the hairs of the pileus. Other hyphæ grow vertically downwards and form the trama of the tubes. At maturity the ends of these hyphæ bend outward at right angles and form the elements of the hymenium (Plate VII).

Size of the Hyphæ.— Measurements were made of hyphæ in different portions of the pileus. In different plants of this species the size of the hyphæ is fairly constant, although there may be a slight difference between their size in the different portions of the same pileus. The hyphæ are stouter in the context of the pileus and become smaller in the trama of the pores. Even within the context of the pileus the size of the hyphæ is extremely variable, but they average from 3–4 μ in thickness. The larger hyphæ are very thick-walled and have small lumina. Clamp connections and cross-walls occur but rarely, especially in the larger hyphæ, and then usually are indistinct. In general the size of the hyphæ is of little diagnostic value since there is so small a range of variation in the different species.

Surface Modifications.— The upper surface of the pileus of *Polyporus pargamenus* not only remains incapable of further growth but has a completely undifferentiated surface. The upper surface is composed only of the unmodified terminations of the hyphæ of the context, which end at the surface singly or in loose strands. The upward extending surface hyphæ become a part of the pileus tissue as growth proceeds and do not differ materially from the hyphæ of the context. The outer hyphæ terminating in many loose ends often give a villous appearance to the surface. Not infrequently minute particles of dirt, bacteria, and occasional spores of other fungi are to be seen among these loosely interwoven ends of the surface hyphæ. Such foreign matter is readily apparent in stained microtome sections. In this and similar forms where no surface growth occurs the exposed hyphæ become darker than those in the tissues below, and, as they become dry, become somewhat appressed. There is no change, however, in the hyphæ themselves or in their arrangement (Plate XII, Fig. 2).

The surface generally is marked by several more or less distinct sulcations. Bayliss (1908), in experiments on *Polystictus versicolor* (L.) Fr., has shown that this sulcation of the pileus is due to an alternate checking and promotion of growth caused by changes in the amount of moisture which, in turn, is dependent upon varying atmospheric conditions. Where pilei were allowed to develop under uniform temperature and moisture conditions hardly any signs of zoning could be observed and the velvety surface, instead of having the usual ribbed appearance, was quite even. The mere changing of conditions of growth so as to secure a drier atmosphere was sufficient to cause a check in the growth and hence a marked zone in the pileus.

The writer observed the natural growth of *Polyporus pargamenus* in the field, making measurements at regular intervals. After a period of drought, during which growth was almost if not entirely arrested, a distinct furrow or zone marked the end of the old zone and the beginning of the new. When the period of drought had been prolonged for a week or more the division line could be seen, in a vertical, radial section through the pileus, extending down to the hymenial surface. When atmospheric conditions were unfavorable to growth the short hairs forming the velvety surface were little or not at all developed. The concentric sulcations appearing commonly on pilei are indicative of the alternation of decidedly wet and dry periods of growth. The faint zoning which always is present on this and similar rapidly growing, thin pilei are indicative of minor changes in the humidity of the air — in many cases doubtlessly they are due to the check in growth resulting from the fall in temperature which takes place during the night. This is especially apt to be true where we have a succession of cold nights and warm days.

Pilei frequently are found that are exceedingly thin and papery, these being pale-colored with scanty pubescence. On the surfaces of these pilei the zones of growth and bands of color show up very strikingly. In some instances the whole surfaces are shining and have a silky appearance. In general, however, the pilei are much thicker and darker colored; also villous or velvety. Such pilei usually assume a dark-gray or grayish-brown coloration with age and the zones of growth and bands of color are very inconspicuous after the pilei have weathered for a time. Not infrequently one finds both combinations within the same pileus. In this case the grayish, weathered part represents the original growth while recent growth is shown by the lighter colored area that has grown out from the old, dark-colored one, possibly some months after the cessation of growth by the older part.

The biological significance of the velvety hairs which occur on the upper surfaces of the pilei of many species of fungi is a matter of doubt. According to Buller (1909, p. 113) they form a capillary system for the purpose of rapidly disseminating any drops of water which may fall on the pileus. This explanation, while unsubstantiated, at least seems plausible for a drop of water let fall on the dry pileus is absorbed almost instantly by conspicuously hirsute pilei such as *Polyporus abietinus* Fr. and *Polyporus hirsutus* Fr. In more glabrous pilei, for example in sparingly pubescent pilei of *Polyporus pargamenus,* the absorption of water dropped on the surface was much slower. In addition to this the pubescence may be of the same use as is that of many xerophytic plants. It is generally accepted that the hairs on the leaves of xerophytic plants serve to reduce materially the transpiration. It is therefore reasonable to suppose that the hairy covering protects the sporophores of fungi from rapid dessication. In support of this it may be mentioned that a pileus stripped of its hairy surface dries up far more rapidly than it otherwise would do.

The surface modifications are almost the only differentiations that the tissues of the sporophore undergo. Consequently they should be considered as important characters in any arrangement of the plants on a structural basis.

The Hymenophore.— From a taxonomic point of view the hymenophore is an important part of the fruit body since its poroid character separates the family *Polyporaceæ* from all related families excepting the *Boletaceæ*. The boletes, however, differ from the polypores chiefly in that they are mostly centrally stipitate plants of fleshy consistency and a terrestrial habit, in which the tubes can be separated readily from the pileus in most species. All plants belonging to the *Polyporaceæ,* with few exceptions, have the poroid configuration of the hymenophore — at least in early youth. In *Polyporus pargamenus*, however, which is poroid at first, the dissepiments generally become torn into teeth or lacerate plates soon after the formation of the pores, so that older specimens might easily be mistaken for one of the *Hydnaceæ*.

Development of the Pores.— In *Polyporus pargamenus* the pores are evolved successively from the center or point of attachment outward and are open from the beginning as is the case with the majority of polypores. Such pores are said to be formed exogenously. In the case under consideration they arise directly from a layer of hyphæ differentiated from the trama. A section through the growing margin shows the early stages of pore formation. On the lower side of this portion of the pileus the hyphæ are more closely interwoven and smaller and instead of the hyphæ extending parallel with the surface they are arranged obliquely. In section a few hyphæ can be seen that grow more rapidly than adjacent hyphæ and extend downward at right angles to those of the surface. These rapidly growing hyphæ extend over the lower surface of the young pileus in the form of a net, the regions in which the hyphæ do not grow corresponding to the meshes and forming the future pores. Basidia begin to appear when the pore cavities are quite shallow. They are formed by some of the hyphæ growing outward at right angles and englarging at the free ends. Consequently the pores at the margin are often immature when those at the rear of the pileus are fully developed. Examination of sections of the sporophores shows that the bases of the pores all lie in the same plane.

Relation of the Hymenophore to the Pileus.— In *Polyporus pargamenus* the hyphæ of the context extend parallel to the surface. When the pores are formed some of the hyphæ or their branches extend obliquely downward, and, turning gradually, soon grow at right angles to the hyphæ of the context. Thus the course taken by the hyphæ of the context extends at right angles to that taken by the hyphæ of the hymenophore. The trama of the pores is no denser than that of the pileus. The hyphæ are slightly finer but then they are not so old as those in the context of the pileus.

The arrangement of the hyphæ in the context of the pileus must determine to a large extent their arrangement in the hymenophore. At least a certain number of the hyphæ must extend in the direction of growth. If, therefore, the hyphæ in the context of the pileus are parallel to the surface as they descend into the hymenophore, they must change their direction to that of the pores which are vertically opposed to the pileus.

The Pore Walls.— Associated with the thickness of the pore partitions or dissepiments are modifications of the edges of the pore openings such as dentations and lacerations. In *Polyporus pargamenus* the pore-walls are very thin. At an early age they become irregularly lacerated and when the slits progress to the base of the cavities the segments appear as hydnoid processes. Such plants can be mistaken easily for *Hydnum ochraceum* Quél., especially when the walls are thus broken up in the young stages of the sporophore, as is often the case with *Polyporus pargamenus.*

Color.— The color of the pilei of *Polyporus pargamenus* varies greatly in different sporophores, the variation apparently being influenced by the host as well as by other external factors. For example, the writer has noticed and is corroborated in his observation by the experience of Mr. C. G. Lloyd who states that he finds that the most intensely colored sporophores occur on wild cherry. In color there may be all gradations from white, at the beginning of the appearance of the fruit bodies, or in the case of their growth in the absence of light, to gray or brownish-gray with age and weathering. The context of the pilei is uniformly white but usually becomes somewhat discolored with age. In fresh growing specimens the hymenial surface is frequently tinted violaceous, sometimes very strikingly so. This peculiar coloration, however, usually is a transient one.

Either coincident with or within the individual zones of growth there are a number of variously colored zones of all color gradation from buff to brown. While these colored bands are prominent they usually are not so striking as those exhibited by *Polyporus versicolor* (L.) Fries. This color, which to some extent intensifies the zoning, is largely dependent upon the light. Bayliss (1908) has shown that the coloration in *Polyporus* (*Polystictus*) *versicolor* is due to the presence of a diffuse-yellowish pigment, which, on exposure to light, gradually changes into sepia brown granules. When the sporophore first makes its appearance it is always white as is also any new growth which takes place at the margin of the pileus. In *Polyporus versicolor* Bayliss found that after three or four days a pigment is developed in the hairs which cover the upper part of the sporophore, and also in the surface of strands of hyphæ from which these hairs arise. According to the same author these pigment granules cause the hairs and superficial hyphæ to vary from buff to dark brown, according to the intensity of the light. Sporophores of *Polyporus versicolor* grown by her in the diffused light of the laboratory, under constant conditions of temperature and moisture, were a uniform pale buff color; only rarely was a zone emphasized by a slight deepening of color. The writer has observed frequently that sporophores of *Polyporus pargamenus*, as well as its near relative, *Polyporus versicolor*, that develop out-of-doors on the lower shaded side of a large log for example, or when shaded by other means, invariably have pale buff upper surfaces. In such a case, however, the zonation of the pileus usually is well marked since the variable atmospheric conditions are responded to by variations in the growth of the hairs. The same sporophores, when they are exposed to a greater intensity of light, develop quite normally and the buff color soon changes to a darker brown shade. If growth is checked rather quickly the margin of the last zone of growth, owing to a deficiency in the formation of pigment, is marked by a lighter band. Therefore the pilei formed in summer, when periods of drought are more frequent and growth is arrested suddenly, generally have many brown bands marking these periods. It is only the fairly young zones of a pileus that show these conspicuous colored bands, for ultimately the whole surface assumes the same dark color, thereby obscuring the bands of color. The zonate appearance visible then is due mainly to the differences in texture presented by the velvety ridges and satiny furrows which become even more conspicuous when the pileus, on becoming quite dry, has the well-known gray appearance. A pale buff-colored pileus, when once detached from its host and allowed to dry for some time is incapable of developing the darker pigment when exposed again to ordinary atmospheric conditions.

The Elements of the Hymenium.—The hymenium of *Polyporus pargamenus* apparently consists of but three distinct structures (Plate VII), viz.: (a) colorless basidia, usually with four sterigmata and spores, (b) blunt cystidia capitate at the apex with an incrustation of mineral matter, and (c) a basidium-like element which is asterigmate, usually shorter, and less enlarged at the tip. The latter element corresponds to what has been termed paraphyses in the Hymenomycetes. According to Curtis (1914) the so-called paraphyses of the Agaricales are nothing more than potential basidia and continue to develop as such during the life of the fungus. It is more reasonable to regard these organs as potential basidia than as inert structures which serve only as reinforcing or spacial agents, as some have viewed them. Owing to the leathery nature of such a fungus as *Polyporus pargamenus* the necessity for special agents or reinforcing structures is precluded. These organs, under favorable conditions, undoubtedly are capable of developing into mature, spore-producing basidia. This view is supported by reason of the fact that spore formation continues for a long period, and careful examination of sporophores of various ages has shown that the spores produced by a basidium mature at approximately the same time. The spores, however, are shed intermittently over long periods, and from this fact it follows that the basidia probably develop successively during moist periods, a circumstance which would account for the continued spore formation. The examination of sections of sporophores developed in a moist chamber likewise gives evidence that the basidia mature successively. This view is further supported by the fact that sporophores sometimes revive and produce a new hymenium the second year due to accelerated growth of certain hyphæ in the hymenial layer.

The basidia are more or less regularly disposed throughout the hymenium. On the enlarged end of each basidium are four minute spine-like sterigmata, each of which bears a basidiospore. Scattered irregularly among the basidia there sometimes occur conspicuous, blunt cystidia usually capitate with an incrustation of mineral matter.

Cystidia may be defined as the more or less conspicuous sterile organs found either in the hymenium or in the subhymenial tissue of various basidiomycetous fungi. They are the modified ends of some of the tramal hyphæ which extend into the hymenial layer and usually project beyond the layer of basidia with their spores. As Overholts (1915, pp. 684–685) states, in *Polyporus pargamenus* the presence of cystidia is a variable character, and that they are abundant in some specimens but very scarce in others. In such cases he recommends the making of longitudinal sections of the tubes as the cystidia are sometimes more abundant in one part of the tubes than another.

The cystidia resemble the basidia in shape but are considerably larger and longer, sometimes reaching a length of twenty microns and a breadth of six microns, as stated by Overholts (1915, p. 685). They are further characterized by being distinctly capitate — probably with minute crystals of calcium oxalate — although no crystalline structure is visible even under the highest power of the microscope (Fig. 1). These colorless cystidia are rendered very conspicuous by reason of their capitate tips. Sometimes they scarcely extend beyond the basidia, although they usually project sufficiently far that one can distinguish them readily with the low power of the microscope. In the sections examined none of the cystidia projected more than ten microns beyond the sterigmata of the basidia.

Spore Characters.— The sporphores of *Polyporus pargamenus* were found to begin the production of spores even before they measured as much as 1 cm. in either dimension, and to continue to shed viable spores intermittently until old age. When a fresh sporophore is placed on a glass slide or paper the falling spores rapidly accumulate and a plentiful supply is obtained within a few hours. The spores may be seen to best advantage macroscopically on black paper, where the numerous little white heaps look like an imprint of the hymenial surface of the sporophore. Owing to their pronounced adhesiveness they adhere to one another and to any surface with which they come into contact with considerable tenacity. Spore-deposits, therefore, cannot be shaken off paper or glass upon which they have collected. In fact they adhere so tenaciously that, when shed upon glass and dried, they can be scraped off as ribbons 4 or 5 mm. long.

The rate of accumulation of a spore-deposit is dependent upon several factors — for example, age of the pileus, amount of moisture present and the rate of dessication, temperature, etc. By moving a pileus from one place to another every hour and thus securing successive spore prints, one may be convinced readily of the continuity and regularity of the spore discharge. Spores which have just been liberated always have a fresh and turgid appearance and even liberated spores of long standing quickly acquire it upon being placed in water for a few minutes.

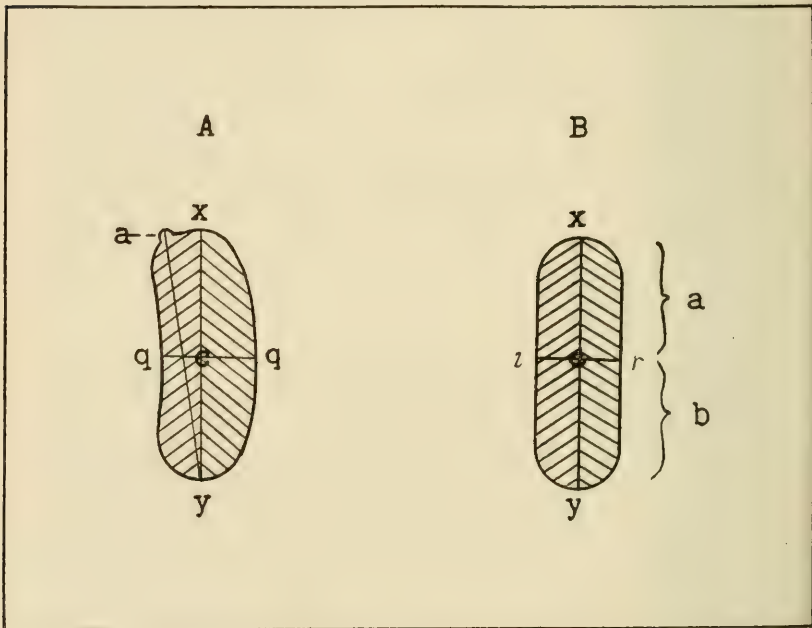

Fig. 2.

Basidiospores of *Polyporus pargamenus* shown in longitudinal section, X 5,000. A. Dorsiventral section, the spore being in lateral position.— *a*, apiculus; *y*, apex; *c*, geometrical center; *ay*, organic axis; *xy*, geometrical axis; *qq*, organic section; , ventral spore-half; , dorsal spore-half. B. Bilateral section, the spore-half being in ventral position.— *a*, apical spore-half; *b*, basal spore-half; *c*, geometrical center; *xy*, geometrical axis; , left lateral spore-half; , right lateral spore-half. This section represents the only symmetry plane possessed by the spore.

Microscopic examination shows each spore to be a colorless, unicellular body measuring 5–6.5 microns long by 2–2.25 microns broad, the protoplasmic contents of which are homogeneous and usually devoid of vacuoles. In the spores of *Polyporus pargamenus* we distinguish first a base (Fig. 2, A), the point at which the spores are attached to the sterigmata and at which their abcission occurs at maturity.[14] The organic center of the base is the apiculus (a), which is usually situated excentrically and as a general rule does not coincide with the geometric center (x). The organic center of the top is the apex (y), which coincides with the geometric center. The line (ay) which joins the apiculus with the apex is the organic spore-axis. The line (xy) which joins the geometric center of the base with the apex is the geometric spore-axis. The symmetry plane (qq) running transversely through the spore at the central point (c) of the geometric axis is to be regarded as the spore cross-section.

As seen from the base and apex, every basidiospore is oriented in a definite manner, and we distinguish therefore four surfaces: a dorsal and a ventral side as well as a right and left lateral surface. The spores on their basidia are directed with their dorsal surfaces toward the outside and with their ventral surfaces toward the inside, while they limit one another laterally with a side surface. The dorsal and ventral sides are divisible into two symmetrical surfaces by a basipetally running symmetry line (Fig. 2, B) (xy). The plane formed by the union of the dorsal and ventral sides is the bilateral symmetry plane which divides the spore accordingly into two symmetrical halves, a left lateral (l) and a right lateral (r) part. This is the only symmetry plane always possessed by each basidiospore.

A plane running through the geometric center at right angles to the bilateral section between the dorsal and ventral sides, the dorsiventral section (Fig. 2, A) (xy), divides the spore into a dorsal and a ventral spore half which are never

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[14] The form of the geometrical description of the basidiospores is based upon that given by Falck (1909, pp. 76–79) for the spores of species of Lenzites.

perfectly symmetrical. If we see the basidiospore from the dorsal or ventral sides (Fig. 2, B) in the outline of the dorsiventral section we denote its position and its cross-diameter as dorsiventral (either dorsal or ventral); on the contrary, if the side surface is turned to us we see it in the contour of the bilateral section (A) and we denote its position as lateral (either left or right).

The spore cross-section lying at right angles to the bilateral and dorsiventral section (B, lr) divides the spore into two more or less unequal halves, a basal half (a) with the apiculus and an apical half (b). If these two halves as seen from the apiculus and the apex (also observed from the dorsal side) are shaped alike or approximately alike we denote the basidiospore as being basally equally halved, in other cases as basally unequally halved. If we see the spore from above or below in the outline of the cross-section we denote these positions respectively as the apical and basal views and the diameter of the cross-section as the basipetal diameter. These symmetry proportions, which correspond with the definite spacial orientation of each individual spore, are possessed by the spores of all Basidiomycetes.

In the microscopic examination the spores of *Polyporus pargamenus* appear according to their positions in a given view. In general we see them in the lateral view with the contour of the bilateral plane (Fig. 3, l and r). In this sidewise position the spores have the form of a small kidney. We distinguish accordingly a convex dorsal side and a concave ventral side. According to the position of the apiculus we can distinguish a left (l) and a right (r) lateral position. Moreover, the various lateral deviations from the sidewise position are to be judged according to the orientation of the apiculus.

In both the dorsal and ventral positions we see the spores in the contour of the dorsiventral section as symmetrically formed, straight rods with both ends rounded (Fig. 3, v and d). By vertical orientation of the spore with the apiculus above we may determine whether the dorsal side lies toward one. The more the spore is shifted from the dorsal or ventral side to the lateral position, just so much the more does it approach the exact symmetry of the allantoid form, while the apiculus changes again to the lateral position.

The transverse diameter of the spore remains approximately the same in the different changes of the indicated positions; at least no noticeable differences could be detected with the measuring devices at my disposal. Therefore it may be inferred that the cross-section (basipetal view) must exhibit an approximately circular contour, which can be corroborated by direct microscopic examination from above or below (Fig. 3, q).

The spores consequently are basipetally bilateral in transverse section; in longitudinal section they are bilaterally symmetrical dorsiventrally and strongly unequally halved laterally. They appear colorless by transmitted light and white by reflected light.

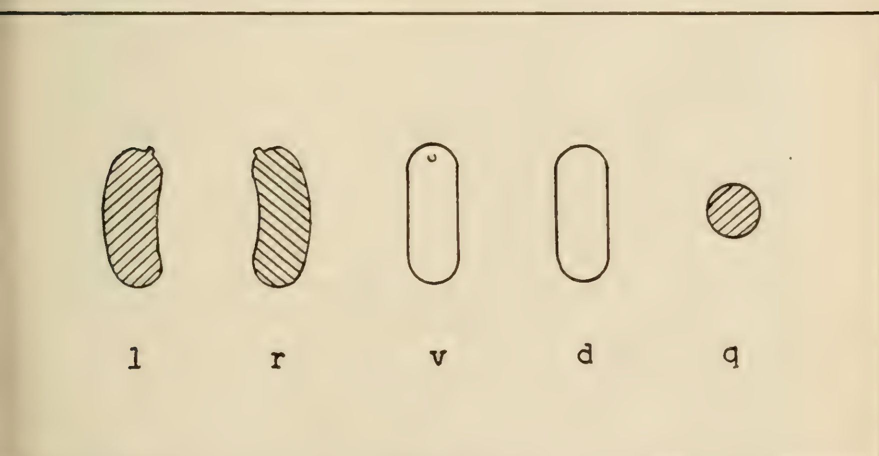

FIG. 3.

Basidiospores of *Polyporus pargamenus* in different positions, X 3,000. *l*, left lateral ew, the apiculus lying to the right side; *r*, right lateral view, the apiculus lying to the ft side; *v*, ventral view, the apiculus lying in the symmetry plane; *d*, dorsal view, the piculus not being visible in this view; *q*, transverse section at the central elevation.

Germination of the Spores.

Methods.— Spores were obtained in most cases from sporophores (dessicated or otherwise) gathered as needed from a nearby tree. The sporophores on this particular tree remained in a state of dessication throughout the winter, so that spores could be obtained whenever needed. In some instances dessicated sporophores were stored in the laboratory and revived at will by soaking in sterile distilled water, after which they were placed in sterile petri dishes. In this way the spore prints were obtained on sterile glass plates. The germination tests were made in the usual way in van Tieghem cells, using various nutrient media. All cultures were made in the laboratory at ordinary room temperatures. It was found that germination of the spores took place readily in any medium that was reasonably suitable for fungous growth. As a general rule a few spores invariably germinated after eighteen hours' time. Occasionally a few spores germinated as early as sixteen hours after their introduction into the hanging drop culture. In general, at the end of twenty-four hours the majority of the spores were germinated. Temperature seemed to be the main factor governing the time required for germination. The presence or absence of light made no perceptible difference in the length of time required for germination. The effect of direct sunlight, however, which Buller (1909) showed to retard the germination of spores of *Schizophyllum commune* Fr., was not tried. The use of different culture media did not have any marked effect upon the interval of time between the introduction of the spores into the hanging drop and the first signs of germination. The percentage and regularity of germination, however, was directly proportional to the suitability of the culture medium used. The germination of the spores, of course, was studied in the more favorable culture media.

Description of Germination.— Germination was found to occur generally, although by no means always, at the apiculate end of the spore. Almost always a single germ tube is put out at one end of the spore and very shortly after this another one is put out from the other end. Occasionally germ tubes are put out simultaneously from both ends, but in general one seems to precede the other. In some instances, however, the one germ tube makes considerable growth before the spore puts out one from the other end. Germination from the side of the spore is of rare occurrence.

No instances were observed in which more than two germ tubes were put forth from a single spore. The spores were not observed to become vacuolate before germination, although spores which failed to germinate became 2-vacuolate and more or less distorted after lying in the hanging drop culture for a few days. After several days they were found to have collapsed. Even after several weeks the collapsed spores could be clearly detected in the drop. Before putting forth germ tubes the spores swelled up to less than twice their original size. The germ tubes are nearly as wide as the spores and germination seems to be merely a gradually tapering prolongation of the spore wall. After a few days' growth it was usually impossible to distinguish the position of the original spore wall in the mycelium. In many instances, especially in slowly growing plants, small globular inflations or cysts were noticed on the mycelium, some being lateral and others terminal (Plate VIII, h; and Plate IX, 2, 3, 4, and 5). These local enlargements of the hyphæ evidently were peculiar to this particular fungus for they were observed to occur after forty hours' growth in a number of hanging drop cultures in practically every medium used in which germination was secured. No such abnormality, however, could be detected in any of the numerous cultures made on solid media.

It was clearly evident that these peculiar cyst-like bodies were not reproductive bodies. It is the writer's opinion that they occur solely as a result of the physiological response of the mycelium to the excessively unnatural conditions of the nutrient medium for its growth. The mycelium invariably developed large numbers of these globular enlargements in the younger stages of its growth, but ceased to develop them and became more regular and constant in its growth as it grew older. Such a physiological response of the mycelium is not phenomenal, since the mycelium of the fungi in general must necessarily be very plastic and susceptible to response in order to more nearly bring it into harmony with the extremely varied conditions under which it must grow.

In those hanging drop cultures in which the growth of the mycelium seemed to have come to a standstill, due probably to lack of sufficient nutriment for further growth, it was noticed that the mycelium invariably became strongly vacuolate. In hanging drop cultures of basidiospores grown in sugar-wood decoction it was observed that the mycelium, after two weeks' growth, began to break up into oidia.

The germ tubes develop rapidly into an extensive primary mycelium characterized by the total absence of clamp connections and the rare occurrence of cross-walls. In thriving cultures the mycelium branches profusely soon after the germination of the spore. After five or six days[15] the hyphæ of the primary mycelium give off branches which differ from those of the primary mycelium in that they possess abundant clamp connections and cross-walls. These hyphæ constitute the secondary or mature mycelium which at first grows intermingled with the primary mycelium and sometimes anastomoses with it. The latter, however, soon loses its contents and disappears from the culture. This change in the mycelium occurs regularly in all cultures, both those in hanging drops and those on agar plates, and apparently is not influenced by the nature of the culture medium or by other external conditions.

The germination of the spores and the method of growth of the mycelium is illustrated by camera lucida drawings on Plates VIII and IX. In connection with each of these plates the age of each germinated spore is indicated approximately. The size attained by the mycelium varies greatly according to the suitability of the culture medium used and the conditions for growth. In general the drawings represent the

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[15] Usually longer in hanging drop cultures.

maximum growth obtained in the indicated time with the best media used.

Culture Media Used and Results Obtained.— Spores germinated as quickly in both distilled and tap water as they did in the nutrient media used. Germination in distilled or tap water was by no means so abundant and the growth of the mycelium was by no means so great as was obtained by the use of suitable nutrient media. It was surprising to find that one spore germinated in distilled water attained a length of 315 microns. Its subsequent growth, however, was not followed farther. The spores, whenever tried, exhibited more or less germination in distilled water. It is evident that an external food supply is not necessary for germination of the spores of this species, although it greatly accelerates the power of germination and serves to sustain subsequent growth.

A good culture medium for the germination of spores in hanging drop cultures was made up as follows: Finely divided basswood (any other dicotyledonous wood may be substituted) to the extent of 15 gms. was boiled in tap water, the extract filtered, and water added until it measured 200 cc. To this filtered extract was added 200 cc. of a 2 per cent solution of cane sugar and the resulting mixture was tubed in small quantities and sterilized. An even better culture medium consisted of a 3 to 5 per cent solution of Merck's malt extract.

A number of germination experiments were performed, using many unusual substances largely out of curiosity to see how resistant the spores would be to adverse conditions. It has been reported frequently that the germination of spores was stimulated by slight quantities of ether or alcohol, but such did not prove to be the case with spores of *Polyporus pargamenus*.

Germination in a 0.5 per cent solution of ether was greatly retarded and only rarely was it observed even after eighteen hours. The mycelium from the few spores that germinated apparently grew well for about two days, but soon became extremely vacuolate and formed numerous globose swellings. Ungerminated spores usually became 2-vacuolate. Germination in 0.5 per cent ethyl alcohol was greatly retarded — even more so than by the use of ether — and confined entirely to a few spores. Subsequent growth and behavior of the mycelium was the same as described for the use of ether. Germination in a 0.5 per cent solution of dipotassium phosphate was retarded to about the same extent as by alcohol, but occasional germination was to be seen. The growth of the mycelium was poor and highly irregular. After the escape of the protoplasm from the spore, through the germ tubes, it was noticed in a few instances that a cross wall was formed through the center of each spore. Spores germinated and grew vigorously in a 0.5 per cent solution of sodium chloride (Plate X). No germination could be observed in the following solutions: 0.5 per cent potassium nitrate, 1.0 per cent tartaric acid, 1.0 per cent ammonium phosphate, 1.0 per cent sodium carbonate, and 1.0 per cent citric acid.

Vitality of Dessicated Spores.—A plentiful supply of spores was shed on waxed paper and the paper was folded up and filed away in a desk on November 8, 1915. It was found that these spores germinated readily after being kept in this condition for two weeks and it seemed desirable to obtain data on the duration of vitality of dessicated spores. As a result of germination tests made at various intervals from these spores, using hanging drops containing a 5 per cent solution of Merck's malt extract, they were found to germinate as readily at the end of six months as when first shed. The growth of the mycelium, however, was very rapid and profuse branching occurred. The spores were again tested at intervals and were found to germinate readily at the end of ten months. Further tests were not made until twelve months had elapsed since the spores were shed. At this time several tests for germination all resulted in failure. The dessicated spores swelled up in the nutrient solution as they had done before, but not a single case of germination was observed.

It is remarkable that such minutely microscopic plant structures as these fungous spores should retain their vitality, germinate, and develop into infectious plants after being kept for ten months in the state of extreme dessication afforded by their storage in a warm room. That these results are not out of accord with the vitality of the spores of other wood-destroying fungi are shown by the experiments of Falck. Falck (1909) succeeded in germinating spores of species of *Lenzites*, some of which had been preserved in a state of dessication on glass slides for one year and nine months. He found that in general the spores of *Lenzites* species retained their vitality longest when they were collected in thick layers on dry glass slides and carefully preserved dry. When the spores became wet by the moisture expelled from the fruit-bodies in the process of shedding, Falck found that they stuck together and died in a proportionately shorter time. If the waxed paper containing the shed spores of *Polyporus pargamenus* had been stored in some cool place or out of doors it is quite likely that they would have retained their vitality for a considerably longer period than when stored in a warm room. Under natural conditions it stands to reason that the shed spores may be blown hither and thither for weeks and months without losing their vitality. As a result of their ability to retain their vitality after being subjected to dessication for long periods, their chances for becoming lodged in favorable situations are greatly enhanced.

Characteristics of the Mycelium in Pure Cultures.

Culture Methods.—The basidiospore was employed as the source for most of the cultures used in the present investigation. Owing to the thin leathery nature of the sporophores, they are not well adapted to the making of pure cultures by the tissue method. Furthermore, in securing pure cultures from very thin, leathery sporophores one is almost obliged to use the spore method since it is usually very difficult to obtain pieces of uncontaminated tissue from such thin sporophores. In addition it was found to be very difficult to transfer bits of rotten wood to agar plates and secure a continuation of the growth of the mycelium, since under the increased moisture content of the new environment the mycelium usually became sodden and died. Without regard for the ease with which pure cultures can be obtained from basidiospores, the basidiospore was regarded as the most logical point to begin the culture study, since the possibility of error would be less than if the culture was obtained in some other way, and it was thought that the young mycelium arising from the basidiospore might possess properties and means of reproduction not seen in the more mature stages of the fungus.

To obtain the basidiospores, fresh sporophores of the fungus were collected in the field, wrapped in waxed paper, and brought into the laboratory. The sporophores were rinsed in sterile distilled water, which served not only to remove some of the bacteria and spores of foreign fungi, but also to thoroughly saturate the sporophores. The sporophores were removed with sterile forceps and the excess water was sponged off with bibulous paper which had been previously sterilized, and were then placed, hymenium downward, in large, dry, sterile petri dishes. As Zeller (1916, p. 442) has pointed out, the moisture in the sporophores serves two purposes other than reviving the tissues, in that it keeps the air in the dish sufficiently humid to prevent too rapid dessication, and it also tends to retain foreign spores on the surface of the sporophore, the latter being beneficial in securing a fairly pure dispersion of spores. After twenty-four hours the sporophores had discharged enough spores to make a white spore print.

Where the ungerminated spores were inoculated directly upon poured agar plates, the spore dispersion was made in sterile distilled water. Several loopfuls of sterile water were transferred to the spore print by means of a platinum loop. By stirring a little with the loop the spores were so dispersed that when a loopful was transferred to the center of a poured agar plate it produced a cloudy drop. Where the spores were previously germinated in hanging drop cultures so that their germination could be observed the spore dispersion was made in the same way except that a number of loopfuls of the spore dispersion were transferred to a blank of the sterile nutrient medium in a test tube which was well shaken by rolling between the palms of the hands. Two or three loopfuls of this diluted spore dispersion were transferred to the cover glasses of sterile van Tieghem cells prepared in the usual way and these were sealed. The germination studies were performed entirely from cultures made in van Tieghem cells. In some cases a platinum loopful of germinated spores was transferred from the van Tieghem cells to poured agar plates as was done in the case of the ungerminated basidiospores. In both cases characteristic colonies were produced on the agar plates, the tufted growth of the mycelium of course appearing on the plates sooner where germinated basidiospores were employed.

Description of Cultures. Both spores germinated first in hanging drops and ungerminated spores, when transferred to poured plates of prune or malt extract agar, developed into a little tuft of mycelium which gradually spread out over the surface of the plate, making a floccose tuft of mycelium. In some cases the floccose growth of mycelium continued (Plate XI, Fig. 1), while in others, where the mycelium grew under apparently the same external conditions except that a richer culture medium may have been employed, it was found to be breaking up into oidia four days after the inoculation of the spores on the plates. In general it may be stated that when basidiospores were inoculated upon the agar plates there was a tendency for filamentous vegetative mycelium to result (Plate XI, Fig. 1). In some cases, however, the filamentous vegetative mycelium gave way to mycelium that continued to break up into oidia. On the other hand, oidia (both ungerminated and those previously germinated), when inoculated on agar plates, instead of producing filamentous vegetative mycelium always produced mycelium that continued to break up into oidia. (Plate XI, Fig. 2, and Plate XVIII, Fig. 1.)

In the case of attempts to infect sterile blocks of wood by inoculation with spores, both germinated and ungerminated, it was noticed that the resulting infection and spread of the mycelium was either very slow or failed altogether. Evidently there are some conditions for the ready development and spread of the mycelium in wood under natural environment that are difficult to duplicate by artificial means. Otherwise wood would not be attacked so readily in nature. A far easier and more reliable means of infecting blocks of wood was found in the method of placing in contact with them a piece of decayed wood containing active mycelium. Upon examination of some successful infections, at the beginning of the appearance of the mycelium, it was found that the mycelium had partially broken up into oidia before any considerable mycelial growth had been made. Learn (1912, p. 544) observed that oidia were present in cultures of *Pleurotus ostreatus* Jacqu. on blocks of wood and that new growths arose at the base of these blocks, apparently due to the shedding of the oidia from above. It is not improbable that in nature the formation of this secondary spore form may be a useful and additional means of propagation.

The growth of the mycelium on inoculated blocks of sterile wood always gave uniform results. In both methods of inoculation (by the use of germinated basidiospores and by contact inoculation by pieces of infected wood) the mycelium spread over the surface of the wood in the form of irregularly running, white mycelial strands of varying thickness. (Plate XII, Fig. 1.) A microscopic examination of these strands showed that they were composed of smaller strands of hyphæ which had anastomosed irregularly to form the larger strands. The smaller strands of hyphæ were composed of varying numbers of colorless hyphæ which were fused together in a highly irregular manner. The individual hyphæ exhibited a large number of cross-walls and clamp connections and innumerable branching of an exceedingly irregular character. As the strands of hyphæ spread over the surface of the blocks, they gave rise to more or less rounded, compact masses of mycelium (Plate XII, Fig. 1), but the strand formation persisted for a long time. Two blocks (1 x 1 x 4 inches) of the sapwood of sugar maple (*Acer saccharum* Marsh.), inoculated with germinated spores of *Polyporus pargamenus*, exhibited but very little evidence of decay even after six months. A similar block of yellow birch (*Betula lutea* Michx. f.) wood, inoculated by placing a piece of decayed wood in contact with it and keeping it in a culture tube plugged with cotton wool, exhibited considerable decay in this period.

Very successful cultures on wood were obtained by making inoculations on a larger scale, using fresh sapwood. A living yellow birch sapling about two inches in diameter was cut up into two-inch blocks, and these were split up into quarters, leaving the bark attached to the wood. A dozen of these blocks were placed in a large Erlenmeyer flask and sterilized under high pressure. After the sterilization the blocks were inoculated with a piece of the inner bark of yellow birch containing actively growing mycelium, the latter having been cultured in a moist chamber for some time previous. The mycelium from this fragment of bark soon spread to the blocks of wood and rapidly attacked the inner bark of these. The mycelium that began to spread over the surface of the blocks exhibited the characteristic strand formation. In the course of a month or so, the mycelium had completely covered the mass of blocks, filling up the spaces between them, and obscuring the strand formation.

The culture was kept on a shelf in the laboratory but was not exposed to the action of sunlight. It was retained for seventeen months, but appeared no different at the end of this time than it did one month after the inoculation was made, and never during this period did it exhibit any signs of sporophore formation. At this time the writer left Syracuse, but sent for the flask two months later. When it was unpacked he was agreeably surprised to find that several abortive sporophores had formed at the margin of the flask where the mycelium had grown part way up the side. (Plate XIII.) These abortive sporophores consisted of small resupinate, hydnoid hymenia, all of which were characterized by the lack of a context and by the flattening of the teeth as in *Irpex*. In some cases where the mycelium had grown part way up the side of the flask the abortive sporophores had grown out from their points of attachment and formed a few flattened teeth projecting downward as do the pores of normal sporophores. No normal sporophores possessing a context were ever produced in artificial culture.

An effort was made to determine spore production. A sterile coverslip was lowered into the flask by means of a platinum loop fused into a long glass rod, and placed under one of the abortive sporophores. On the following day the coverslip was withdrawn and mounted on a slide on which a drop of water had been placed. A microscopic examination revealed thousands of basidiospores, all of those examined having the characteristic shape and size of the spores of *Polyporus pargamenus*. These abortive sporophores continued to shed basidiospores for several days, the spores tested being viable and germinating in the characteristic manner for the basidiospores of *Polyporus pargamenus*.

It may be that the formation of sporophores previous to the time noted was retarded by the lack of an adequate supply of moisture within the flask since there was very little free water in the bottom of the flask when the experiment was started and none was introduced during the succeeding eighteen months that the experiment was conducted. Upon examination the blocks of wood were found to be soft and spongy, and to have the same pocket type of decay characteristic of yellow birch wood when decayed by *Polyporus pargamenus* under normal conditions.

The Vegetative Mycelium.— Two periods are clearly discernible in the development of the mycelium of *Polyporus pargamenus*, and the mycelium produced in these two periods will be designated respectively as primary and secondary mycelium. The primary mycelium is the product of the germination of the basidiospore and is distinguished by the absence of clamp connections. The hyphæ of the primary mycelium soon lose their protoplasm and disappear. The secondary mycelium arises from the primary in a few days as a direct outgrowth of the latter; it is composed of hyphæ of normal size that bear numerous clamp connections. In *Polyporus pargamenus* the clamp connections form as lateral outgrowths of one cell fusing with the cell beneath it, the separating wall sometimes being formed before the clamp has fused with the next cell (Plate XIV, Fig. 1). The secondary mycelial system consists of an intricately branched network of hyphæ comprising both large hyphæ with distinct thin walls, and hyphæ of smaller diameter, formed by the repeated branching of the larger ones; these hyphæ in turn branch and rebranch. At certain points along the larger hyphæ short branches are given off which divide very rapidly into the finest threads which penetrate the cells in all directions. Connections between adjacent hyphæ occur frequently; also rhizomorph-like masses where large numbers of hyphæ have fused together more or less. The latter occur most abundantly in the vegetative mycelium growing over the surface of blocks of wood.

Polymorphism.— Lyman (1907, p. 127) defines the basidiospore, borne on the basidium which is the characteristic organ of the group, as the primary reproductive body of the Basidiomycetes, and denotes all other spore forms, that is, those not borne on basidia, as secondary spores. According to Lyman (*l. c.*) the secondary spores thus far known to belong to species of Basidiomycetes are of four types: (a) chlamydospores — encysted vegetative cells; (b) oidia — the dissociated cells of vegetative hyphæ; (c) budding cells — produced by a yeast-like growth; and (d) conidia — exogenously abjointed cells which show more uniformity of size and shape than do the other types of spores mentioned, and are produced on more or less specialized structures called conidiophores.

Oidia.— In the cultures of *Polyporus pargamenus* the division of the hyphæ into oidia was preceded by a contraction of the protoplasm, leaving empty hyphal walls at numerous points along the filament. Later the hyphæ become divided into many short cylindrical cells with rounded ends, these cells being retained for a time within the walls of the original hyphal filament. If such a filament is mounted dry on a glass slide and viewed through the microscope, the empty membranes between the oidia appear to have collapsed as shown in Plate XIV, Fig. 2, a. At a still later period, the divided filament disintegrates, setting free cells with rounded ends of all shapes and sizes (Plate XIV, Fig. 2, b), most of them being short cylindric bodies varying from 7–25 μ in length and possessing dense refractive contents. In the formation of oidia, both the primary and secondary types of mycelium are equally active, although the oidia usually are not formed directly from the hyphæ provided with clamp connections, but from smaller branches of the size and appearance of the primary hyphæ. The retention of vitality by this secondary spore form was not tested as was done with the primary spores — the basidiospores. [illegible] 907, p. 149), however, states that the [illegible] vitality by oidia is short, and it is reasonable to suppose that these asexual spores are of less vitality than the basidiospores which probably are of sexual origin.

Recently formed oidia of *Polyporus pargamenus* were found to germinate readily upon being transferred to hanging drop cultures. The germination of the oidia was followed in as much detail as was that of the basidiospores. Oidia transferred from pure cultures on agar plates to hanging drop cells containing sugar-wood decoction were found to germinate in about the same time required for the basidiospores, and always in less than twenty-four hours. Most of the oidia germinated at first from one end only; occasionally, however, germ tubes were put forth simultaneously from both ends. In case only a single germ tube was put forth, a second one was later put forth from the remaining end, although it did not follow as quickly as was the case in the basidiospores, and usually there was considerable growth of mycelium before germination occurred from the other end. Three successive generations of oidia were secured in hanging drop cultures by isolating the oidia when formed and transferring them to new hanging drop cells. Evidently the process of oidia formation can continue indefinitely. Upon germination, the oidia produce mycelium of the primary type, that is, mycelium lacking clamp connections (Plate XV and XVI). Falck (1902) cultivated a considerable number of the *Agaricaceæ* through the formation of oidia to the mature fructification and concluded that the oidium form is a definite stage in the life-cycle of many of the higher fungi. Lyman (1907) shows that the production of oidia appears to be confined almost entirely to the higher families of the Hymenomycetes, as was indicated by Brefeld (1889).

Chlamydospores.— The formation of chlamydospores in *Polyporus pargamenus* agrees with the process in other groups of fungi. Any cell of the mycelium, under certain conditions, may form a chlamydospore; hence their position is either terminal or intercalary. Cross-walls are not abundant in the vegetative mycelium of *Polyporus pargamenus* and chlamydospores are of only occasional occurrence. They may be formed either on superficial hyphæ or on hyphæ that have become submerged under the surface of the agar. In the process of their formation the protoplasm of the hypha becomes vacuolate, certain cells losing their contents entirely, while in others which are to produce chlamydospores the condensing protoplasm contracts away from the ends of the cell and concentrates in the middle region where the side walls become greatly distended to receive it (Plate XVII). Here a resistant wall (endospore) forms about the encysting cell within and adnate to the surrounding hypal walls, and cuts off the empty portion of the parent cell at each end. Continued contraction of the protoplasm may cause the abandonment of these end walls, and new walls may form farther in (Plate XVII, *c*). The mature chlamydospore is thick-walled with dense, granular, refractive contents which become vacuolate with age. As a general rule the terminal chlamydospores are pyriform while the intercalary ones are more or less lemon-shaped, but great variation is exhibited owing to the different degrees of contraction of the protoplasm. The mature spores are freed only by the decay of the empty portion of the parent hyphæ, and are able to withstand adverse conditions for a considerable period. Their germination was not followed. No chlamydospores were observed upon the primary mycelium, all those observed occurring upon the secondary type of mycelium. Oidia and chlamydospores were the only secondary spore forms encountered in the cultures of *Polyporus pargamenus* and it is believed that the occurrence of these additional spore forms in connection with the life history of this plant is reported for the first time.

In a number of cultures coiled or helicoid hyphal formations were of common occurrence. They were observed both

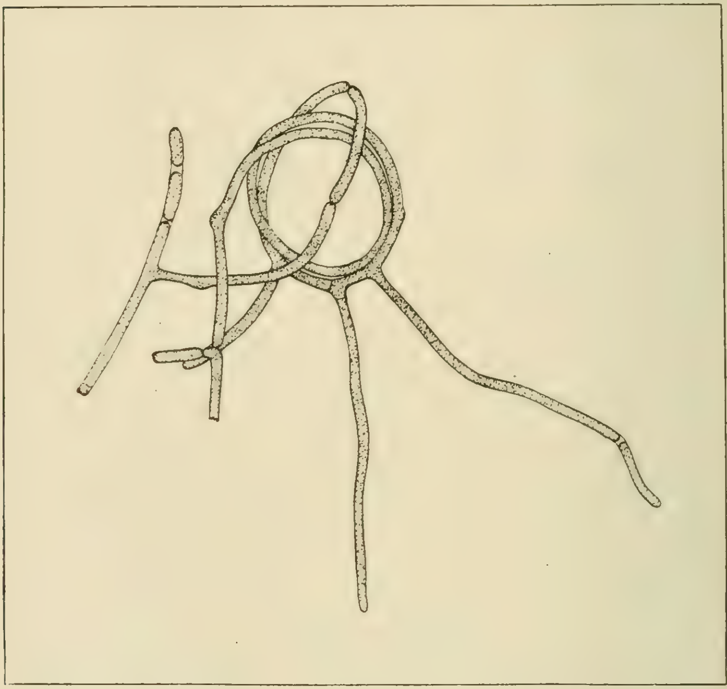

Fig. 4.

Helicoid hyphal formation from agar plate culture of *Polyporus pargamenus*, X 1,000.

in hanging drop cultures where a solution of malt extract was employed for the nutrient medium, and in cultures made on poured plates of malt extract agar. In the former case they were observed in cultures made for the purpose of testing the vitality of shed basidiospores that had been kept in a state of dessication for four months. In the latter case the same formations were found in abundance on the submerged mycelium growing on plates of malt extract agar. In both cases they were associated with mycelium that was breaking up into oidia and the one illustrated in Figure 4 depicts the mycelium breaking up into oidia. Nor particular significance could be attached to these helicoid hyphal formations. Similar hyphal formations have since been seen by the writer on agar plate cultures of Pythium and other fungi.

A portion of a culture on malt extract agar in which the mycelium was breaking up into oidia was transferred to another plate of the same medium. In the course of the next four weeks the developing mycelium spread over the surface of the agar and continued to break up into oidia. At the margins of the plate, where the agar ended, the mycelium grew up off the agar and formed a white filamentous growth in contrast to the mycelium in contact with the agar which habitually broke up into oidia. The filamentous mycelial growth running up the side of the petri dish later became yellowish or tawny and began to form a brownish pitted hymenium. The beginning of a hymenial formation occurred seven weeks after the oidia-forming mycelium had been inoculated on the agar plate. Three weeks later the hymenium became labyrinthiform. Since the culture was beginning to dry out seriously, the fruiting portion was transferred to a fresh plate and its growth continued. The mycelium which developed out over the surface of the plate broke up into oidia while the hymenium exhibited a tendency to become hydnoid (Plate XVIII, Fig. 2), eventually appearing the same as the previously described ones formed in the flask culture of blocks of wood and, like these, also shed copious quantities of basidiospores. A number of such transfers, made from old oidia-forming mycelium, repeatedly resulted in the formation of a basidosporic hymenium similar to the one just described, thus completing the life history of this fungus.

Reactions of the Sporophores to External Stimuli.

Relation to Water.— Buller (1909) has ably emphasized the xerophytism of the hymenomycetous stick or log flora. While the same author has demonstrated that the sporophores of many of the wood-inhabiting fungi are able to withstand dessication unharmed — some upwards of four years — the resistance of the mycelium to dry conditions still requires experimental investigation. It may be that the xerophytism of a fungus is only partial — that dessication is fatal to the mycelium but harmless to the sporophores. However, the rapidity with which sporophores, on the event of rain, develop upon sticks which have been dessicated for weeks in the summer, points to the conclusion that the mycelium in the wood frequently must retain its vitality in a state of dessication for long periods. Bayliss (1908) was able to develop new sporophores on a stick bearing a number of sporophores of *Polyporus (Polystictus) versicolor* (L.) Fr. that had been kept four years as a museum specimen, by keeping it in a moist chamber for a month. The old sporophores, however, upon being revived, did not shed any spores but became discolored and appeared to have lost their vitality. This observation seems to prove conclusively that the mycelium in the wood must have retained its vitality for four years in the dessicated condition.

An experiment similar to the above one was tried with *Polyporus pargamenus.* A bolt of a trunk of a white oak (*Quercus alba* Linn.) was cut by the writer in November, 1914, and stored on a shelf in the cellar. In November, 1916, a section was sawn off this bolt, moistened, and kept in a moist chamber for over two months. At no time, however, could active mycelium be observed — at least none other than that of various moulds. While the writer had no other material with which to test the vitality of dessicated mycelium, the failure of this test does not deter him from thinking that the mycelium of *Polyporus pargamenus* should retain its vitality as long as that of its near relative, *Polyporus versicolor.*

The extreme xerophytism of *Polyporus pargamenus* is shown by the ability of its sporophores to revive occasionally the second year. In the fall of 1915 the writer located a dead black oak bearing numerous sporophores of *Polyporus pargamenus* at its base. When observed, the sporophores appeared to be somewhat old and weathered, although certain of them shed copious quantities of spores upon being revived, while others shed few or none. From this fact it would appear that this crop of sporophores probably developed in the early spring of 1915. Frequent observations were made on this particular tree to determine whether a new crop of sporophores would be produced and whether any of the old ones would revive and continue growth. No growth whatsoever was to be seen until the middle of June, 1916, when it was noted that a whitish mould-like growth was appearing at the base of certain of the sporophores. On some the growth appeared on the upper surface; on others the new growth made its appearance as a new hymenium beginning to form over the old one; and in still others a new growth appeared simultaneously on both sides. Opportunity to examine the progress of this growth was not afforded until early in the fall of 1916. At this time the growth evidently was complete. The upper surfaces of certain sporophores were found to be covered with a new mold-like growth of hyphæ, causing them to appear grayish. The presence of this new layer of hyphæ gave the sporophores the appearance of being of the current year's growth. On many sporophores a new hymenial layer developed over the old one, either partially or entirely covering it. Where new growth was put out on both sides of the pilei the resulting sporophores appeared to be just as normal in structure as the original ones, excepting that they were extraordinarily thick. A few sporophores, in addition to putting out a new growth over both the upper and hymenial surfaces of the sporophores, also enlarged extensively by outgrowths from the margins. (Plate XIX.) The revival of the sporophores of *Polyporus pargamenus* is to be attributed to a direct outgrowth from the old tissues, beginning at the base of the individual sporophore and spreading gradually to their margins. Later in the fall of 1916 the tree bearing these sporophores was cut down and burned incident to the improvement of the grounds on which it stood, so that the possibility of future observations was necessarily precluded. From the observations recorded above, however, it is evident that sporophores of *Polyporus pargamenus* which have remained in a dessicated state for nearly a year (possibly more), under certain conditions, may revive and produce a new growth in the form of surface additions, formation of a new hymenial layer and spores, or additions to the margin. Peck (1880) has likewise observed that this plant sometimes revives to a certain extent the second season by putting on a new hymenium and a new growth from the margin of the pileus. In addition the writer has also observed the revival and growth of old sporophores taking place frequently when blocks from logs bearing sporophores are kept in a moist chamber for a few weeks.

Buller (1909, p. 111), in a list of Hymenomycetes with sporophores which can become dessicated without losing their vitality, states that the sporophores of *Polyporus pargamenus* recovered after dessication for one year, the recovery being judged by their ability to shed viable spores upon being revived. The xerophytism of the plant is further exemplified by the ability of the spores to germinate and produce infectious mycelium, after having been shed and kept in a state of total dessication for ten months, as described earlier.

Gravity and light both play a very important role in determining the development and direction of growth of the sporophores of many of the Agaricales, so that it is not surprising to find that the combined action of these two stimuli is necessary for the development of a perfectly formed sporophore.

Relation to Gravity.— Under natural conditions the pileus is invariably horizontal while the hymenial tubes are vertical. It can be proved by simple experiment or by observations of instances of natural occurrence in the woods, that the pileus is diageotropic and that the tubes are positively geotropic. Trunks of trees that are covered with young pilei of *Polyporus pargamenus*, and then subsequently break off, are commonly met with in the woods. Quite frequently the trunks fall so that the margins of the pilei project vertically upward or at least come to lie in a more or less perpendicular direction. Under these conditions all new growth from the margins of the pilei develops in such a manner that the upper surfaces of the subsequently formed portions of the pilei are brought into a horizontal plane. When this has taken place the pilei become diageotropic and now expand rapidly in a direction parallel to the earth's surface. At the same time hymenial tubes develop from the lower surface of the newly formed portions of the pilei. They are positively geotropic and grow vertically downward. The original pilei, now in a vertical position, soon cease to grow and all new growth is concentrated in the new, horizontally forming portion of the pilei. It thus becomes evident that the stimulus of gravity strongly favors the growth of the horizontally placed portions of the pileus. In all cases the hymenial tubes develop and grow vertically downward, thus reacting in a positively geotropic manner. It has been noticed repeatedly in a number of different species of polypores that newly formed sporophores, whose positions have become reversed through the overturn of the wood upon which they were growing, always would tend to restore themselves to their original and normal position in their subsequent growth. Spaulding (1911, p. 17) gives an account of an instance of this in the case of *Lenzites saepiaria* (Wulf.) Fries. A railroad tie, with a newly formed sporophore upon it, had been turned with its former surface underneath, so that the gills were on the upper instead of the under surface of the sporophore. When found the gills had just begun to produce a new growth of mycelium. On the sixth day new gills began to form on the former upper surface of the fruit-body and on the eighth day the transformation was complete. The writer has found sporophores of *P. pargamenus* which had had their hymenial surfaces turned uppermost owing to a reversal of the substratum. When found the pilei already had enlarged from one-fourth to one-half inch in breadth since becoming inverted, the new growth being reversed with respect to the position of the old. In other words the original hymenial surface abruptly changed to the upper surface of the new portion of the sporophore while the original surface became overgrown with a hymenial layer. The time required for such a change, however, would be but little or no greater than that required for normal growth and would vary with the climatic conditions.

It appears then that the stimulus afforded by gravity decides not only the direction of the growth of the pileus and hymenial tubes, but also which part of the sporophore shall develop and where the tubes are to be formed. In other words, gravity acts upon the fruit-body both as an orienting and as a morphogenic stimulus. As Buller (1909) has so ably pointed out in his "Researches on Fungi," the geotropic reactions enable the hymenial tubes to be developed in such a position that, with a given diameter, the maximum number of them may be produced in such a position as to be quite protected from rain and that the spores may fall out in the easiest possible manner.

Relation to Light.—A portion of a fallen trunk (three inches in diameter) of the wild red cherry (*Prunus pennsylvanica* Linn. f.) with numerous sporophores of *Polyporus pargamenus* beginning to make their appearance on it, was brought into the laboratory. Two pieces about four and one-half inches long were cut from this stem, immersed in water for a time, and placed into two glass culture jars. These blocks of wood were placed in the jars in the same positions with respect to gravity that they occupied in the field. Both jars were placed side by side on a table in the laboratory, one being covered with a light-proof pasteboard box, and the other, kept exposed to the light of the laboratory, was used as a control. At the beginning both blocks of wood bore partially formed sporophores on the sides and under surfaces, but on the tops the mycelium was just appearing through the lenticels and had not begun to differentiate into the parts of a sporophore. In a few days a floccose growth appeared from each of the lenticels of the block kept in darkness. Soon after this these hyphal growths assumed the form of loosely interwoven bosses. In the case of the block kept in the light a slow scant growth was made by the mycelium but it was of a compact leathery nature and never loose and fluffy as was the growth made in the dark. In addition the mycelium which developed in darkness made a much greater and more rapid growth than that which developed in the light of the laboratory. It was evident that the absence of light stimulates the mycelium to a much greater vegetative growth than otherwise would occur. After a month the mycelium put forth from each lenticel, which at first appeared as a fluffy boss, became more or less compacted and spongy in consistency. In no case, however, did any sporophores form on the block kept in the dark. Even the embryonic ones originally present failed to develop farther and became covered over by the outgrowth of mycelium. On the block kept exposed to the light of the laboratory, however, the mycelium developed into a number of imbricate sporophores which shed copious quantities of spores.

This experiment points to light as the controlling factor in sporophore production, although no account has been taken of the combined action of light and gravity. Experiments were made on a similar form with this idea in view by Bayliss (1908) as follows: Two small branches bearing normal sporophores of *Polyporus* (*Polystictus*) *versicolor* were secured. One branch was attached horizontally to a clock clinostat and the other used as a control. The apparatus was set up outside of the laboratory window where the branches had the advantages of ordinary atmospheric conditions and could be assured of a continuous supply of moisture by means of a dripping device. Never, however, during the several months' duration of the experiment did a typical dimidiate sporophore form. Only small, white waxy bosses appeared and these spread irregularly in all directions, sometimes uniting with one another; later they formed an incrustation over the surface of the branch. The white waxy bosses soon turned cream color and showed signs of pore formation on the exposed surface, while the surface next to the bark assumed the velvety zoned appearance so characteristic of the upper surface of a normal pileus. A piece of the pore-forming part, laid on a glass slide for an hour, yielded a good supply of spores. On the control a well-developed series of imbricate sporophores appeared.

From these experiments it seems quite evident that the dimidiate form of the sporophore is not to be ascribed, either solely to the stimulus of light nor yet to that of gravity, but to the combined action of both. It is very evident, however, that the formation of pores, and thus spore production, is a response to the one tropism only — that of light. We see that light likewise acts upon the sporophore as a morphogenic stimulus, and much more strongly than the tropism induced by gravity.

Relation to Chemotropism. — Studies were made upon germinating spores and pure cultures of *Polyporus pargamenus* in order to determine whether the mycelium would respond to chemotropic stimuli. Spores were germinated in hanging drops of nutrient medium in which thin sections of yellow birch wood had been placed. The germ tubes, however, continued to grow according to their own inclinations and the direction of growth did not seem to be influenced by the presence of a section of wood in the hanging drop. Bayliss (1908) observed the same behavior for *Polyporus (Polystictus) versicolor.*

Transfers were made from pure cultures of *Polyporus pargamenus* to plates containing a rich malt agar, on top of which (in the center of each plate) a small, sterile block (¼″ x ¼″ x 1″) of yellow birch wood had been placed. The inoculations were made on the agar beside the blocks of wood, the whole experiment being performed under sterile conditions. In a few days the mycelium completely enveloped the blocks in a luxuriant growth and eventually filled the whole dish. At the end of two months the blocks were examined and exhibited but little or no evidence of decay. The results would indicate that the mycelium of this fungus, at least so long as food is readily available, will take it from the source of least resistance — in other words, the source from which the food can be most easily assimilated.

Regeneration of Lost Parts of Sporophores.—As is commonly the case in the less highly organized plants, the lost parts of their structures often are replaced — a direct regeneration thus taking place. This procedure is of especially common occurrence among the sporophores of the wood-destroying fungi but the regeneration is limited to actively growing sporophores. The regeneration of lost parts can be demonstrated readily in *Polyporus pargamenus* by cutting off carefully a portion of the pileus or even the hymenium alone. It is only a matter of a few days, in case conditions for favorable growth are present, for the lost part to be entirely restored.

The Destruction of Wood by Polyporus Pargamenus.

Chemistry and Physics of the Decay.

Wood decay in general consists of a series of chemical and physical changes brought about by the action of the mycelium of the fungus. As in other wood-destroying fungi, the decay caused by *Polyporus pargamenus* is essentially a process of digestion and absorption. The digestion of woody tissues by this fungus is due to the excretion of a number of enzymes or organized ferments which reduce the woody substance to simpler organic compounds capable of being absorbed through the walls of the mycelial filaments, and which determine the manner of the decay of the woody substance. It is by means of their enzyme excretions that the minute and delicate, thin-walled fungal hyphae are enabled to dissolve their way through the lignified membranes of their host. This action is comparable to that of the ferment secreted by yeast cells in breaking down sugar. After the fungal hyphae of *Polyporus pargamenus* have penetrated the lignified membranes of their host in all directions they continue to exert on the cell-walls a solvent action which extends over a considerable area. In this way the original holes dissolved through the cell-wall continue to enlarge. When the enzyme excretions have accumulated to a sufficient amount the dissolution of the cell-walls becomes wide-spread and entire lamellæ disappear in a definite sequence.

The dissolution of the cell-walls is to be attributed to the fact that they, as a potential source of food, are valueless to the fungus until broken down and reduced to a condition suitable for translocation and assimilation. The transfer of the food materials through unbroken cell-walls to the various points of consumption can be accomplished only when they are in solution. In other words, they must first be converted into soluble substances capable of osmosis in order to be utilized by the fungal hyphæ. The agents instrumental in bringing about these changes belong to those substances termed ferments or enzymes — substances which possess the power of decomposing or transforming certain organic compounds into other substances without themselves being changed or consumed in the process. By virtue of this property they are enabled to transform unlimited quantities of certain substances if the resulting product be continuously removed, as would be done by the fungal hyphæ developing and ramifying through the woody substance. The peculiar manner in which enzymes act is illustrated by the following examples.

In the diastatic transformation and dissolution of starch the starch grain is not dissolved from the surface inwards as a homogeneous crystal, but becomes corroded by narrow canals until finally it is completely disorganized and disintegrated. The reduction of woody tissues by fungal hyphæ offers another example. Wood is generally considered to be made up of a complex lignocellulose, comprising such higher carbohydrates as lignin, cellulose, hemicellulose, and pectic bodies. Each of these respective carbohydrates may be split into simpler constituents by being acted upon by the accompanying cyto-hydrolytic enzyme. For instance, ligninase, called hadromase by Czapek (1899), designates the enzyme capable of splitting lignin; cellulase, the true cellulose-hydrolyzing ferment; hemicellulase, the ferment hydrolyzing hemi-cellulose; and pectinase, an enzyme which hydrolyzes into reducing sugars the pectinous substances, especially the middle lamellæ of plants. All of these different enzymes and many others, when present, enact a definite role in the dissolution of the woody substance.

Recent investigations prove conclusively that, in order to accomplish the dissolution of the woody substance, each wood-destroying fungus secretes a number of different enzymes, each of which is so specialized that it acts only on certain individual substances or groups of related substances. Furthermore, these various enzymes may act simultaneously. In a word, enzyme action is the strategic center of vital activity. The chemical action induced by such agents causes a rapid dissolution of certain constituents of the cell-contents and the cell-walls of the wood, the ultimate product being a reduced, disintegrating mass which crumbles readily under the slightest pressure.

In all cases, regardless of how the decay proceeds or what constituents are removed from the wood, there is a momentous change in its physical character. This change is most strongly exemplified by the decrease in its specific gravity. In case the fungus has delignified the cell-walls of the wood, partial or complete collapse occurs, since it was through lignification of the fundamental cellulose wall originally that the essential element of strength was afforded.

The ultimate effect of *Polyporus pargamenus* is to reduce the essential physical properties of the wood attacked and thereby lessen or completely destroy the utility and consequently the value of the timber.

The Decay of Yellow Birch Wood.

Structure of Normal Wood.— Macroscopically the wood of yellow birch (*Betula lutea* Michx. f.) is heavy, hard, and strong, but not durable when exposed. The sapwood is a light yellowish-brown color, the heartwood somewhat darker, there being no sharp line of demarcation between them. In a transverse section of the wood the pores are numerous, indistinct to the unaided eye, and uniformly distributed throughout the growth ring. The pith-rays likewise are mostly indistinct without a lens.

Microscopically the wood of yellow birch presents the usual features of the diffuse-porous type. The annual rings are defined principally by a tangential row of wood parenchyma which terminates the growth ring. The definition of the annual rings is somewhat further enhanced in that the vessels are slightly smaller and more sparsely distributed in the late wood. (Plate XXI, Fig. 1.) Microscopically the wood of the yellow birch is seen to consist of (a) uniseriate and multiseriate pith-rays, (b) pitted vessels, (c) metatracheal parenchyma with simple pits, and (d) wood prosenchyma with either simple or bordered pits. The medullary rays are from 1–3, more rarely 4, seriate, and homogeneous. The ray cells are mostly elongated in a radial direction and are connected with one another by numerous simple pits. As units the rays are peculiar in that the lateral walls of the uniseriate forms and similarly the lateral walls of the peripheral cells, in the case of the multiseriate forms, are characterized by having very thin walls, while the interior cells in the latter case have fairly thick walls. The vessels occur either solitary or in radial groups of from two to three; they are uniform in size and distribution throughout the growth ring. Their walls are comparatively thin and densely covered with small bordered pits with narrow, slit-like openings. These occur on the contiguous walls of the vessels and where they are in contact with wood or ray parenchyma. The vessel segments are characterized by very oblique end walls which are provided with numerous scalariform perforations. A small amount of wood parenchyma is scattered irregularly throughout the growth ring (metatracheal), sometimes appearing in broken tangential lines in the late wood.

The individual cells of wood parenchyma are characterized by very thin walls (much thinner than those of the wood prosenchyma elements) and abundant simple pits, particularly on their end walls. On the other hand the wood prosenchyma of yellow birch offers the usual features. It is characterized, however, by elements provided either with small simple pits, or more rarely, small but distinctly bordered pits. (Fig. 5.) In shape and size the bordered pitted elements resemble wood fibers rather than tracheids.[16]

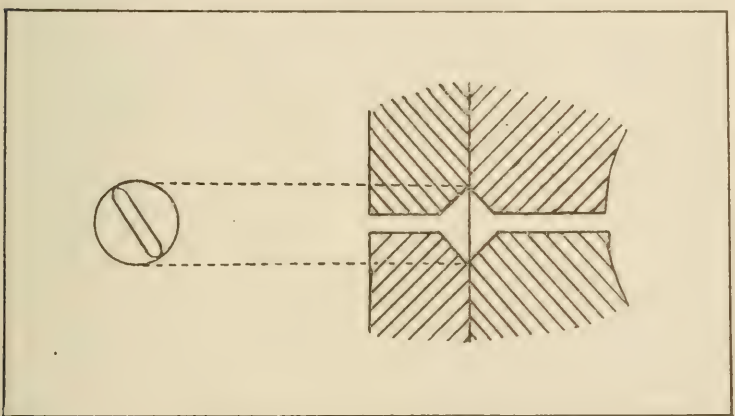

FIG. 5.
Bordered pit in yellow birch (*Betula lutea*) wood, transverse section, X, 3,000.

Microchemical Reactions of Normal Wood.—The course of the destruction of the cell walls and the chemical changes occurring in them can be observed readily by studying temporary mounts of sections of decayed wood treated with the various microchemical reagents commonly employed for the recognition of cellulose and lignin. Studies of this kind,

[16] Many authors avoid distinguishing between such similar elements as wood fibers and tracheids by classifying both as wood prosenchyma. In many woods all gradations occur in the pitting of these elements from simple pits on the one hand to semi-bordered or bordered pits on the other hand.

however, should be preceded by a study of sections of normal wood treated with these respective reagents in order to determine the relative degree of lignification of the various woody elements and any structural peculiarities that would aid materially in explaining the course of the decay in the wood.

Normal wood, when treated with chlorzinc-iodine, shows the presence of considerable cellulose. The middle lamellæ of all the cell-walls become colored golden brown. The wood prosenchyma elements are peculiar in that the tertiary layers (layers bordering on the cell lumina) assume a pronounced violet coloration which extends into the secondary layer but is only faintly perceptible in the primary layer or middle lamella. The violet coloration assumed by the tertiary layer of the wood prosenchyma cells, however, diminishes in intensity toward the outer margin of the growth ring until it is scarcely discernible in the elements of the summerwood. The vessels, pith-ray cells, and thin-walled wood parenchyma fibers exhibit only a golden brown coloration with chlorzinc-iodine. Tests for lignification were made with phloroglucin-HCl, aniline sulphate-H_2SO_4, resorcin-HCl, phenol-HCl, orcin-HCl, and thymol-HCl, each reagent exhibiting its respective color reaction throughout.

In sections of wood treated with phloroglucin-HCl the vessel walls and middle lamellæ of all the cells are stained most strongly, becoming old rose or wine-colored. The coloration assumed by the middle lamellæ is especially pronounced in the terminal cells of the growth ring. The remaining layers of the medullary ray and wood parenchyma cells also become rose-colored. The secondary and tertiary layers of the prosenchyma elements are colored almost uniformly rosy-violet — at least they are considerably lighter than their middle lamellæ. When sections are treated with aniline sulphate-H_2SO_4 the vessel walls and the middle lamellæ of all the cells stain most deeply, becoming golden yellow. The remaining layers of the medullary ray and wood parenchyma cells stain only to a pale lemon color. The secondary and tertiary layers of the prosenchyma elements remain quite pale in contrast to their middle lamellæ, they take on merely a yellowish tint, excepting in the terminal cells of the growth ring where they become somewhat more strongly colored.

From the tests described above in full detail, and from still other tests employed for the differentiation of both cellulose and lignin, it is evident that the entire vessel walls and the middle lamellæ of the other elements are lignified to a much greater degree than the secondary and tertiary layers of these elements and that the tertiary and secondary layers of the wood prosenchyma elements are lignified to an approximately equal extent. As a result of the variable structure and microchemical reactions of the various elements, we naturally would expect to find that the vessel walls would resist delignification longer than any one part of the other cells. Of the latter the middle lamellæ would be far more resistant to the solvent action of the fungus than the secondary and tertiary layers of these respective elements. In the description of the course of the decay, which is given later, we shall see to just what extent this inference is substantiated.

Macroscopic Appearance of Decayed Wood.—The first evidence of incipient decay in yellow birch wood is the appearance in the wood of small, irregular areas in which the tissues have lost their natural brownish color and appear as though bleached. The wood between the lighter areas remains moderately sound for a time, at least it does not begin to decay until they are considerably disintegrated; even then their decay proceeds very slowly. All parts of the annual ring are equally susceptible to the attacks of the fungus.

Cross sections of trunks in the early stages of decay usually exhibit a number of conspicuous, irregular zones of blackish wood which sharply delimit decayed from sound wood or portions of the wood in different stages of decay. In cross sections of partially decayed trunks these black zones in the wood have the appearance of irregular lines. Longitudinal sections show that they extend for varying distances up and down the stem, their general course being parallel to the elements of growth. They are not limited by the annual rings, however, for they may cross and recross these repeatedly. Examination shows that these black zones consist of wood of unusual hardness. As shown in a previous paper by the writer (1917[2]), these black zones are caused by the infiltration into the wood of decomposition products formed from the woody substance as it decays. They are of common occurrence in the decay of all dicotyledonous woods by *Polyporus pargamenus* and other wood-destroying fungi, but appear to be of comparatively rare occurrence in the decay of coniferous woods. Further discussion of black zones will be presented later.

Yellow birch wood in an advanced stage of decay has a mottled appearance. The decay is localized mainly in minute areas, each of which is bounded by a thin zone of firmer wood. The areas of advanced decay appear as white spots while the less decayed wood bounding these is more or less yellowish and resembles superficially a delicate network (Plate XX) visible on all three sections. This network is rather inconspicuous in dry wood but stands out quite prominently after the surface of the wood has been moistened.

As the solvent action of the fungus progresses, the white, decayed areas, or pockets, continue to enlarge. Within the individual centers of decay the disintegration progresses in a direction parallel to that of the woody elements and in time the woody elements in these respective areas are reduced rapidly both in color and hardness until they become pith-like.

This method of decomposition results in the formation of a series of pronounced pockets or cavities within the wood (Plate XXI, Fig 2). In the latter stages of the decomposition two or more decayed areas frequently coalesce into one so that the wood has a decided "pocketed" appearance. Although highly irregular in size and outline, the largest of these decayed areas, or pockets, as bounded by the meshes of firmer yellowish wood, average two mm. or less in diameter and one cm. or less in length. In general their length coincides with the direction of the woody elements, although occasionally they may extend at right angles to them. At this stage they are quite empty of contents save for a few scattered tubular elements — the vessels. Owing to their greater lignification, these elements are the last to disappear under the dissolving action of the fungus. In time, however, even these disappear, leaving practically nothing within the pockets, which by this time are separated by almost membranous layers of woody tissue merely a few cells thick. (Plate XXIV, Fig. 1.) Numerous strands of white mycelium, running both longitudinally and radially through the decayed wood, can be seen with the unaided eye. By the time the decay has progressed to this point, the wood has lost all of its original characteristics of color, odor, hardness, and strength, and has become a bleached mass of pithy consistency.

Blocks of wood cut from a decayed log and kept in culture chambers decayed much more rapidly than they normally would under field conditions. In a few weeks they became covered with a growth of mycelium which thrived for several weeks. After that time the growth of the mycelium seemed to cease and portions of the mycelial mass died and became discolored. Portions of these blocks of decayed wood were even softer in texture than a wet sponge and the decay seemed to have progressed to its utmost extent since the mycelium within the woody tissue apparently was functioning no longer. The decayed wood appeared like a honeycomb composed of the finest and most delicate, whitish membranes. By this time the decayed pockets had fused together to such an extent that some were found to measure three mm. in diameter and to extend lengthwise through the wood for three cm. It may be assumed with reasonable certainty that the wood at this time was in the final stage of decomposition for we have no reason to think that woody tissue must be entirely destroyed in order that the specific decay be completed. It is only natural to suppose that the growth of the mycelium will terminate when the nutrient substances have been extracted reasonably thoroughly from the woody tissue. It is definitely known that wood-destroying fungi, owing to their power of disorganizing their own substratum by fermentation and putrifaction, not only cause the substratum to become an unfavorable nutrient medium for the entrance and growth of other fungi but may in time render it unfit for their continued growth. Under normal conditions the woody tissue that has been reduced partially by cellulose and lignin ferments will of course be attacked by molds, bacteria, and other micro-organisms and split up into simpler compounds. It is to these agencies that we must attribute the final reduction to "humus" of the refuse material left from woody tissue after its partial destruction by the more potent agencies — the wood-destroying fungi.

The outer, paper-like bark of the yellow birch is exceptionally resistant to decay. Yellow birch trees frequently are found with this outer bark sound and entire while the inner portion of the bark and all of the underlying wood may be completely rotted, either by this or by other wood-destroying fungi. This great resistance to decay, according to Stevens (1910, p. 336), is to be attributed to the presence of betulin — a glucoside which occurs in the form of fine granules in thinner-walled cork cells of birch bark. This is strongly antiseptic and protects birch bark against the attacks of lower organisms.[17] The inner, brown fibrous bark, however, is speedily decayed by the action of the fungus and is converted into a whitish crumbling mass, which can be pulverized readily between the fingers to a gritty powder containing a large percentage of a crystalline substance, doubtlessly calcium oxalate.

Microscopic Characters of Decayed Wood.— In sections of wood in an advanced stage of decay, all stages of decomposition, from incipient delignification to the complete disappearance of the elements, may be seen. Separating the pockets or decayed areas are irregular zones of less decayed wood (Plate XXI, Fig. 2) varying from a few to several cells wide. In the median cells of such zones, all three layers

[17] Outer bark of any kind, however, would be quite resistant to decay, owing to its corky nature.

of the cell-wall of the prosenchyma elements respond to lignin tests as they do in normal wood. The cells bordering on these elements are in various stages of decomposition. In some the tertiary layer no longer gives the characteristic color reactions when treated with various lignin reagents, but remains colorless. In other cells the secondary lamella of the cell-wall also remains colorless and undoubtedly consists of practically pure cellulose. As a general rule, both the secondary and tertiary layers remain in place until after all of the cell-wall but the middle lamella is delignified, whereupon the destruction of the cellulose commences. Those layers of the cell-walls that remained colorless after treatment with lignin reagents take on a pronounced violet color when treated with cellulose reagents such as chlorzinc-iodine. Groups of these cells sometimes are seen in which the middle lamellæ are colored brown with chlorzinc-iodine, while the secondary and tertiary layers are colored a deep violet and frequently exhibit a pronounced swelling. If sections are subjected to the action of chlorzinc-iodine for several hours, the cellulose layers swell up to such an extent that the cell lumina often entirely disappears. The behavior of these membranes with chlorzinc-iodine affords a double proof of their cellulosic nature; first, by reason of the violet color assumed, and second, by reason of the swelling of the cell-membrane after the application of this reagent.[18]

It is evident from the above description that the dissolution of the cellulose does not occur within any one cell until some time after its wall, the middle lamella excepted, has become completely delignified. Within the individual cell, the cell corners, where the middle lamellæ often are thickened characteristically, respond the longest to tests for lignin. Owing either to the fundamentally different composition of the basic principle of the middle lamella or to its subsequent infiltration by lignin constituents, it resists decay longer than

[18] This swelling of decaying membranes is too often attributed to the action of the fungus effecting the decay. As a general rule, the swelling does not occur until after the application of chlorzinc-iodine, and the swelling is to be attributed to the action on the cellulose of the excess zinc chloride found in this reagent.

the secondary layers and remains in place long after the disappearance of the secondary and tertiary lamellæ of the cell-wall. After the secondary layers of thickening have been dissolved, the resulting woody tissue has a skeletonized appearance (Plates XXII and XXIV, Fig. 1). It has all of the elements but their walls consist principally of the middle lamellæ. These retain the nature of lignified walls and offer considerable resistance to dissolution, and are the last portion of the individual cell-wall to disappear. However, they too gradually become thinner and thinner until they break up into irregular fragments. It is not until they have disintegrated to this extent that the middle lamellæ respond to the cellulose test with chlorzinc-iodine. The corners of the middle lamellæ, where they are thickest, are the last to disappear.

Within the decayed areas the uniseriate pith-rays frequently are dissolved out quickly early in the course of the decay. These are the first elements to disappear and doubtlessly disappear first because of their exceedingly thin cell-walls, as explained earlier. Frequently the medullary rays are dissolved entirely while cell-walls of normal thickness may be found immediately adjoining them on both sides (Plate XXII). The thick vessel walls are strongly lignified and are the last elements to disappear. They continue to respond to tests for lignification long after the surrounding cell-walls fail to do so and frequently persist quite intact while the surrounding cell-walls are dissolved until only the middle lamellæ remain. In still later stages of decay, the partially disintegrated vessel walls often are the only elements remaining within the pockets. They are retained in their original positions within the pockets by reason of being held in place by numerous mycelial threads which penetrate their walls in all directions. Where two or more vessels are contiguous, they frequently separate before they are entirely dissolved. Where they remain attached until completely decayed, however, the common walls between two or more vessels are the last portions to be decomposed by the action of the fungus. Finally even the resistant vessel walls become so much eroded that they break up into irregular fragments, among which can be detected portions of pitted walls and scalariform bars from the end walls of the vessel segments. Even those fragments of vessel walls retain their lignified nature until they become almost completely dissolved. Within any one center of decay the dissolution of the cell-walls progresses very uniformly, as shown by the fact that the distance from normal cell-walls to walls that have been completely decayed is often no more than thirty-five microns.

An examination was made of prepared slides for the purpose of determining the relation of the mycelium to the wood. In the earlier stages of the decay the hyphæ may follow the course of the vessels and wood parenchyma elements for some distance before diverging, and again they may branch off profusely and enter the medullary rays. In the much decayed wood the mycelium is abundant in all the woody elements and branches profusely in all directions, perforating the walls of the woody elements at random. In the later stages of the decay it is evident that many of the hyphæ deliquesce, or, at least, disappear in some way, for the perforated cell-walls are commonly seen but no hyphæ can be found associated with them. The hyphæ found in decaying yellow birch wood are exceedingly delicate and minute. No cross-walls or clamp connections were observed in them although failure to see these structures may have been due to the extremely small size of the hyphæ. Dense plugs or mats of hyphæ frequently occlude the vessels. These mats of hyphæ are brown by reason of being incrusted with some decomposition product.

From the above study it is evident that the first main chemical change which is brought about by the action of the fungus is that of delignification. It is due to this action that the elements lose their normal brownish color and appear as though bleached. At the beginning of delignification, the decay seems to be localized in small areas which appear as pockets in the wood after the woody tissue within them is completely destroyed. From the results obtained, it is apparent that delignification commences in the tertiary layer and proceeds toward the middle lamella. After the cell-wall is delignified down to the middle lamella, the reduction of the cellulose commences. With the destruction of the cellulose, nothing is left but a skeletonized framework of middle lamellæ, which in turn break up and undergo complete reduction. Within a pocket or unit area of decay, all stages of decomposition from incipient to final may be seen within the range of a few cells (Plate XXI, Fig. 2).

The Decay of Sugar Maple Wood.

Structure of Normal Wood.— The wood of the sugar maple (*Acer saccharum* Marsh.) is heavy, hard, strong, and close-grained, but is not durable in the soil or otherwise exposed. The sapwood is creamy white while the heartwood is light brown tinged with red, there being no sharp demarcation between them. In a transverse section of the wood, the pores are numerous, indistinct to the unaided eye, and uniformly distributed throughout the growth ring. The pith-rays, while not conspicuously broad, are very distinct without a lens.

Microscopically the wood of sugar maple presents the usual features of the diffuse-porous type. The growth rings are distinct and regular in outline; their width, however, is subject to considerable variation. The wood is seen to consist of (a) uniseriate and multiseriate pith-rays, (b) pitted vessels with spiral thickenings, (c) scanty wood parenchyma which is mostly paratracheal, and (d) wood prosenchyma with simple pits. The pith-rays are composed of small, homogeneous, radially elongated cells bearing numerous simple pits. Part of the rays are comparatively large — from five to seven cells wide — and many cells high. The intermediate rays are mostly uniseriate. The vessels are distributed uniformly throughout the growth ring and diminish gradually in size from the spring to the summerwood. The vessel segments, which do not possess large lumina, are comparatively thin-walled, provided with simple perforations at the ends, and are characterized by spiral thickenings. The vessels occur singly or in radial groups of from two to five, or rarely six. The vessel walls, at their points of contact with one another and where they border on ray or wood parenchyma, are provided with densely packed and rather large bordered pits, the borders often hexagonal owing to crowding. The interior walls of the vessels are provided with spiral thickenings. The wood parenchyma is developed to a limited extent, the walls remaining comparatively thin. It occurs sparingly on the radial sides of the vessels and is also to be found scattered irregularly over the outer face of the summerwood. The individual cells of wood parenchyma, as well as the ray parenchyma, responded to the iodine test for starch, since the wood was cut late in the autumn. Chambered parenchyma containing crystals occurs occasionally but was by no means common in the sapwood studied. The wood prosenchyma has simple pits and the elements are of the nature of typical wood fibers. These elements sometimes contain starch. The growth rings are defined mainly by a tangential flattening of the outermost cells and by the somewhat smaller size of the vessels in the late wood (Plate XXIII, Fig. 1).

Microchemical Reactions of Normal Wood.— Cross sections of normal wood, when treated with cellulose reagents such as chlorzinc-iodine, exhibit comparatively little of the characteristic violet coloration indicative of cellulose. The middle lamellæ of all the cells and the entire walls of the vessels and medullary rays all color yellowish-brown. Certain of the prosenchyma elements, particularly those on the outer face of the late wood, exhibit a slight violaceous coloration in the secondary and tertiary layers. The majority of the prosenchyma elements, however, exhibit little or no such coloration with chlorzinc-iodine. In sections of wood treated with phloroglucin-HCl the vessel walls and the middle lamellæ are colored most strongly, becoming reddish-violet. The remaining layers of the medullary ray cells likewise become reddish-violet and appear to be stained almost as deeply as the vessel walls. The secondary and tertiary layers of the wood prosenchyma elements are colored much less strongly than their middle lamellæ and appear to be almost violaceous or violaceous tinged with red, especially in the terminal cells of the growth ring. When sections are treated with aniline sulphate-H_2SO_4, the vessel walls and the middle lamellæ of all the cells stain golden yellow. The remaining layers of the medullary ray cells appear brownish-yellow. The secondary and tertiary layers of the wood prosenchyma elements stain much lighter than their middle lamellæ, becoming a pale lemon color.

From the tests described above in full detail, and from still other tests employed for the differentiation of both cellulose and lignin, it is evident that the vessel walls are lignified to a much greater extent than any other one element excepting the multiseriate pith-rays. Of the individual cells, the middle lamellæ are lignified far more strongly than the secondary layers. The secondary layers of the wood prosenchyma elements, therefore, are the least strongly lignified tissues of the wood. The lignification of these elements, however, increases markedly on the outer face of the growth ring. As a result of the dissimilar structure and the microchemical reactions of the various elements, we naturally would expect to find that the vessel walls and the broad medullary rays would resist decay longer than any other element. Of the other elements the middle lamellæ would be more resistant to the solvent action of the fungus than the secondary layers of thickening possessed by these respective elements. We also would expect to find that the terminal margin of the growth ring would resist decay longer than the remainder of the growth ring. When it is understood that the first result of the decay caused by this fungus is the delignification of the woody substance, it would be expected that those elements which are strongly lignified (the vessels, medullary rays, and the terminal cells of the growth ring) will resist destruction far longer than the less lignified elements (the wood prosenchyma).

Macroscopic Appearance of Decayed Wood.— The decay of sugar maple wood is very similar to that of yellow birch, which has been described in full detail so that it may serve as a type. The decay of sugar maple differs from that of yellow birch only in the following respects. The pockets, which are highly irregular in outline, are much broader as viewed radially than in the tangential section. On the radial surface of the decayed wood examined, the largest pockets were one cm. long and five mm. wide; on the tangential surface, however, the largest pockets were not over two mm. wide. The tendency for the pockets or decayed areas to enlarge mostly in a radial direction is explained by the peculiar structure of the wood. The wood is of homogeneous structure except for the numerous broad pith-rays which transverse the growth rings in a radial direction. Examination of a transverse section of decayed wood reveals the fact that the broad medullary rays, the outer margin of the growth ring, and the vessels are the last elements of the growth ring to decay. The broad medullary rays offer exceptional resistance to the spread of the decay in other than a radial direction. The vessels remain behind until long after practically all the other elements in the growth ring between the broad medullary rays have been dissolved out. At this stage of the decay the vessels appear as isolated capillary tubes loosely held between the medullary rays by partially disintegrated tissue. The numerous broad medullary rays which transverse the annual rings of growth in a radial direction serve to bind together the layers of growth so that there is no separation of the decayed wood along the line of the annual rings. The numerous broad medullary rays act like so many reinforcing structures so that the decayed wood responds far less to tangential compression than to radial compression. They likewise materially increase the transverse breaking strength of the decayed wood. As a result of the strengthening effect afforded by the medullary rays of this wood, a trunk of sugar maple rotted by *Polyporus pargamenus* would be less subject to breakage than a similar trunk of yellow birch rotted to the same extent by the same species of fungus. The difference in the appearance of the decay by this fungus of two woods so similar in their general structure is noteworthy when one considers that these differences are brought about solely by minor structural differences of certain elements of these respective woods, in this case the elements being the medullary rays.

The inner fibrous bark of the sugar maple decays quite rapidly and soon becomes soft and spongy. The outer scaly bark, however, owing to its corky nature, is quite resistant to decay.

Microscopic Characters of Decayed Wood.— The dissolution and course of the delignification of the woody elements is essentially the same as that described for yellow birch. In fact it differs from the decay of yellow birch only in so far as would be necessitated by the different structure of sugar maple wood.

The solvent action of the fungus proceeds very irregularly. Often cells, whose entire walls still respond strongly to lignin tests, are left among cells which have been decomposed to such an extent that only the middle lamellæ remain. The wood prosenchyma and wood parenchyma elements are the first elements to disappear. In this connection it will be remembered that these elements were less strongly lignified than any of the other elements of the growth ring. In sections of badly decayed wood, the effect of the numerous large pith-rays in retarding the decay from spreading tangentially is strongly exemplified. In addition, the terminal calls of the growth rings, which are very resistant to decay, are potent factors in retarding the spread of the decay in a radial direction. Their retarding effect, however, is less than that offered by the medullary rays. As a result of the structure of the wood and the method of decay induced by this fungus, the decay necessarily would proceed most rapidly up and down the stem, less rapidly in a radial direction, and least rapidly in a tangential direction. Within each growth ring the wood elements which adjoin the vessels decay less rapidly than the more distant-lying ones, excepting the few layers of tangentially flattened cells on the outer face of the growth ring. In sections of wood in an advanced stage of decay, aside from this resistant zone of wood, the vessels with a few adjoining cells may be the only elements left of the original tissue of the growth ring lying between the pith-rays. (Plate XXIII, Fig. 2.)

Longitudinal sections of decayed wood showed a great abundance of matted growths of fungal hyphæ which, in addition to occluding the vessels, often extended across a great number of elements, sometimes forming veritable zones through the wood. As in the decaying yellow birch wood, these mats of hyphæ appear to be encrusted with brown decomposition products.

The fungal hyphæ apparently did not exert any solvent action on the crystals of calcium oxalate which were of occasional occurrence in the chambered wood parenchyma cells, since they remained intact despite the complete decay of the cells containing them.

Sections (taken near the black zones) of wood in the early stages of decay, exhibited considerable quantities of decomposition products infiltrating various portions of the wood. These decomposition products were most abundant in the vessels where they appeared as individual brown globules or more often a number of globules had coalesced into a brown, gummy mass completely occluding the vessels in a number of places.

These brown, gum-like masses dissolve slowly and without heating when allowed to stand in a 5 per cent solution of potassium hydroxide for a few hours.

The Decay of Bitternut Hickory Wood.

Structure of Normal Wood.— The wood of the bitternut hickory [*Hicoria minima* (Marsh.) Britton], is heavy, hard, moderately strong, and tough, but is not durable in the ground or if exposed; the sapwood especially is always subject to the inroads of boring insects and fungi. The sapwood is white and characteristically narrow; the heartwood is of a reddish nut-brown color. The pith-rays are abundant but not conspicuous. The wood parenchyma is arranged in fine tangential lines which do not appear as distinct as the rays.

Microscopically the wood of bitternut hickory presents the usual features of the ring-porous type. The growth rings are fairly well defined by the zonate arrangement of the large vessels in the early wood of the growth ring and by the tangential flattening of the cells on the outer face of the late wood. In the late wood the vessels become fewer, smaller, and scattered; the larger ones of the early wood are characterized by their abundance of tyloses. The wood of the bitternut hickory is seen to consist of (a) uniseriate and multiseriate pith-rays, (b) pitted vessels, (c) metatracheal zonate wood parenchyma, and (d) wood prosenchyma with both simple and bordered pits. The pith-rays, which are composed of small, mostly radially elongated, homogeneous cells, are irregularly disposed, not uniform in height or shape, and vary from one to four, or rarely five, seriate. In the beginning of the growth ring the large vessels, or pores, as they are termed when viewed in cross section, are scattered and never more than two to three rows deep. In the remaining portion of the growth ring they may be either solitary or arranged in radial groups, usually of from two to three, or rarely five. Great variation is exhibited in the thickness of the vessel walls. The larger vessels in the early wood usually have comparatively thin walls with their lumina rather densely occluded by tylosal formations. The smaller vessels in the late wood as a rule have exceedingly thick walls, especially where contiguous. In general it may be stated that all solitary vessels have comparatively thin, uniform cell walls. The grouped vessels, however, usually have very thick walls which decrease in thickness characteristically at their distal ends. The walls of contact between two vessels bear densely packed and rather large bordered pits, the borders sometimes being hexagonal owing to crowding. Where they border on the medullary rays the walls of the vessels are furnished with simple pits. The scalariform markings characteristic of yellow birch and sugar maple woods are totally lacking in this one. Wood parenchyma occurs abundantly but is exceedingly variable as to its distribution. In transverse section the individual cells of wood parenchyma resemble in general shape the fibrous elements, but have wider lumina by reason of their thinner walls. They predominate in the more porous parts of the growth rings and often closely surround the vessels. In the dense late wood, the wood parenchyma forms conspicuous, tangentially arranged bands alternating with irregular, compact rows of thick-walled wood fibers. On a perfectly smooth transverse section having well-defined late wood, these parenchyma bands can be detected with the unaided eye. When greatly interrupted by wood fibers the parenchyma bands become indistinct and can be distinguished only by means of a microscope.

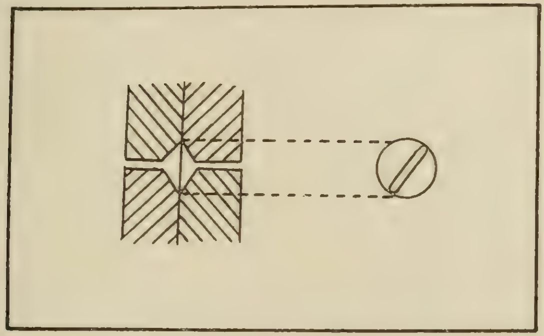

Fig. 6.
Bordered pit in butternut hickory (*Hicoria minima*) wood, transverse section, X 2,000.

As seen in longitudinal section the wood parenchyma cells extend vertically in short rows, the terminal cells of which taper to a point. Structurally they resemble the pith-ray cells but have their long axes at right angles to these. The individual cells of wood parenchyma are mostly short and prismatic, their thin walls being furnished with simple pits. Many of the individual cells contain solitary crystals of calcium oxalate belonging to the tetragonal crystal system. These crystals are only slightly soluble even in the strongest acids and are readily seen under the high power of the microscope in all sections. In such cases the whole cell becomes merely a repository for the crystal and in so doing the walls usually become greatly distended. The wood prosenchyma elements compose the greater part of the dense outer portion of the annual growth ring and are relatively thick-walled. They have comparatively wide lumina and walls furnished with numerous small but distinct bordered pits, the orifice of which is slit-like and usually oblique (Fig. 6). These elements have a constant structure and in shape and size resemble wood fibers more than tracheids.

Microchemical Reactions of Normal Wood.— Cross sections of normal wood, when treated with chlorzinc-iodine, exhibit comparatively little of the characteristic violaceous coloration indicative of cellulose. The middle lamellæ of all the cells, the vessel walls, medullary ray cells, and the thin-walled wood parenchyma cells all color yellowish-brown. The wood prosenchyma elements exhibit a slight violaceous coloration which is strongest in the tertiary layer bordering on the cell lumen and fades off gradually toward the middle lamella of each cell. This violaceous coloration is most prominent in the springwood elements and diminishes in intensity toward the outer face of the growth ring at which point it is scarcely distinguishable. In sections treated with phloroglucin-HCl the thick vessel walls and the middle lamellæ of all of the cells color most strongly, these becoming dark rose-colored or wine-colored. The remaining layers of the medullary ray and wood parenchyma cells are found to be tinted less strongly but still much more so than the remaining layers of the wood prosenchyma elements which appear almost violet. After treatment with aniline-sulphate-H_2SO_4 the vessel walls and the middle lamellæ of all the cells exhibit a brilliant golden yellow coloration. The remaining layers of the medullary ray and wood parenchyma cells likewise become strongly colored, but assume more of a brownish-yellow instead of the golden-yellow color. The remaining layers of the wood prosenchyma elements stand out much less strongly than the middle lamellæ and appear to be of a pale lemon color.

From the tests described above in full detail, and from still other tests employed for the differentiation of both cellulose and lignin, it is evident that the vessel walls are by far the most strongly lignified of any of the elements. It is also evident that the medullary ray and wood parenchyma cells, while less strongly lignified than the vessel walls, are more strongly lignified than the wood prosenchyma elements. Of the individual cells the middle lamellæ are lignified to a much greater extent than their secondary layers of thickening. It is further evident that the secondary and tertiary layers of thickening of the prosenchyma elements are the least lignified tissues of the wood. As a result of the dissimilar structure and microchemical reactions of the various elements we naturally would expect to find that the vessel walls would resist decay longer than any other one element. Of the other elements the middle lamellæ would be more resistant to the solvent action of the fungus than the secondary layers of thickening possessed by these respective elements. It would therefore appear that the secondary layers of thickening possessed by the wood prosenchyma elements would decay most rapidly.

Macroscopic Appearance of Decayed Wood.— In its general features the macroscopic appearance of decayed bitternut hickory wood is essentially the same as that described for yellow birch. The last element to resist decay within the individual pockets was the vessels, which evidently were strongly lignified. In well-decayed wood the vessels, under a hand lens, appear as minute glass tubes lying loosely within the various pockets, all the other elements having disappeared long ago. In fact the wood was decayed to such an extent that the individual vessels could be removed readily with tweezers and used for microscopic study. Numerous mycelial strands, running both longitudinally and radially through the decayed wood, were readily visible to the unaided eye.

Microscopic Characters of Decayed Wood.— The dissolution and course of delignification of the woody elements is essentially the same as that described for yellow birch. The various kinds of elements, however, decay in somewhat different order than in yellow birch, due to the entirely different structure of bitternut hickory wood.

Cross sections of well decayed bitternut hickory wood when treated with phloroglucin-HCl, present a very striking appearance. After staining with this reagent one is able to see clearly that the elements disappear in a definite order. The vessel walls take on an intense red-violet coloration even when remaining as almost isolated elements in a completely decayed mass. The cells immediately bordering the vessels likewise become colored deeply but the reddish-violet coloration is less intense than that exhibited by the vessel walls and diminishes rapidly in intensity so that a few cells away from the vessels this coloration is very slight or entirely lacking. Closer investigation, however, shows that the vessels usually are surrounded by a layer of wood parenchyma cells which, as will be shown later, also are very resistant to decay. Owing to this peculiarity and the fact that their walls were more intact it is apparent that the cells immediately adjoining the vessels are less susceptible to decay or at least decay more slowly than the more distant-lying elements. The pith-ray cells, as evidenced by the deep coloration acquired by their walls and their resistance to decay, are second only to the vessels in resisting decay. The pith-rays frequently remain in place with the cell-walls moderately intact and exhibit a good coloration with phloroglucin-HCl, while the elements on either side may be considerably disintegrated. The wood parenchyma cells are decayed before the pith-ray cells but remain intact much longer than the wood prosenchyma elements. Hickory wood, as explained earlier, is characterized by lines of wood parenchyma which extend tangentially between the pith-rays. In portions of decayed wood these two lines of elements can be seen remaining in a partially decayed state while the intervening spaces contain only the remnants of cells or may be entirely empty (Plate XXIV, Fig. 2).

In decayed wood treated with chlorzinc-iodine the lamellæ of the prosenchyma elements which remained colorless after treatment with lignin reagents were colored violet. The vessel walls, medullary ray cells, and wood parenchyma, as well as the middle lamellæ of the prosenchyma elements assumed a brownish-yellow tint, thus indicating that they were still lignified. The tertiary and secondary layers of the prosenchyma elements which fail to respond to lignin tests doubtlessly have been reduced to free cellulose, as evidenced by their violet coloration after treatment with chlorzinc-iodine. They remain in place until after all the cell-wall is delignified but the middle lamella. After all the layers of the cell-wall but the primary lamella have become delignified the destruction of the cellulose commences. As was seen to be the case in the decay of yellow birch wood, these cellulose layers frequently undergo a decided swelling upon the application of chlorzinc-iodine. The middle lamellæ of the prosenchyma elements remain in place and respond to tests for lignin not only until the tertiary and secondary walls have become delignified but even long after they have completely disappeared due to the dissolution of the cellulose remaining in them. In time, however, even the middle lamellæ become thinner and thinner until they break up into dissociated fragments. Even here microchemical tests show that the parts of the middle lamellæ which originally formed the cell corners, still respond to lignin tests while the other portions respond only to tests for cellulose.

In the earlier stages of the decay the hyphæ tend to extend themselves in the direction that offers the least resistance. As a result they are found to follow mainly the lumina of the various elements, especially those of the vessels. The vessel segments, however, are more or less occluded by tylosal formations which at first offer some resistance to the spread of the hyphæ. These tyloses, however, are comparatively thin and only serve to retard the spread of the hyphæ for a time as the fungal hyphæ soon dissolve their way through and continue their growth. In time the vessels often become filled with a dense growth of mycelium. As the decay progresses the hyphæ quickly ramify and penetrate adjoining cells, soon extending in all directions throughout the woody tissue. They are comparatively small, rarely being over two microns wide, usually much less. Cross-walls and clamp connections are occasionally discernible in the larger hyphæ.

Careful examination was made of sections of decayed wood to determine the action of the fungal hyphæ on the crystals of calcium oxalate in the wood parenchyma cells. In no case could any solvent action be noted. In a number of instances, however, crystals were seen which remained intact after all the surrounding woody tissue had been completely dissolved away. The crystals, of course, were retained in their original position in the sections by the celloidin matrix in which the material was imbedded. It would seem from this circumstance that these crystals are not only of no use to the fungal hyphæ but are not capable of being reduced by their enzyme secretions.

As in the decay of sugar maple wood, longitudinal sections of decayed wood showed a matting of fungal hyphæ within the vessels, these hyphæ often being encrusted with brown decomposition products. Sections (taken near the black zones) of wood in the early stages of decay exhibited abundant brown gum-like masses of decomposition products occluding the lumina of the vessels and other elements.

The Decay of Chestnut Oak Wood.

Structure of the Normal Wood.— The wood of the chestnut oak (*Quercus prinus* Linn.) is heavy, hard, strong, tough, moderately close-grained, and durable in contact with the soil. The heartwood is yellowish or reddish brown and sharply defined from the lighter and slightly reddish, narrow sapwood.

Macroscopically the wood of chestnut oak presents the usual features of the ring-porous type, the pores abruptly diminishing in size from early to late wood. The larger pores contain abundant tyloses. The pores in the early wood are arranged in 3–5 rows and are conspicuously large; those in the late wood are minute and arranged in radial lines branching toward the periphery of the growth ring. The pith-rays are exceedingly numerous and vary in size from those too small to see with the unaided eye to great broad ones.

Microscopically the wood of the chestnut oak is seen to consist of (a) both uniseriate and multiseriate pith-rays, (b) pitted vessels, (c) metatracheal zonate parenchyma with simple pits, and (d) wood prosenchyma of two distinct types, one having thin walls and bordered pits, and the other having thick walls and simple pits.[19] The pith-rays are exceedingly numerous and constitute about one-fifth of the cellular substance of the wood. Large pith-rays are often from twenty to thirty cells wide and from three to six times as high, and appear as long, well-defined lines in transverse sections. The pith-ray cells occur in from one to many rows closely packed together. Individually they are arranged end to end with their long axes in a radial direction. In a transverse section these radial rows of parenchyma cells appear as narrow but more or less distinct lines, the larger ones extending from the pith to the periphery of the stem. Where these cells are in contact with one another or with wood parenchyma fibers the pits are simple, but if they lie next to the vessels or tracheids the portion of the converging pits in the vessel walls is bordered, and that of the ray cells is simple.

The vessels or tracheæ make up chiefly the inner and more porous part of the growth ring. In the early wood they are round or elliptical and from 2-5 rows deep. Small vessels in the late wood are often polygonal and sometimes so small that their diameters hardly exceed those of the wood parenchyma elements. Radial rows of small vessels, which occur in the late wood, are wavy or slightly branched and surrounded by numerous wood parenchyma cells which often form narrow tangential bands. The vessels are composed of comparatively thin-walled tube-like segments arranged longitudinally end to end, the cavities of the vessels communicate

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[19] The description of the anatomical structure of this wood is based partially upon that given by Sudworth and Mell (1911, pp. 15–21; 38–39).

directly with one another, the adjoining ends being more or less completely absorbed so that the rows of cells or vessel segments finally form long, continuous tubes. The segments of the large vessels are barrel-shaped. After the vessels lose their sap and the air in them is rarified, tyloses (very delicate partition-like walls) begin to form and block up the cavities, rendering the heartwood impervious, or nearly so, to the passage of fluids. Tyloses consist of parenchymatous tissue which has been forced out of the turgescent adjacent thin-walled pith-ray cells or wood-parenchyma fibers into the lumina or channels of the vessels.

The individual cells of wood-parenchyma resemble the pith-ray cells, but are grouped in vertical instead of horizontal rows. They predominate in the more porous parts of the annual rings and often closely surround the vessels and tracheids. In either case they remain extremely thin-walled. In the early wood they occur isolated or scattered. In the dense late wood, the wood parenchyma elements form conspicuous regular or branched and interrupted tangential bands which can be seen readily with the unaided eye. The pits are chiefly simple. Wood parenchyma cells usually contain starch and also a certain amount of tannin. The amount and nature of the contents of the parenchyma depends largely upon the age of the tree, the time of felling, and the part of the tree from which the wood was taken. Crystals of calcium oxalate are of common occurrence in all parenchymatous tissue. As in sugar maple wood they are developed singly in the cells and belong to the tetragonal crystal system. In contiguous pith-ray cells they often form rows of 3–6, while in the wood parenchyma fibers they occur in much longer rows, particularly in the early wood, and are technically known as idioblasts. In such cases the whole cell becomes merely a repository for the crystal. Both the wood and ray parenchyma cells of the material examined were packed full of large starch grains, varying in shape from globoid to ellipsoid.

As stated earlier, two kinds of wood prosenchyma are present — compactly arranged, thick-walled fibers and scattered, thin-walled fibers. The former have occasional minute simple pits and are of the nature of typical wood fibers; the latter have numerous, more or less narrow, oblique bordered pits and resemble typical tracheids. The thick-walled wood prosenchyma elements are very fine, thread-like cells about 1.31 mm. long and 0.020 mm. wide. They occur in large compact groups alternating with the radial rows of more or less minute vessels of the late wood and are traversed radially by the uniseriate pith-rays and tangentially by irregular, more or less broken rows of wood parenchyma cells. The thin-walled wood prosenchyma elements occur scattered among the vessels, both the large vessels in the early wood and the radial rows of small ones in the late wood. (Plate XXV, Fig. 1.) The bordered pits in these prosenchyma elements are present irrespective of whether the contiguous elements are vessels, thick or thin-walled prosenchyma, or wood parenchyma cells. Except for the differences in the pitting of their walls, the thin-walled wood prosenchyma elements are essentially the same as the thick-walled ones. Tracheids are single fiber-like elements and are, therefore, easily distinguished from the vessels since the latter are formed by the fusion of cells placed end to end. In transverse sections, however, it is more difficult to separate them from the very small vessels.

Microchemical Reactions of Normal Wood.— Cross sections of normal wood, when treated with chlorzinc-iodine, exhibit comparatively little of the violaceous coloration indicative of cellulose. The large groups of thick-walled wood prosenchyma elements are the only elements to exhibit any appreciable violaceous color. The middle lamellæ of all the cells and the entire vessel walls are colored a golden brown. Both the secondary and tertiary lamellæ of the tracheids, the wood parenchyma and the ray parenchyma cells are colored a lighter brown than the middle lamellæ and exhibit little or no violaceous coloration. The ray parenchyma cells and the wood parenchyma fibers were very conspicuous after staining with chlorzinc-iodine, due to the dark blue coloration taken on by the starch grains contained in these cells. In the areas of the growth ring occupied by large groups of thick-walled wood fibers both the secondary and tertiary lamellæ of these elements exhibited a light violaceous coloration. In sections treated with phloroglucin-HCl the walls of the large vessels and the multiseriate pith-ray cells are stained most strongly, becoming reddish violet. The middle lamellæ of all the cells also exhibit about the same degree of coloration; this is especially striking at the cell corners where the middle lamellæ often are thickened. The remaining layers of the small vessels, the cells of the uniseriate pith-rays, and the tracheids also become colored reddish-violet, but the coloration is much less intense than that exhibited by the walls of the large vessels. The secondary and tertiary layers of the wood fibers are colored still lighter, in fact, almost violet. The elements immediately surrounding the large vessels in the early wood of the growth ring frequently are colored almost as deeply as the vessel walls. After treatment with aniline sulphate-H_2SO_4 the walls of the large vessels and the multiseriate pith-rays take on a rich golden-yellow. The middle lamellæ of all the cells also are colored to the same extent and the coloration is especially striking at the cell corners. The remaining layers of the small vessels, the cells of the uniseriate pith-rays, and the tracheids also become strongly yellow-colored, but not nearly so much as the walls of the large vessels. The secondary and tertiary layers of the wood fibers turn only to a very pale yellow. The elements immediately surrounding the large vessels are colored almost as deeply as the vessel walls.

From the above tests described in full detail, and from still other tests employed for the differentiation of both cellulose and lignin, it is evident that the vessel walls and the cells of the multiseriate pith-rays are the most strongly lignified elements of the wood. Of the individual elements the middle lamellæ is the most strongly lignified layer. It is clear that the secondary and tertiary layers of the wood fibers are the least lignified portions of the wood. As a result of the dissimilar structure and microchemical reactions of the various elements we would expect the multiseriate pith-rays to resist decay even longer than the comparatively thin-walled vessels. Of the individual elements the middle lamellæ would resist decay longer than the secondary layers of thickening of the respective elements. The least resistant layers would be the secondary and tertiary layers of the wood fibers.

Macroscopic Appearance of Decayed Wood.— The macroscopic appearance of decayed chestnut oak wood shows essentially the same type of decay that occurs in the other woods. Numerous fine black zones are to be seen in decayed trunks, when the decay has not progressed too far. Their occurrence is the same as in the other decayed woods described, namely, surrounding areas of undecayed wood and demarking them from the surrounding decayed wood. The black zones occurring in decaying chestnut oak (or other oak) wood usually are thinner and less conspicuous than those which predominately occur in the decay of most other dicotyledonous woods. The decayed wood examined was very friable but by no means in the last stages of decay. The pockets occurring in the decayed wood were somewhat inconspicuous owing to the heterogeneous structure of the wood. They were clearly visible, however, after the surface of the wood was moistened. Owing to the broad pith-rays of this wood its decay is quite comparable to that of sugar maple wood. The effect of the broad pith-rays in retarding the decay from spreading in any other than a radial direction is even more strongly exemplified in chestnut oak wood than that of sugar maple. The multiseriate pith-rays of chestnut oak wood are exceptionally thick, high, and broad, many of them extending unbroken from the pith to the bark. Unlike sugar maple wood, however, they do not lie so closely together. Nevertheless, they are important factors in forcing the decay to spread mainly in a radial direction, since, owing to their lignified nature, they are not attacked and penetrated nearly so readily as the other elements of the growth ring. As a result of this unequal spread of the fungus the decayed wood tends to rupture far easier in a radial direction than in any other. In the more advanced stages of decay the broad medullary rays are still fairly sound and can be separated readily from the other elements which are considerably decayed. The numerous broad medullary rays which transverse the annual rings of growth serve to bind together the layers of growth so that there can be no separation along the line of the annual rings. In this way the medullary rays act as reinforcing structures so that the decayed wood responds far less to radial than to tangential compression. They likewise serve to increase materially the transverse breaking strength of the decayed wood. In consequence of the strengthening effect afforded by the medullary rays of this wood a trunk of chestnut (or any other) oak rotted by *Polyporus pargamenus* would resist breaking longer than those of most any other kind of wood decayed to a like extent by the same species of fungus.

Microscopic Characters of Decayed Wood.—The dissolution and course of the delignification of the woody elements is as near like that described for yellow birch wood as could be expected of a wood of such dissimilar structure. The thick-walled wood prosenchyma elements are the first to disappear and are closely followed by the thin-walled ones. After the disappearance of these elements the decayed wood appears skeletonized. At this stage of the decay the uniseriate pith-rays, the tangential rows of wood parenchyma cells, and the partially dissolved small vessels are still visible and are the only elements remaining within the intersections formed by the radially extending pith-rays and the tangential rows of wood parenchyma cells of the late wood. In this connection it may be mentioned that the late wood decays faster than the early wood of the annual ring, since the latter is composed mostly of large vessels surrounded by tracheids, both of these elements being highly lignified in this portion of the growth ring. Within the late wood of the growth ring the wood parenchyma cells are the next elements to disappear. By the time the parenchyma cells have disintegrated more or less completely the uniseriate pith-rays and the small vessels begin to break up. The large vessels in the early wood of the growth ring remain fairly intact until practically all of the elements of the late wood have become considerably broken down. However, even these elements undergo digestion earlier than the occasional large multiseriate pith-rays. Even in thoroughly decayed wood these large pith-rays still remain hard and resistant, while the rest of the wood can be powdered readily by rubbing it between the fingers. It will be noticed here again that the elements in general disappear in a definite sequence which depends upon the degree of lignification exhibited by them. The individual cells of the multiseriate medullary rays probably are no more lignified than the large vessels, but their greater resistance to decay is to be attributed to the fact that they contain a greater mass of lignified tissue than do the vessels, and hence they are not penetrated so readily by the fungal hyphæ. Although the broad medullary rays do not occur so closely together as in sugar maple wood, they are much broader than the rays of the latter wood and would offer a very efficient barrier to the spread of the decay within the trunk in any other than a radial or perpendicular direction. The outermost rows of tangentially flattened cells in the growth ring are no more lignified than the other elements of the late wood and do not appear to resist decay any longer than the other elements. In the decay of sugar maple wood it will be remembered that the reverse circumstance occurred.

Longitudinal sections of decayed wood usually exhibit a great abundance of matted growths of hyphæ. In the later stages of the decay the network of resistant wood bounding the pockets largely disappears and in its place zones of matted fungal hyphæ occur, often forming a reticulum through the wood. (Plate XXV, Fig. 2.) The mats of hyphæ extend through the elements in all directions, crossing the vessels and even the large pith-rays. As a rule they are practically free from incrustations of brown decomposition products. As in the decay of sugar maple and bitternut hickory wood the fungal hyphæ apparently do not exert any solvent action upon the crystals of calcium oxalate commonly occurring in the wood parenchyma cells.

The Decay of Hemlock Wood.

Structure of the Normal Wood.—The wood of the hemlock [*Tsuga canadensis* (Linn.) Carr.] varies from light to medium weight, is soft, weak, stiff but brittle, coarse, and not durable in contact with the soil. The sapwood and heartwood are not well defined. The heartwood is but little darker than the sapwood; its color may be described as light brown with a slight reddish hue. The medullary rays are very fine, numerous, and inconspicuous to the unaided eye.

Microscopically the wood of the hemlock is of the nonporous type. Vessels are absent and the wood is composed of elements fairly uniform in structure. The contrast between the early and late wood is very decided, the transition frequently being abrupt. The growth rings are defined by the greater density of the late wood. Resin ducts normally are lacking. The wood consists of (a) uniseriate pith-rays; (b) tracheids with bordered pits, and (c) terminal wood parenchyma cells. The rays are numerous, distant 2–10 rows of tracheids, and vary from low to high. They are composed of two elements: (1) ray parenchyma cells with simple pits and (2) ray tracheids with bordered pits, the latter elements often interspersed, but mostly of marginal occurrence when viewed radially. According to Penhallow (1907, p. 267) the ray cells are somewhat contracted at the ends and average 3–5 spring tracheids in length. The upper and lower walls are very irregularly and often imperfectly, sometimes very sparingly, pitted. The terminal walls are not strongly pitted except in the summer wood. The lateral walls have small, oval pits, at first with a very narrow border which becomes more prominent toward the summer wood, the lenticular orifice becoming oblong; there are from 2–4, or in the summer wood from 1–2, pits per tracheid.

The wood tracheids in the spring wood are large and very thin-walled, conspicuously squarish or often elongated radially; furthermore, they are very uniform and in regular rows. In the summer wood they are more numerous, with thicker walls and smaller lumina, and in tangential section appear flattened, especially at the outer margin of the growth ring. Bordered pits, either round or elliptical in 1–2 rows, more rarely in 1 row only, with large orifices, occur on the radial walls of the wood tracheids. According to Penhallow (*l. c.*) pits also occur on the tangential walls of the summer wood tracheids and are rather numerous, prominent, and flat. The resin cells or wood parenchyma cells (transverse section) are rather prominent, being more or less numerous on the outer face of the growth ring and rarely zonate. In addition the wood of hemlock normally is characterized by the absence of resin passages.

Microchemical Reactions of Normal Wood.— Normal hemlock wood treated with chlorzinc-iodine demonstrated the presence of comparatively little cellulose, most of the coloration being in the late wood. The entire cell-walls of the spring tracheids, the pith-ray cells, and the middle lamellæ of the summer wood tracheids exhibited a brown coloration. The tertiary and secondary lamellæ of the summer wood tracheids, however, did not color brown but exhibited a faint violaceous coloration. Evidently the reaction for cellulose was obscured by the presence of other substances within the cell-walls. In sections that had soaked for a time in a mixture of alcohol and glycerine the violet coloration exhibited by these layers of the cell-wall was far more pronounced. In sections treated with phloroglucin-HCl the middle lamellæ of all the cells were stained the strongest of all, becoming wine-colored. The remaining walls of the tracheids in the late wood colored deeply, but less strongly that the middle lamellæ; they colored to a deep reddish-violet. The secondary walls of the early wood tracheids assumed a somewhat lighter coloration. The cells of the medullary rays are very thin-walled and exhibit the same coloration as the tracheids of the early wood. After the treatment of sections with aniline sulphate-H_2SO_4 the middle lamellæ of all the cells again colored most strongly, becoming golden yellow. The remaining layers of the late wood tracheids likewise were colored golden yellow, but not quite so strongly as were the middle lamellæ. The golden yellow color acquired by the late wood tracheids diminished in intensity in the tracheids of the early wood.

From the above tests described in full detail, and from still other tests employed for the differentiation of both cellulose and lignin, it is evident that of the individual cells the middle lamella is more strongly lignified than any other layer of the cell-wall. The tests employed indicate that the tracheids of the late wood are lignified to a much greater degree than the other elements of the growth ring. The medullary ray cells in the late wood apparently are no more strongly lignified than those in the early wood of the growth ring. From the dissimilar structure and microchemical reactions of the various elements we would expect the tracheids of the late wood to be far more resistant to decay than those of the early wood. The cells of the medullary rays of the wood examined responded strongly to the iodine test for starch, since the wood was cut late in the autumn.

Macroscopic Appearance of Decayed Wood.— As in the other woods studied the first evidence of decay is the occurrence in the wood of small irregular areas in which the tissues have lost their natural light brownish coloration and appear as though bleached. As the decay progresses it is evident that it is confined to numerous centers of activity, resulting in the formation of small pockets separated by narrow zones of wood which decay far less rapidly. At first the future pockets appear as bleached areas separated by a network of wood retaining its natural color. Within the individual pockets the decay progresses in a direction parallel to the woody elements, and in time the wood in these areas rapidly disintegrates and becomes pith-like. Even when the decay in the individual pockets is more or less complete the wood between the pockets is but little decayed so that it appears as a network of lines bounding the pockets.

The fungus usually begins to decay at the point of union of two growth rings. In hemlock wood the progress of the decay seems to be dependent upon the physical qualities of the woody tissue in the different portions of the growth ring.

In this wood the contrast between early and late wood is very decided. Consequently it is only natural that the decay should start between the annual rings where the soft spring wood adjoins the hard summer wood. Therefore, as the decay progresses we should expect to find the soft spring wood decaying far more rapidly than the harder summer wood. It is characteristic of the decay that the early wood, especially the innermost portion, becomes badly disintegrated and full of large pockets, while only the outermost surface of the late wood is attacked, and then only very superficial pockets appear. Thus we have an explanation of one of the most conspicuous features of the decay of hemlock wood by *Polyporus pargamenus* — the separation of the annual layers of growth in the early stages of the decay. Owing to the peculiar structure of this wood and the manner in which it is decayed by the fungus, it is only natural that it should separate along the line of the growth rings when subjected to any stress.

In the later stages of decay the wood becomes almost uniformly pith-like and full of conspicuous pockets of varying size. (Plate XXVI.) Within local areas of the wood disintegration often becomes so complete that a mere shell of wood of quite uniform thickness is all that separates the pockets from one another. The pockets are very variable in size, depending upon the extent to which they have united. The largest of the pockets rarely exceed 10 x 2 x 2 mm., extending in the wood in a direction parallel to the axis of growth. At this stage of the decay most of the pockets are entirely empty and free of any partially decomposed woody fibers and present a clean-cut appearance. Closely appressed to the inner walls of the pockets are numerous fine white strands of mycelium, which can be seen to best advantage in a longitudinal section of the wood. In addition larger white strands of mycelium frequently transverse the pockets at right angles (Plate XXVI), the same strand frequently extending through several pockets. At this stage of the decay the finer grained wood and wood of uniform and regular growth at least has a regular honeycombed appearance, as shown by the transverse view. The separation of the wood along the line of union of the growth rings is now less conspicuous, for by this time it has become so thoroughly decayed that it tends to break in all directions with equal facility, although it still is far more resistant to transverse breakage than to breakage in any other direction.

At the beginning of the decay all the pockets originated on the inner face of the early wood. In the latter stages of the decay the unequal structure of the two portions of the annual ring is overcome, especially in trees in which this difficulty is not so pronounced, and the whole of the annual ring frequently is uniformly decayed. In general the decayed wood is characterized by a single zone of pockets occupying most of the annual ring, all of which lie well within their respective growth rings. In other words, the pockets are confined to the interior of each growth ring and do not occur with equal facility at the line of junction of two adjacent growth rings as is commonly the case in most of the dicotyledonous woods which have a far more uniform structure so far as the density of the elements in the early and late wood respectively is concerned.

In the very late stages of the decay, when the unequal structure of the two portions of the growth ring is overcome, the pockets, by the successive fusion of adjacent ones, may extend from one growth ring into the next so that the zonate arrangement of the pockets within each growth ring becomes entirely obscured. By this time many of the pockets have attained an unusually large size, some being 3.5 cm. or more long and 6 mm. or more broad. They are still highly irregular in outline and are separated by very thin, almost membrane-like layers of spongy wood. The larger pockets are free from contents and their walls appear clean-cut and smooth save for numerous mycelial strands, most of the larger of which run radially in the wood. The remaining woody substance no longer presents a brownish and whitish mottled appearance, but the honeycombed wood now is of a uniform light brown color. This is due to the complete destruction of the partially disintegrated elements that earlier remained in the pockets and gave them a whitish appearance. The remaining woody tissue is now very soft and sponge-like when wet; when dry it becomes somewhat stiffer and more brittle, but still retains much of the spongy texture.

The bark of the hemlock, on the other hand, is very resistant to decay and remains entirely sound, even though all of the sapwood immediately underlying it be reduced to pith-like consistency. Its extreme durability is due, in a large measure, to the high tannin content.

Comparison of the Decay of Hemlock Wood by Polyporus pargamenus and P. abietinus.— Earlier in this paper an effort was made to distinguish between the sporophores of *P. pargamenus* and its near relative, *P. abietinus.* The resemblance of the decay produced in hemlock by these respective fungi, however, is even more confusing than the resemblance between their sporophores. In hemlock wood of a more nearly uniform structure it has been noticed that *P. abietinus* sometimes begins to decay the late wood first. Whether this ever occurs in the decay caused by *P. pargamenus* the writer is unable to say. In other cases *P. abietinus* decays the early wood just as rapidly as the late wood, and in hemlock wood of a decidedly uneven texture the early wood is considerably decayed before the late wood of the annual ring is attacked appreciably. Hemlock wood decayed by *P. pargamenus* had numerous prominent white strands of mycelium running radially in the wood. In that decayed by *P. abietinus* the radially running white mycelial strands were even more abundant and conspicuous. Aside from these minor differences no other difference in the manner of the decay of hemlock wood by these two closely related fungi could be observed macroscopically.

Microscopic Appearance of the Decayed Wood.— From the microscopic appearance of the decayed wood it is evident that extensive chemical changes must have occurred to produce such great structural alterations of the woody substance. A comparison of cross sections of both normal and decayed wood after treatment with various microchemical reagents reveals the action of the fungus.

In sections of decayed wood narrow, irregular zones of wood, in which the cell-walls respond to lignin tests as strongly as they do in normal wood, separate the pockets or decayed areas. Bordering on these cell-walls, which react the same as those of sound wood, are other cells in all stages of decomposition. The cell-walls of the decayed wood become colored variously, the coloration assumed corresponding with the degree of decay exhibited by the cell-walls. Those walls remaining but little or not at all decayed color the same as those in the sound wood. In other parts of the sections the tertiary layer — that portion of the cell-wall which borders upon the lumina of the cells — fails to take on the characteristic coloration or at least becomes stained only slightly, thus indicating the beginning of delignification. In other groups of cells both the tertiary and secondary layers of the cell-wall fail to take on the characteristic coloration to any appreciable extent. This indicates a more advanced stage of the decay and consequently the delignification.

The layers of the cell-walls that remained colorless after treatment with lignin reagents become colored violet when treated with cellulose reagents such as chlorzinc-iodine. In some cells only the tertiary lamella colors violet, the secondary and primary lamellæ becoming brown. In other cells only the middle lamella colors brown, both the secondary and tertiary layers becoming violet. Sections from a number of blocks of decayed wood were examined to see if any swelling of the cellulose layers occurred after treatment with chlorzinc-iodine. In the material examined, however, but little or no swelling of the delignified layers of the cell-wall could be detected after treatment with this reagent. The middle lamellæ retain their lignified nature long after the complete dissolution of the secondary and tertiary lamellæ of the respective cells. After the dissolution of the other layers of the cell-wall the middle lamellæ do not remain intact as long as those of yellow birch. Soon after the destruction of the tertiary and secondary layers the middle lamellæ become broken up into dissociated fragments, among which the lignin reaction persists longest at the cell corners where the middle lamellæ are the thickest. In time, however, even these portions of the middle lamellæ become delignified and take on a pronounced violet coloration with chlorzinc-iodine.

Sections of decayed wood are stained permanently with aniline safranin and Delafield's hæmatoxylin and depict the occurrence of lignin and cellulose respectively within the cell-walls. In those cell-walls which are still comparatively free from decay the middle lamellæ stain a bright red while the secondary and tertiary lamellæ are paler. In adjoining cells where the tertiary lamella has been delignified this layer appears blue thus indicating the presence of free cellulose. In cell-walls that are still further decayed very little red (indicating lignified walls) appears and more blue (indicating free cellulose) appears on the inner portion of the cell-walls. Examination of cells immediately bordering on the empty pockets shows that the thickened corners of the middle lamellæ are the last elements to disappear under the action of the fungus. In portions of sections of decayed wood where a crumbled mass of fragments is all that remains of a group of elements, these thickened corners of the middle lamellæ may still be seen on account of their bright red color. In other parts of this mass of material consisting chiefly of dissociated remnants of the middle lamellæ it can be seen that the latter have taken on a blue coloration, thus indicating that even that portion of the cell-wall which originally was most strongly lignified ultimately has been reduced to free cellulose.

Sections were not made of hemlock wood in an early stage of decay where only the springwood was decayed and the harder summerwood remained normal. All of the wood studied microscopically was in the advanced stages of decay and had pockets distributed uniformly throughout the growth ring, each pocket being separated by irregular, narrow zones of less decayed wood. The medullary ray cells do not appear to be dissolved any quicker than the adjoining tracheids. In fact within any one pocket or center of decay all the elements disappear with approximately equal rapidity. In the earlier stages of the decay the hyphæ follow mainly the course of the tracheids and medullary rays. The lumina of the tracheids frequently become occluded by a dense growth of minute fungal hyphæ. By the time pockets have been formed in the wood the fungal hyphæ are found to be abundant in nearly all the woody elements, penetrating them in all directions and filling their walls with numerous perforations. The perforations made in the walls of the elements are exceedingly minute at first but continue to enlarge until they become many times their original size. The hyphæ frequently pass from one tracheid to another by means of the bordered pits on their radial walls. In such cases the entire pit — border and all — often is dissolved out entirely. The hyphæ found in decaying hemlock wood as a rule are so fine and minute that their morphological features necessarily are indistinguishable. Occasionally, however, larger hyphæ occur which lack protoplasmic contents and in which cross walls and clamp connections can be observed. In radial sections of decayed wood numerous mats of hyphæ may be seen extending across one or more tracheids, occluding the cell lumen of each tracheid. These wefts of hyphæ seem to be incrusted with a light brown substance — possibly certain by-products of decomposition.

Tests for lignified and cellulosic tissue agree with one another in that they show a gradual delignification of the cell-wall, commencing at the lumina of the cells and proceeding outward, the thickened corners of the primary lamellæ being the last elements to become delignified. The destruction of the cellulose follows closely after delignification — in fact so closely that but little free cellulose is left temporarily in the partially decomposed cell-walls. From the closeness with which the destruction of the cellulose follows delignification it is evident why the pockets found in hemlock wood in the latter stages of decay always are so clean-cut and free from partially decomposed woody material which, in the majority of decays, usually consists of free cellulose.

The Decay of Other Woods.

The foregoing five particular woods were selected on the basis of their structure as type woods for the study of the decay produced by *Polyporus pargamenus*. At the beginning of this part of the investigation it was thought that broader and more momentous conclusions could be drawn regarding the nature of the decay produced by this particular fungus if the study was made on a number of representative woods of as widely different structure as possible, rather than on a number of woods selected more for the convenience with which they could be obtained. At the same time the idea of working with species of wood of commercial value for lumber was not lost sight of. In view of this feeling, type woods were selected from each of the three commonly recognized groups of woods. Among the heterogeneous (dicotyledonous) or porous woods yellow birch and sugar maple were selected as representatives of the diffuse-porous group, while bitternut hickory and chestnut oak were selected as representatives of the ring-porous group. Among the homogeneous (coniferous) or non-porous class of woods hemlock was selected as the representative wood. As a matter of fact, the selection of hemlock was a necessity since, with one exception, it was the only coniferous wood found to serve as a host for this particular fungus.

The results secured from the study of these five woods were further supplemented by macroscopic studies on other woods, although only the five type woods were imbedded in celloidin and sectioned on the microtome. The macroscopic appearance of the decay of the following woods by *Polyporus pargamenus* was examined and found to be essentially the same as occurred in the five type woods that were studied in full detail: Butternut (*Juglans cinerea*), pignut hickory (*Hicoria glabra*), glaucous willow (*Salix discolor*), trembling aspen (*Populus tremuloides*), large-tooth aspen (*Populus grandidentata*), white birch (*Betula populifolia*), paper birch (*Betula papyrifera*), sweet birch (*Betula lenta*), river birch (*Betula nigra*), blue beech (*Carpinus caroliniana*), chestnut (*Castanea dentata*), beech (*Fagus atropunicea*), white oak (*Quercus alba*), live oak (*Quercus virginiana*), red oak (*Quercus rubra*), scarlet oak (*Quercus coccinea*), yellow oak (*Quercus velutina*), pin oak (*Quercus palustris*), black jack oak (*Quercus marilandica*), willow oak (*Quercus phellos*), tulip-tree (*Liriodendron tulipifera*), sassafras (*Sassafras sassafras*), red gum (*Liquidambar styraciflua*), wild plum (*Prunus americana*), wild red cherry (*Prunus pennsylvanica*), black cherry (*Prunus serotina*), red maple (*Acer rubrum*), and striped maple (*Acer pennsylvanicum*).

Summary of the Physical and Chemical Changes in Decayed Wood.

Macroscopic Characters.— Cross sections of trunks of the four dicotyledonous woods studied here in full detail, as well as many of the other dicotyledonous woods studied only macroscopically, exhibit a number of conspicuous, irregular zones of black wood. These black zones are present invariably in the early stages of the decay of most dicotyledonous woods and often are prominent features of the decomposition. No such black zones, however, were present in decaying hemlock wood. A more detailed discussion of these black zones, in which their origin, physiologic significance, and chemical relationships will be considered, will later be taken up under the heading "The Metabolic Products of *Polyporus pargamenus.*"

The decays of the five woods of widely different structure selected for study here, all agree in their salient features. The first evidence of incipient decay is in the appearance of small, irregular areas in which the tissues have lost their natural color and appear as though bleached. These lighter areas are destined to become individual centers from each of which the decay spreads in all directions. The decay is at first localized or confined to these innumerable centers in which the destruction of the woody elements becomes completed before the decay spreads farther. As a result of the peculiar manner in which the decay acts the wood is decayed unequally, the decayed wood appearing as light-colored areas while the less decayed wood lying between these areas still retains much of the normal color of the wood and appears on all three sections as a delicate network of lines. This network of less decayed wood usually is rather inconspicuous on the surface of dry wood but stands out quite prominently after the surface of the wood has been moistened. Even after moistening it sometimes still remains somewhat obscure in woods that possess very broad pith-rays, such as species of *Quercus*. In the course of time the elements within the individual centers for the spread of the decay become more or less completely disintegrated, while the thin zones of wood remaining between the decayed areas are still but little decayed. In general, excluding hemlock, all parts of the annual ring are equally susceptible to the attacks of the fungus. In hemlock, however, the decay originates in the soft early wood of the growth ring, the hard late wood not being attacked until much later.

As the solvent action of the fungus continues to progress the white, decayed areas continue to enlarge. Within the individual decayed areas the decay progresses mainly in a direction parallel to that of the woody elements. In the course of time the woody elements in these respective areas are reduced rapidly both in color and hardness until they become more or less pith-like. This method of decomposition results in the formation of innumerable pockets throughout the wood, these pockets being separated by thin, often almost membranous, layers of less decayed wood. In the intermediate stage of the decay numerous white strands of mycelium, running both longitudinally and radially through the wood, often can be seen with the unaided eye. The presence of these strands of mycelium, however, seems to be dependent upon the activity of the fungal hyphæ within the decayed wood. By the time the decay has progressed to this point the wood has lost all of its original characteristics of color, odor, hardness, and strength, and has become a bleached mass of pithy consistency. Standing trees frequently are broken-off long before they become decayed to this extent.

This, however, depends largely upon the age of the tree, structure of the wood, and the durability of the heartwood of the attacked species.

In still later stages of the decomposition two or more adjoining decayed areas or pockets frequently coalesce into one so that the wood has a decided " pocketed " appearance. The individual pockets are highly irregular in outline and their size depends entirely upon the extent of the decay. The largest pockets observed were in yellow birch wood, where they attained a maximum size of three mm. in diameter and three cm. in length. In general the greatest dimension of the pockets occurs in the same direction that the woody elements extend; occasionally, however, it extends at right angles to them. In the later stages of the decay the individual pockets are quite empty of contents save for a few scattered tubular elements — the vessels. Owing to their greater lignification these elements are the last ones to disappear under the dissolving action of the fungus in most woods.

In woods with very broad pith-rays, such as the maples and oaks, the larger pith-rays outlast the vessels and are the last element to disintegrate under the dissolving action of the fungus. In those woods having such broad pith-rays the tendency to the formation of pockets is more or less retarded by the presence of these pith-rays which are very resistant to decay. The broad pith-rays possessed by both maple and oak offer exceptional resistance to the spread of the mycelium in any other than a radial or horizontal direction. In the late stages of the decay these broad pith-rays which transverse the annual rings of growth in a radial direction, serve to bind together the layers of growth so that there is no separation of the decayed wood along the line of the annual rings as usually occurs in those woods which lack the broad pith-rays. Woods possessing such broad pith-rays would tend to resist the decay produced by *Polyporus pargamenus* much longer than other woods which lack them. The former type of woods, when decayed while in use, would hold under the strain imposed upon them much longer than would those woods which lack these reinforcing structures.

The outer, corky bark of all the trees studied (both microscopically and macroscopically) has proved to be exceedingly resistant to decay. This outer, corky bark frequently remains entirely sound and free from decay in many trees even after the inner bark and the underlying sapwood may be completely rotted. The great resistance of the outer bark of most trees to decay is to be attributed to the presence of tannins which are noted for their preservative qualities. The efficacy of intact and uninjured mature bark as a barrier to the entrance of parasitic fungi into the trunk cannot be too strongly emphasized. When the outer, corky bark has become injured, however, the inner fibrous bark is of no avail in keeping out the spores of wood-destroying fungi. As a matter of fact the exposed cambial layer, which is exceedingly rich in food materials, immediately affords a highly favorable environment for the germination and subsequent development of any fungous spores that may chance to lodge thereon. In attacked trees, especially felled ones, the rapidity with which the fungous mycelium spreads between the bark and the sapwood is nothing short of surprising. In the course of the decay of the inner bark pockets or cavities are produced in it similar to the ones found in the decaying sapwood.

Microscopic Characters.— Prepared slides of the decayed woods, when examined under the microscope, show up the pocket formations very clearly. The pockets containing wood elements in various stages of decomposition are separated from one another by irregular zones of less decayed wood, varying from a few to several cells wide. In sections of wood in an advanced stage of decay all stages of decomposition, from incipient delignification to the complete disappearance of the elements may be seen. In the central cells of such zones all three layers of the cell-wall of the elements respond to lignin tests as they do in normal wood. The cells bordering on these elements are in various stages of decomposition. In some the tertiary layer no longer gives the characteristic color reactions when treated with various lignin reagents, but remain colorless. In other cells the secondary lamella of the cell-wall also remains colorless and undoubtedly consists of practically pure cellulose. As a general rule both the secondary and tertiary lamellæ remain in place until after all the cell-wall but the middle lamella becomes delignified. After all the layers of the cell-wall but the primary lamella have become delignified the destruction of the cellulose commences. Those layers of the cellulose walls which remained colorless after treatment with lignin reagents take on a pronounced violet color when treated with cellulose reagents, such as chlorzinc-iodine. Groups of these cells sometimes are seen in which the middle lamellæ are colored brown with chlorzinc-iodine, while the secondary and tertiary lamellæ are colored a deep violet and frequently exhibit a pronounced swelling. Occasionally these cellulose layers swell up to such an extent that the cell lumen is scarcely visible. In general the dissolution of the cellulose does not occur within any one cell until some time after its wall, excepting the middle lamella, has become completely delignified. Within the individual cell the cell corners, where the middle lamellæ often are thickened characteristically, respond the longest to tests for lignin. Owing to the great degree of lignification exhibited by the middle lamella it remains in place long after both the tertiary and secondary layers of the cell-wall have disappeared. After the secondary layers of thickening have been dissolved the resulting woody tissue has a skeletonized appearance. It has all the elements but their walls consist principally of the middle lamella, the other lamellæ having practically all been dissolved away. These middle lamellæ retain the nature of lignified walls and offer considerable resistance to further dissolution. They are the last part of the cell-wall to disappear and, as stated before, remain in place long after the other lamellæ have completely dissolved. However, they too gradually grow thinner and thinner until they break up into irregular fragments. It is not until the middle lamellæ have disintegrated to this extent that they respond to the cellulose test with chlorzinc-iodine. The corners of the middle lamellæ, where they are thickest, are the last portions to disappear under the dissolving action of the fungus.

Within the individual pockets or decayed areas the various classes of elements disappear in a definite order, depending upon the thickness of their walls in conjunction with their degree of lignification. In general, in the dicotyledonous woods studied, the thick-walled but little lignified wood prosenchyma elements are the first to disappear. In the decay of yellow birch wood the uniseriate pith-rays sometimes disappear before the other elements. It is highly probable that, in the case of living trees at least, the rapidity with which the pith-rays are attacked and destroyed depends largely upon the time of year that the wood was attacked by the fungus. If a tree was attacked at a time when large amounts of reserve food was stored in the pith-ray cells, it is quite likely that the smaller medullary rays at least would be the first elements to be attacked and dissolved by the mycelium. After the wood prosenchyma elements have disappeared the next element to go usually is the uniseriate pith-rays. The order in which the other elements disappear is subject to considerable variation in the different woods. In those woods containing but scanty wood parenchyma this element disappears before the multiseriate pith-rays. In those woods containing well-developed wood parenchyma this element disappears simultaneously with the multiseriate pith-rays. In those woods having no very large pith-rays, such as yellow birch and bitternut hickory, the vessels are the last element to disappear within the individual pockets. In those which contain broad pith-rays, such as sugar maple and chestnut oak, the broad pith-rays resist decay longer than the vessels. In general it may be stated that the vessels resist decay longer than any other one element excepting the broad medullary rays. Where the vessels occurred in groups they frequently separated from one another before they became entirely dissolved. The vessel walls behave very similarly to the middle lamellæ; they are very uniformly lignified throughout but at the same time they are lignified to a much greater extent than the middle lamellæ of the other elements. In the case of hemlock, however, most of the elements being uniform in structure, they decay at approximately the same rate.

The mycelium exhibited essentially the same relation to each of the woods studied. In the early stages of the decay of dicotyledonous woods the larger hyphæ tend to extend themselves in the direction that offers the least resistance. As a result of this tendency they extend longitudinally, following mainly the lumina of the various elements, particularly the vessels. When medullary rays are reached the hyphæ frequently branch off and enter them. The vessels often become filled with dense plugs or matted growths of fungal hyphæ. These mats of hyphæ are brown by reason of being incrusted with decomposition products. The latter are partially soluble in 5 per cent KOH and entirely soluble in warm nitric acid. In general the majority of the hyphæ elongate horizontally in the direction of the majority of the elements, during the earlier stages of the decay. In the later stages of the decay, however, the mycelium branches profusely and grows in all directions, perforating the walls of the woody elements at random. As the hyphæ continue to branch and multiply beyond the ordinary conception they permeate the woody substance in all directions and are thereby enabled to slowly dissolve the woody substance by means of their enzyme excretions. The hyphæ observed in the wood, as a general rule, are exceedingly fine and minute, rarely being over two microns wide and usually much less. Cross-walls and clamp connections are discernible occasionally in the larger hyphæ. In the course of the decay the hyphæ seem to disappear from the wood as soon as the decay of any one portion becomes completed. Numerous holes occur all through the wood indicating where the hyphæ had passed through the cell-walls. The threads exhibit no particular preference for the pits but penetrate the cell-walls at will. In those woods (sugar maple, bitternut hickory, and chestnut oak) which contain abundant crystals of calcium oxalate, these crystals were found to be left perfectly intact after all of the surrounding woody substance was dissolved. From this observation it must be concluded that they are not only of no use to the fungal hyphæ but that they are not even capable of being dissolved by their enzyme excretions.

In all of the five woods studied in full detail it is evident that the first main chemical change brought about by the action of the fungal hyphæ is that of delignification. It is due to this action that the elements lose their natural brownish color and appear as though bleached. The results obtained indicate that the decay begins at the interior of the cell-wall and destroys the cell-wall progressively from the internal or last-formed lamella to the middle or primary lamella between two adjoining cells, first removing the lignin constituents. It is evident, furthermore, that delignification commences in the tertiary layer and proceeds outward toward the middle lamella or primary layer. After the cell-wall is delignified down to the middle lamella the reduction of the remaining cellulose layers then commences. After the destruction of the cellulose nothing is left but a skeletonized framework of middle lamellæ which in turn break up into fragments and undergo dissolution. Thus within a pocket or unit area of decay all stages of decomposition from incipient decay to final decay may be seen, all within the range of a few cells.

The results obtained from the above study of the decay by *Polyporus pargamenus* of five species of woods of such dissimilar structure are especially interesting in that they show a correlation between the structure of the wood and its detailed course of decay. The results obtained show clearly that the minor variations in the decay of different woods by this fungus are due to the dissimilar physical and chemical structure of the respective woods. In view of this fact it behooves us in describing the decay by any particular fungus not to draw too broad conclusions from the study of the decay of one or two species of woods when the fungus in question may attack a great number of species. To illustrate more specifically, it would not be advisable to conclude from the study of the decay of one or two woods that the fungus destroys the pith-rays first, for example, since while such might be the case in woods with uniseriate or small pith-rays; the same course might not hold true in other woods possessing large multiseriate pith-rays. To my mind, in the past sufficient emphasis has not been laid upon the physical structure and chemical composition of wood when considering its decay by any particular fungus or when considering its predisposition to decay when subjected to known conditions under given uses. A knowledge of the chemical nature and physical structure of wood, however, has long been taken advantage of in connection with the preservative treatment of wood. In this connection a knowledge of both points would be of the utmost fundamental importance. For example, the Chicago, Burlington and Quincy Railroad has found by actual experimentation that it was not worth while to apply a preservative treatment to chestnut ties, since treated ties exhibited no greater resistance to decay and consequently no greater length of life in service than the untreated ones. The reason for this is that chestnut wood already contains a large amount of tannin which acts as a natural antiseptic or preservative and thereby retards the establishment and growth of wood-destroying fungi. Again, the abundance of tyloses in the vessels of the white oak group of woods has been found to render the wood very difficult to impregnate with preservative solutions. By reason of this peculiarity of structure, the woods of the white oak group are especially suitable for making liquid-tight containers (tight cooperage stock).

Localization of the Decay.

Undoubtedly the most peculiar and perplexing point in connection with the decay resulting from the action of *Polyporus pargamenus* is its habitual tendency to produce a minute, inconspicuous pocket type of decay. Unlike a great number of decays that produce a rot in which the entire mass of the wood is immediately affected, *Polyporus parga-*

menus produces a type of decay in which the destructive changes at first are confined to localized areas of the wood but later spread so that the whole mass of the wood is soon involved. The pocket formation is not so pronounced at first in the earlier stages of the decay but becomes a conspicuous feature of the late stages as explained in the descriptions of the decay of individual woods. With the progress of the decay the destruction of the woody substance tends to be completed within the numerous individual pockets so that in the late stages of the decay practically no sound wood is left except the narrow zones separating the pockets. The pockets are not sharply defined until the late stages of the decay for in the intermediate stages they are more or less filled with a mass of partially reduced woody elements which remain in position next to the unchanged wood. In the late stages of the decay, however, the pockets frequently coalesce into larger ones separated by a mere membranous layer of resistant wood and become devoid of all contents save for a few vessel segments which resist decay unusually long. Microscopic sections of wood in this stage of decay show that the pockets are separated only by a thin zone of resistant wood from one to several cells wide (Plate XXIV, Figs. 1 and 2). This was especially marked in the sections studied in connection with the decay of yellow birch, bitternut hickory, and hemlock. In the sections of decayed sugar maple wood studied this resistant zone of wood was less pronounced and contained abundant masses of matted fungal hyphæ within the lumina of the elements of this resistant zone. In some of the sections of decayed chestnut oak wood studied the resistant zones of wood demarking the pockets had completely disappeared and in their place was left a reticulum or network of matted fungal hyphæ occupying the position formerly held by the resistant zones of wood. In fact suggestions of this transformation could be seen occasionally in certain sections of the other woods. In connection with the microscopic descriptions of the individual decays of the five woods studied in full detail mention was made of mats of hyphæ within the wood, particularly in the vessels, which frequently were encrusted with brown decomposition products. The decay of the wood within the individual pockets was marked by a tendency toward an accumulation of decomposition products between the adjoining cavities. In this respect it is somewhat analogous to the decay of spruce by *Trametes pini* described by von Schrenk (1900[2], p. 33). In the latter decay, however, a distinct minute dark-brown zone, situated midway between two adjoining cavities, entirely surrounded the individual cavities. Von Schrenk states that a detailed examination of these dark-brown zones showed that they were due to masses of dark-brown hyphæ which filled each wood cell so as to completely occlude it, and that the hyphæ were encrusted with a brown substance which dissolves in part in dilute potassium hydroxide and entirely in warm nitric acid. The brown products encrusting the mats of hyphæ found in the decayed woods studied to determine the course of the decay caused by *Polyporus pargamenus* exhibited the same solubility tests as those enumerated by von Schrenk in the rot caused by *Trametes pini*. As von Schrenk (*l. c.*) observed, the brown encrusting substances occur in or on the cell-walls in the immediate vicinity of the pockets, and their manner of occurrence leads one to suspect that they were deposited in liquid form, for they have diffused through the various cells in all directions from the wall of the cavities.

As yet the causes which influence this local initiation of the physical and chemical changes, which is characteristic of several wood-destroying fungi, has not been determined. The decay of the light spots progresses rapidly until the wood becomes filled with distinct cavities or pockets. The hyphæ apparently branch out rapidly in all directions from each of the original centers of infection, and as they do so the metabolic by-products of decomposition likewise pass outward, passing along the woody elements faster than across them. After a period the advancing hyphal masses of two adjacent pockets meet in the narrow lamella of unchanged wood lying between the two unchanged pockets. By this time more or less of the brown substance representing decomposition products has accumulated. This brown substance tends to occlude the lumina of the cells and collects in part on the fungal hyphæ and partly in and on the cell-walls so that these become brownish-black. As stated before, warm nitric acid removes these substances entirely, leaving the wood almost colorless. In the decay by *Polyporus pargamenus* of those woods studied there is only a slight accumulation of these partially decomposed substances midway between adjoining pockets. That this accumulation of the partially decomposed substances is not sufficiently great to arrest the decay at this point is shown by the anastomosing of adjacent pockets with one another in the later stages of the decay. It is evident, however, that even the slight accumulation of decomposition products midway between two adjoining pockets has a decided tendency to retard the advancement of the decay, since such infiltrated substances are more difficult for the fungus to assimilate than those constituents which have not been oxidized. Owing to this, the cell-walls of those cells, that have become infiltrated with by-products of the decomposition, which otherwise would be an important source of nutriment for the growth of the fungal hyphæ, have assumed through chemical decomposition a form more difficult to assimilate. On these grounds it is to be expected that the network of resistant wood left between the original centers of infection would be more resistant to decay than the centers of initial decay, owing to the tendency for resistant by-products of the decomposition to accumulate midway between the centers of initial decay.

The results obtained from the detailed study of the decay of five species of wood of dissimilar structure indicate that the decay may progress to a varying extent within different woods. Such a study requires the securing of abundant material so that sections may be made from each wood in all of its various stages of decay. While it is not claimed that all stages of the decays of each of the five different woods were studied, sufficient sections of each were included so that the general course of the decay of each of these woods could be ascertained. In the decay of yellow birch and bitternut hickory the last stages of the decay were represented by membranous partitions of resistant wood separating the pockets. As seen microscopically the membranous layers of wood varied from one to several cells thick, and the elements often were full of matted hyphæ. Within the individual pockets practically nothing was left save for a few scattered, half-disintegrated vessels weakly held together by a few fungal hyphæ. Practically all of the woody substance, as well as the fungal hyphæ, had disappeared within the individual pockets (Plate XXIV, Figs. 1 and 2). In the decay of sugar maple wood the pocket formation was less pronounced than it was in either decayed yellow birch or bitternut hickory wood. In the sections studied the decayed wood was by no means reduced to the same extent as that just described for yellow birch and bitternut hickory, but the decay seemed to become completed before less of the woody substance was so completely destroyed. Microscopic examination showed a reticulum of resistant wood but it was much less conspicuous than that observed in either decayed yellow birch or bitternut hickory woods. The more lignified cells within the center of these zones often were stuffed with matted hyphæ as in the case of the decay of the two last-named woods. Within the less sharply demarked individual pockets considerable partially decayed material remained, including the multiseriate pith-rays, the vessels together with the cells immediately surrounding them, and the terminal zone of more lignified cells on the outer face of the growth ring (Plate XXIII, Fig. 2). It would appear, therefore, that the decay either does not progress so far in sugar maple as it does in yellow birch and bitternut hickory wood or that the localization of the decay into pockets is in time overcome before the decay becomes completed, after which the subsequent decay would progress uniformly and involve the whole of the remaining woody substance. In the decayed chestnut oak wood studied the pocket formation was inconspicuous. The woody substance had not disintegrated quite as far as it had in the decayed sugar maple wood studied. Microscopic sections exhibited a distinct reticulum bounding the pockets.

This reticulum contained very little resistant woody substance in most cases and consisted mostly of masses of intricately interwoven minute hyphæ. Within the individual pockets even more partially decayed woody substance remained than in the decayed sugar maple wood studied. It would appear either that the decay does not progress so far in chestnut oak as it does in sugar maple wood, or that the original localization of the decay into pockets is in time overcome before the decay becomes completed, after which the subsequent decay progresses uniformly and involves the whole of the remaining woody substance. From the results obtained it would seem that the decay continues to progress longer and to become more complete in certain woods than in others. This irregularity is determined apparently by the resultant of the action of the hyphæ of this particular fungus in conjunction with the inherent qualities of the wood attacked. In any event the last trace of the reticulum of resistant wood separating the pockets is found in the reticulum of matted hyphæ remaining at the same point aftr the reticulum of resistant wood is destroyed.

Just why the hyphæ should collect into zones at these points is not clear. We know that in general in the decay of wood by wood-destroying fungi but comparatively little or scanty mycelium is to be found in the much-decayed portions of wood. This peculiarity is clearly evident within the pockets produced by *Polyporus pargamenus* and is very striking in the last stages of the decay. In the study of most any wood-destroying fungus one can almost always observe numerous perforations of the cell membranes in which the fungal hyphæ no longer are present. In the course of the progress of the decay the hyphæ branch and rebranch until they permeate all of the woody elements. It is not to be supposed that all of this increasing volume of fungal mycelium functions in the decay of wood but that it is mainly the minute, last-formed hyphæ that are active in secreting enzymes which gradually render the woody substance soluble and capable of absorption and translocation by the fungus. It is evident, from the habitual disappearance of most of the mycelium within the wood upon the completion of the decay within any one portion, that the older mycelium has served its purpose, ceased to function and disappears, doubtlessly being dissolved by the enzyme excretions from the younger active hyphæ. We know that the membranes of fungal hyphæ consist of cellulose as a fundamental substance, its detection being rendered difficult by the presence of infiltrated substances, possibly of a protein nature. As evidence of cellulose constituting the basis of fungal membranes, we find that young fungal hyphæ in decaying wood frequently color violet with cellulose reagents instead of yellow or brown as do the older ones. When we consider that the chemical composition of the membranes of the fungal hyphæ is not so unlike that of woody membranes, it seems quite likely that the non-functioning hyphæ, under certain conditions, may be digested either by closely related or possibly the very same kind of enzymes which they formerly secreted to effect the dissolution of the surrounding woody membranes. If such procedure occurred within decaying wood, it is conceivable that, after a time, we might have a dissolution of the hyphæ which, in this case, might be most complete within the individual pockets and be retarded at the boundary between two adjacent pockets just as was the case in the decay of the woody elements. In this way we might account for the final reticulum of matted fungal hyphæ left surrounding the individual pockets where early in the course of the decay they were demarked by resistant zones of wood forming a reticulum at the same points which later come to be occupied by the reticulum of matted hyphæ.

The Metabolic Products of Polyporus Pargamenus.

Enzyme Activity in Polyporus Pargamenus.—From the anatomical and microchemical studies of various woods undergoing decay through the agency of *Polyporus pargamenus* evidence was obtained that several enzymes are secreted by the vegetative mycelium of this fungus. Thus the disappearance of starch, proteids, pectic bodies, cellulose, and lignin constituents from the wood indicates that the mycelium produces diastatic, proteolytic, and a number of cyto-hydrolytic enzymes, among which are pectinase, cellulase, and ligninase. Aside from the histological methods employed in the study of the decay of these woods, no specific methods were employed for the detection of enzymes.[20]

The Black Zones Formed in Decaying Wood. Undoubtedly the by-products most frequently met with in decaying wood are the extremely chemically resistant brown humic products which infiltrate portions of the wood, causing them to appear as brownish discolored areas, or which more often collect in narrow zones between the decayed and undecayed portions, causing the wood at this point to appear as a blackish zone or line or varying thickness. (Plate XXVII.) As shown by the writer (1917[2]) in an earlier publication dealing exclusively with the study of the black zones formed by wood-destroying fungi,[21] these formations, limiting various stages of the decay, are characteristic features of the early stages of the decay of dicotyledonous woods by wood-destroying fungi. These zones may extend in any direction through the wood or bark, their courses being determined by the initial starting point of the fungus and its subsequent growth and advancement through the wood. Their occurrence may be observed best on cross sections of a tree or log that is but partially decayed. Here they usually appear as irregular black or brownish-black lines of varying thickness, which occur between areas of wood in different stages of decay, either demarking decayed from undecayed wood or else demarking adjacent portions of wood that are in different stages of decay. Strictly speaking, the term "lines" should not be applied to these formations unless done in

[20] In planning the ground to be covered by the present investigation it was not considered advisable to lay any particular stress on the qualitative and quantitative determination of enzymes, since, although of fundamental importance, work of this kind is of such specialized nature that it falls more nearly within the domain of the physiological chemist, by whom it can best be done.

[21] Portions of this study dealt particularly with the black zones formed in wood decayed by *Polyporus pargamenus.*

describing their appearance in a section of wood. In reality they are thin zones of discolored wood which at first sharply separate the various stages of decay in the wood. If, however, the decay starts from several centers the dark zones extend very irregularly throughout the whole mass. Longitudinal sections of trunks in the early stages of decay show that these blackish zones extend for varying distances up and down the stem, their general course being parallel to the elements of growth. Their course, however, is in no way influenced by the annual rings of growth, but only by the progress of the decay effected by the fungal hyphæ; they may cross and recross the growth rings repeatedly.

These blackish zones are not constant in position, since the decomposition products which cause the discoloration move forward with the advance of the decay in any part of the stem and ultimately disappear upon its completion within that part. The continual occurrence of the blackish zones between decayed and undecayed wood is due to the fact that the decomposition products are destroyed, together with the wood containing them, while new ones are formed constantly from the sound wood as fast as it is attacked by the advancing mycelium.

The prominent blackish zones which are such characteristic features so commonly associated with many of the decays of deciduous woods are of rare occurrence in decaying coniferous woods. Similar formations are characteristic of various decays of coniferous woods, but they are inconspicuous when compared to the broad zones of decomposition products which commonly occur in the decay of dicotyledonous woods. Such decomposition products arising through the decay of coniferous woods by wood-destroying fungi, although of common occurrence, apparently are small in quantity compared with those arising through the decay of dicotyledonous woods. Such being the case, this difference must be attributed to the inherently dissimilar character of these respective groups of woods.

Macroscopic examination shows that these discolored zones are composed of wood of unusual hardness. Microscopic examination shows that they are caused by brown infiltrations in the cell-walls and lumina of the cells, these infiltrations often becoming so abundant that they exude into the lumina of the cells, particularly the vessels, and occlude these completely. (Plate XXVIII, Figs. 1 and 2, and Plate XXIX.) This brown substance usually collects in a blackish zone or layer between two adjoining areas in different stages of decay. If it should happen that for some reason the progress of the decay be indefinite and retarded the brown product may appear merely as an unlocalized brown discoloration in the wood. When seen in mass it is responsible for the dark coloration mentioned above. At the time of its formation the brown product is a liquid, but, upon further decomposition, it changes to a brown, amorphous brittle substance, frequently becoming more or less cracked after dessication.

Chemical Origin of the Brown Decomposition Product.—The physical appearance and chemical composition of the brown by-product of decomposition varies greatly according to the extent to which it has become chemically altered. In the earlier stages of the decay much of this decomposition product is soluble in and can be extracted from finely divided wood with a 5 per cent solution of potassium hydroxide. If the potash solution be neutralized with dilute hydrochloric acid a reddish-brown gelatinous precipitate of humic acid is formed slowly, which gradually settles to the bottom. When dried the residue resembles the brown masses seen in many of the wood elements. Von Schrenk (1900^2, p. 37) describes the decomposition product as follows: "In mass it is reddish-brown, soft, tasteless and odorless, insoluble in alcohol, ether, chloroform, acetone, turpentine, etc., but very soluble in alkalies, KOH, $NaHPO_4$, etc., and can be reprecipitated from such solutions by acids." Because of its peculiar physical and chemical properties the substance has been classed among the "humus compounds." As was stated earlier in connection with the description of the decay of individual woods by *Polyporus pargamenus,* the hyphæ frequently are coated with a thin layer of this compound, so that their walls look brown and show several contour lines. The accumulation of this brown product signifies the first step in the decomposition of wood, and numerous investigations have shown that wherever there is any sign of decomposition this product appears immediately. Its formation appears to be associated with starch-containing cells, and for this reason it is most conspicuously developed in the pith-ray and wood parenchyma cells, these cells in the living wood having been largely concerned in the storage and conduction of food in the wood.

In the later stages of the decay the brown decomposition products appear to become further changed and more resistant to the action of chemical reagents. In this more resistant condition the brown decomposition product is mostly insoluble in alkalies and apparently can be brought into solution only by the use of powerful oxidizing agents, such as nitric acid or a mixture of hydrochloric acid and potassium chlorate. Such powerful reagents must necessarily change the nature of the substance under consideration. In a previous paper the writer (1917[2]) has reported the results of the analysis of the infiltrated substance giving rise to the black zones formed in wood decayed by *Polyporus pargamenus.* As much of the results as deal with the present problem will be included in this discussion. The subject for experimentation was a log of pignut hickory [*Hicoria glabra* (Mill.) Britton] exhibiting an advanced sap-rot resulting from the decay caused by *Polyporus pargamenus.* The thick corky bark of the log had proved to be very resistant to decay and remained of normal hardness. The thick sap-wood underlying the bark was almost completely destroyed save for a few isolated, small resistant areas of wood which were surrounded by conspicuous, thick, black zones, due to the accumulation of decomposition products at this point. A number of these resistant areas of the sapwood were removed and scraped free of the surrounding completely decayed sapwood, which was of pith-like consistency (Plate XXVII), and used for chemical analysis. The heartwood of the log, to all purposes, was sound and comparatively free from decay. It was evident that the fungus had subsisted upon the sapwood of the log for a period of years and that it had died out upon the completion of the decay of the sapwood.

Radial sections (10 microns), made of peripheral portions of these resistant zones of wood, exhibited an abundant accumulation of the brown decomposition products. The walls of the woody elements traversed by the peripheral black zone were browned; the pith-ray cells contained abundant brown drops, and the lumina of many of the cells were occluded by accumulations of the brown decomposition product. Farther within the resistant zones of wood, the cell-walls were free from the brown coloration, but practically all of the pith-rays contained abundant brown drops of humic products within their cells. All stages in the formation of this decomposition product were present from recently formed droplets to those which had coalesced to form gum-like masses which completely occluded the cell lumina. (Plate XXVIII, Figs. 1 and 2.) The wood evidently was in the first stage of decay, that is, it had been penetrated by fungal hyphæ, but its disintegration had not commenced.

A series of radial sections were cut from the material described and employed to determine microchemically the solubility of these decomposition products. The solubility tests were made by exposing ten micron sections to the action of the reagent (without heating) in watch glasses, meanwhile making observations with the microscope. If the numerous globules of the humic products, which were readily visible in the pith-ray cells under the low power of the microscope, did not dissolve after a reasonable length of time a small quantity of the reagent and sections were transferred to a test tube, heated to the boiling point, emptied out into a watch glass, and again examined under the microscope. The globules of humic products were found to be insoluble in water, concentrated ammonium hydroxide, 10 per cent solution of sodium hydroxide, 10 per cent solution of potassium hydroxide, and concentrated hydrochloric acid. In cold concentrated sulphuric acid the wood was carbonized but the globules remained intact. Upon heating the acid to boiling the wood dissolved together with more or less of the humic products. In cold concentrated nitric acid the decomposition products were insoluble, but upon heating to boiling the globules dissolved together with the wood, forming a brown solution. Moreover, tests performed with other sections indicated that the decomposition products in question were insoluble in absolute alcohol, xylene, acetone, ether, petroleum ether, chloroform, carbon bisulphide, and carbon tetrachloride. In addition to this, sections of the wood containing the globules of humic products were placed in a concentrated solution of chloral hydrate and kept at a temperature of 55 degrees C. for one week. There was no effect other than a slight swelling of the globules. The same sections were then washed in water and dehydrated by alcohol. Part of them were treated with clove oil and the remainder with cedar oil, but the humic products remained insoluble in both cases.

An attempt was made to determine more fully the chemical nature of the brown decomposition product by means of a comparative analysis of sound and decayed wood. The resistant areas of sapwood removed from the pignut hickory [*Hicoria glabra* (Mill.) Britton] log were again employed for the study of the decayed wood, and sapwood (gathered in the spring) from a living tree of the same species was employed for the study of the sound wood. In the case of the resistant areas of sapwood in the early stages of the decay the periphery of each piece was bounded by a conspicuous thick, black layer of infiltrated wood as described earlier. The external black layer sharply demarked the completely decayed wood from the remaining resistant areas which were only in the first stage of decomposition. This black layer, as well as the wood enclosed by it, was very hard. The infiltrated wood was shaved off carefully, care being taken not to include the underlying, uninfiltrated wood. The normal sapwood also was reduced to shavings, and, after thorough drying, both samples were ground finely.

These samples of finely divided wood were first successively submitted to a preliminary extraction, without heating, for twenty-four hours with ether, 95 per cent alcohol, a 10 per cent solution of sodium hydroxide, and a 5 per cent solution of hydrochloric acid so that, when the dominant decomposition products were extracted finally they would be free from many extraneous substances. Parallel tests were conducted on equal quantities of infiltrated wood and of the normal sapwood. The ethereal and alcoholic filtrates, in both cases, contained such exceedingly small amounts of substance that they were not further investigated. The alkaline filtrate from the sound wood residue, upon the addition of 90 per cent alcohol, gave a characteristic precipitate of xylan (wood gum). The alkaline filtrate from the infiltrated wood, however, upon the addition of 90 per cent alcohol, gave a brown flocculent precipitate which, judging from its solubility and other chemical reactions, consisted mainly of the group of humic substances known as humic acid. After the alkaline extraction the woody residues were washed and then subjected to extraction with a 5 per cent solution of hydrochloric acid for twenty-four hours. The acid filtrates thus obtained were practically colorless and the woody residues, in both cases, apparently remained unchanged. After this extraction the one from the infiltrated wood was, as far as could be determined by microscopic examination, as darkly colored as it was at the beginning of the original treatment.

Both the woody residues were then subjected to the action of an oxidizing agent (hydrochloric acid and potassium chlorate), after which, according to Frank (1884) and Temme (1885), the decomposition products are rendered soluble in alcohol. Münch (1910), however, considers that Frank and Temme are in error for giving this reaction (alcohol solubility after digestion with hydrochloric acid and potassium chlorate) as a characteristic of wound gum, as they had termed the decomposition product, and shows that starch-containing cells which do not exhibit the slightest browning or gum formation likewise respond to this reaction. These authors, however, did not continue to investigate the chemical nature of the brown decomposition product beyond finding that it was soluble in alcohol after digestion with a mixture of hydrochloric acid and potassium chlorate. This has been one of the chief objects of the present study.

Both of the residues were digested by boiling in a mixture of hydrochloric acid and potassium chlorate (5 gms. of potassium chlorate to 100 cc. of 80 per cent hydrochloric acid) for fifteen minutes. The woody residues from this oxidizing treatment, after thorough washing, were compared. It was found that neither was destroyed by the strong oxidizing action, but the residue from the infiltrated wood had lost all of its original blackish color and was only slightly darker than that from the sound wood. When examined under the microscope the cells of the ground infiltrated wood appeared to be filled with a light, reddish brown substance, while the cells of the sound wood also appeared to contain a similar substance but in smaller quantity. Both the oxidizing liquors left from this treatment were brown in color and when neutralized with sodium hydroxide gave brown precipitates respectively, the one in the case of the sound wood being the darker. These precipitates in both cases undoubtedly represent additional humic acid, the formation of which was rendered possible by the decomposition of humic substances resulting from the digestion of the woody substance with the hydrochloric acid-potassium chlorate mixture. Since they did not represent the main product to be studied, their investigation was not carried further.

The woody residues left from the oxidizing treatment were then submitted to a cold extraction with absolute alcohol for twenty-four hours. In both cases the alcohol instantly assumed a brown hue due to material entering into solution. This treatment seemed to take most of the coloring substance from both woods, although the residues responded slightly to a second and even to a third extraction. The alcoholic filtrates were evaporated to dryness and weighed. Roughly estimated, about twice as much material was obtained from the infiltrated wood as from the sound wood. Both extracts were dark brown in color and exhibited a vitreous fracture.

The one from the infiltrated wood was of the deeper hue. A small quantity of each extract when heated upon a platinum wire burned readily with a pale yellowish flame, emitting small quantities of a whitish vapor and giving off odors apparently peculiar to these substances. The extract from the infiltrated wood, when burned upon a platinum wire, left a dark brown, bead-like residue, while the extract from the sound wood, when treated in like manner, burned completely.

Both alcoholic extracts were insoluble in cold or boiling water, concentrated hydrochloric acid, ether, petroleum ether, chloroform, carbon bisulphide, and carbon tetrachloride. Their specific gravities are indicated by the fact that they were not suspended in or floated upon any of the organic solvents tried, of which the heaviest, carbon tetrachloride, has a specific gravity of 1.63. Neither, however, sank in concentrated sulphuric acid, whose specific gravity is 1.84. Both alcoholic extracts, however, were soluble in cold absolute alcohol, acetone, and a 10 per cent solution of sodium hydroxide. When the last-named solution was neutralized with sulphuric acid the extracts, in both cases, were precipitated — that is to say, they were insoluble in the exactly neutral sodium sulphate solution thus prepared. Both alcoholic extracts were soluble to a brown solution, but dissolved more slowly and without carbonization, when shaken in cold concentrated sulphuric acid. The alcoholic extract from the infiltrated wood was soluble in cold ammonium hydroxide, whereas that from the sound wood was soluble only by heating the reagent to boiling. When hydrochloric acid was added to the ammoniacal solutions until they were slightly acid both extracts were precipitated, leaving the solutions colorless in both cases.

None of the treatments thus far applied have secured a separation of the substances peculiar to the infiltrated wood and giving to it its distinguishing color. The solubilities and other properties of the respective extracts from the decayed wood indicate that a portion of the carbohydrate substance, particularly the hemicellulose xylan, had been converted into humic substances of two principal groups: First, a relatively small amount of humic acid as represented by the humic substance soluble in alkali and precipitated from the alkaline solution by alcohol; second, a much larger quantity of humin as represented by the great majority of the brown decomposition product insoluble in alkali until after the digestion with a mixture of hydrochloric acid and potassium chlorate, by which it was transformed into soluble humic acid. The solubilities and other properties of the respective extracts from the sound wood in which all of the normal carbohydrate substance was present indicate that the humic substance originated from boiling the carbohydrate substance (minus the hemicellulose, xylan) with a strong solution of hydrochloric acid and potassium chlorate.[22]

As much of the results of the writer's previous work (1917[2]) upon the black zones formed by wood-destroying fungi as deals with the decomposition products formed by *Polyporus pargamenus* has been summarized as follows:

(1) The brown decomposition products formed in the decay of dicotyledonous woods infiltrate the cell-walls to a greater or less extent, frequently becoming so abundant as to form numerous brown drops within the lumina of the cells. Such deposits appear in the wood as blackish zones of varying thickness which occur at first between decayed and undecayed areas and later separate areas in different stages of decay.

(2) The blackish zones are not constant in position since the decomposition products which cause the discoloration move forward with the advance of the decay in any part of the stem and ultimately disappear upon its completion within that part. The continual occurrence of the blackish zones between decayed and undecayed wood is due to the fact that the decomposition products are destroyed by the advancing fungus together with the wood while new ones are formed

[22] It is well known that other carbohydrates may also yield humic bodies. For instance sugars on boiling with a number of mineral or organic acids artificially yield mixtures of humic acid and humin bodies, varying in proportion with the different sugars used.

constantly from the wood as fast as it is attacked by the advancing fungus.

(3) In the decay of coniferous woods the formation of humic substances similar to those studied here is very small in quantity as compared with those arising in the decay of dicotyledonous woods.

(4) In wood free from fungous attack the formation of the brown decomposition products is dependent mainly upon the concurrence of three factors: (a) the presence of dead cells, (b) an optimum supply of moisture, and (c) a supply of oxygen sufficient to promote oxidation.

(5) The partially decomposed material of woody plants forms a particularly vague and indefinite group of substances containing all the non-volatile products of fungal, enzymic, and oxidative actions on the plant residues. The resultant humic substances are exceptionally resistant to chemical reagents.

(6) It is evident that the cell contents and certain other substances, particularly the hemicellulose, xylan (wood gum), that originally were combined with the cellulose to constitute the cell-wall furnish the formative material which, through oxidation upon the entrance of air and the presence of water, coagulates to thick drops and gives rise to the decomposition products which ultimately infiltrate certain portions of the wood, causing them to appear as blackish zones.

(7) In the wood of the pignut hickory the hemicellulose, zylan, is destroyed early in the progress of the decay. In the early stages of the decomposition of the wood the wood gum apparently is the substance which gives rise to most of the humic substance.

(8) By the action of a strong oxidizing reagent on fresh sapwood a brown humic substance can be prepared artificially, which is essentially like that occurring naturally in dicotyledonous woods, whether in wounded areas of living trees, dead wood, or as the result of their decay by *Polyporus pargamenus* and other wood-rotting fungi.

(9) The properties of the extracts obtained respectively from sound and decayed hickory wood indicate that, in the course of the decomposition, a portion of the carbohydrate substance, particularly the hemicellulose xylan, becomes converted into humic substances of two principal groups, namely, humic acid and humin. It is the accumulation of these humic substances which gives rise to the dark brown decomposition products which are of such common occurrence in decaying wood.

(10) Humic acid and humin were produced artificially from the carbohydrate substance of the sound hickory wood by boiling with a mixture of strong hydrochloric acid and potassium chlcrate. The substances thus produced indicate close relationship with the humin-like decomposition products formed as black zones in decaying wood.

(11) The chemically resistant by-products, often forming blackish zones in wood decayed by *Polyporus pargamenus,* have proved to be a group of substances analogous to or nearly identical with those substances concerned in the brownish discolorations in dead wood that is entirely free from fungous attack. The formation of the brown decomposition products in the latter case likewise is a sign of the humification which gradually sets in when the cell contents become dessicated or when their walls or contents undergo decomposition. This humification is greatly accelerated by the presence of wood-rotting fungi which greatly hasten the decomposition.

Chemical Affinity of the Brown Decomposition Product.— Now that the source of the decomposition product has been indicated, it is advisable to consider its final chemical nature. In the discussion of the chemical composition of the cell-wall the elaboration of those changes of tissue substances — celluloses and compound celluloses — which accompany or follow the cessation of vital activity has been deferred purposely until this point. It is more difficult to apply the term "death" to the vegetable than to the animal organism. In the sense of the elaboration of new material, the active life in a perennial plant is linked only with structural portions. In a forest tree, for example, the leaves are these active agents; the tissues of the trunk, on the other hand, are largely depleted of the organic nitrogenous matter (protoplasm) upon which the vital activity depends. They have ceased to live in the strict sense of the term, but, on the other hand, they are known by casual observation to live in the sense opposed to decay. While there are various phases of life in the plant recognized by ordinary observation, and more exactly defined by the physiologist, these phases pass by insensible gradations to the point where decay and chemical disintegration are predominant. The most striking general feature of the cellulosic group is that its members are non-nitrogenous. It might be reasoned, therefore, that from the very first they are excreta and never live in the strict sense of the wood. We may conclude that, from the moment of origin, the history of the cellulose group is one of progressive withdrawal from the realm of the main vital processes, and that to re-enter that realm they must undergo a process of proximate resolution as a result of external action. This reabsorption of cellulosic tissues is a frequent phenomenon. The process by which the tissues become broken down is of the character of an ordinary hydrolysis, that is, it is determined by enzymes.

The writer has endeavored to trace the changes and modifications which these substances undergo in the normal life of the plant, and evidence has been given showing them to be highly reactive and susceptible of modification in various directions. He now wishes to follow the fate of these substances in the ordinary processes of the natural world. Under these processes "death" is succeeded by a variety of processes of decay and disintegration. They are in part intrinsic and in part determined by external agencies. They are of two kinds — processes of resolution and processes of combination or condensation — which usually are concurrent. The former are attended with evolution of gaseous products; the latter are defined by an extended series of their products, through all stages from "humus" to the coals. The chief characteristic of this series of degradation products of plant tissues is the accumulation of carbon at the expense of ogygen and hydrogen.

The group of indefinite and complex organic substances formed in the decay of vegetable and animal matter are normal constituents of all soils and fulfill important functions therein. The resulting compounds may be those that were in the living tissues and have resisted decay, those that result from a splitting or degradation of complex bodies in the living plant, or compounds arising through changes brought about by micro-organisms, and nearly all classes of organic compounds known may be represented. These products have been classed under the general term "humus",[23] and so long as the term is used in a collective sense it may be retained as a convenient term.

The brown humus substances must be considered as a mixture of closely related bodies with and without nitrogen. These various substances have been divided into a number of groups by different writers, the subgrouping depending upon the solubilities of the substances. Schreiner and Shorey (1910) have grouped the various compounds they have isolated from the organic matter of soils as follows:

Extract soil with alkali

- Alkaline solution, acidify
  - Acid filtrate
    - Crenic Acid
  - Precipitate, boil with alcohol
    - Humic Acid, soluble
    - Humic Acid, insoluble
- Insoluble
  - Humin.

The brown humin substances are insoluble in water and alkalies, but are rendered soluble by fusing with caustic soda or potash, from the solution of which humic acid can

[23] In the light of recent investigations on the nature of organic matter of the soil it is necessary to revise this relict of the older terminology. The term "humus" is rather to be regarded as a loose generic term applicable to a group of organic compounds found in the soil.

again be precipitated. The humic acids comprise substances thrown down as brown collodial precipitates by mineral acids or alkaline extracts of humus. The humic acids (their chemical composition is insufficiently known), containing possibly 59 to 63 per cent C., 4.4 to 4.6 per cent H, and 35 to 36 per cent O, are easily dissolved in alkalies and reprecipitated from their solutions by stronger mineral acids. If they are withdrawn from acid soils or from ground decayed wood with alkalies or NH_3 and precipitated with HCl, a voluminous, gelatinous substance is obtained which, in drying, forms a brown or black amorphous mass. The humic acids are separated from their solution by freezing, in the form of a dark-colored powder, which gradually passes over again into solution.

Products similar to these are obtained in a large number of decompositions of the carbohydrates, both simple and complex. Trusov (1915) reports experiments in which it was found that the humification of various organic compounds consists of both chemical and biological processes, woody substances being humified by chemical compounds and fungi, albumin by biological processes alone, and substances containing tannin and chlorophyll by chemical processes alone. He found that the process of humification was aided by good aeration and relatively high temperatures. The time necessary for complete humification of the various compounds varied, albumin requiring a longer period than lignin substances containing tannic acid and chlorophyll. Starch was humified very slowly. Water extracts of undecomposed woody substances were very active in humus formation. Humus was not formed from proteids from substances containing tannic acid and chlorophyll, and was formed from lignin only when that substance decomposed together with albumin.

While it is true that the tendency in the decay of organic matter is toward simpler compounds and ultimately to a few simple compounds or the elements, the material known as soil organic matter is in the transition stage from the complex compounds of living organisms to the simple ultimate products.

By the advancing decomposition, the nitrogen which in organic combinations is accessible to plants with difficulty, is carried over into compounds easily absorbed. In proportion as the carbohydrates are attacked by destructive agencies, the residue tends to constitute itself into a complex of increasing resistance. This entire group of by-products is extremely ill-defined and requires much more exhaustive investigation to establish their definite relationships with the carbohydrates from which they result. The partially decomposed material of woody plants forms a particularly vague and indefinite group of substances containing all the non-volatile products of fungal, enzymic and oxidative reactions on the plant residues. A detailed study of this group thus being out of question, we can merely ascertain what relation it bears to the original woody substance, since we have already discovered, in a general way, the particular constituents of the woody plant that entered into its formation.

The formation of the brown humic substance in woods decayed by *Polyporus pargamenus* is similar to the description given by von Schrenk (1900[1]) of that occurring in pecky cypress, except that none of the intermediate stages of the humification described by him could be detected. In the decay of dicotyledonous woods by *Polyporus pargamenus* the transformation of lignified membranes to humic substance is much greater and decidedly more abrupt than occurs in coniferous woods attacked by the same fungus. After comparing the description of the formation of the humic compound with that of the method of disintegration of the wood, it seems that the formation of humic compounds is due to certain chemical changes in the normal lignified membranes, as a result of which certain of its constituents which ordinarily react with phloroglucin-HCl, are extracted. These preliminary changes are followed by more profound changes ending in the formation of certain by-products of humic nature. These substances ordinarily diffuse through the adjoining cells, and ultimately harden within the lumina of the woody elements surrounding them. Oftentimes all the remaining contents of the cells, including starch grains, fungal hyphæ that may have penetrated, etc., are covered with the same substance. From the manner of occurrence and distribution of the humic substance found in wood surrounding decayed areas of a trunk it would seem that this substance is formed as a by-product from the action of a fungus on the membranes of the woody substance, and that incidentally it is probably one of the products effective in preventing the unlimited spread and destructive action of the fungus.

MEANS OF ENTRANCE AND RATE OF DECAY.

The general occurrence of any given species of fungus over wide areas differing greatly in character, and the multitude of sporophores produced in any one locality, shows that spore formation and dissemination is of enormous magnitude. Every sporophore produces, figuratively speaking, "millions" of spores, and each perfectly formed spore carries with it the possibilities of the formation of a new plant, provided that spore falls on a suitable substratum and meets with conditions suitable for growth. For their dissemination the spores are dependent upon a great number of agencies, the most effective agency being wind which may carry these bodies for miles. Insects, especially the beetles, are also an aid in spore dissemination, since, after feeding on the sporophores, they escape bearing spores which they carry elsewhere. While innumerable spores are formed and disseminated — many chances thus being given for the development of new plants — the difficulty with which the spores germinate, owing to unfavorable natural conditions, is very great. Of the relatively small number of spores that actually succeed in falling on a suitable substratum and germinating thereon but few ever develop to mature plants owing to numerous adverse influences. Owing to the peculiar requirements of the spore for germination and further development, hundreds or thousands usually fail to develop where a few find suitable conditions and give rise to mature plants. Moreover, spores are microscopically small and hence cannot contain very much nutriment. They cannot, therefore, withstand unfavorable conditions for germination for such protracted periods as can most seeds of seed-bearing plants. While spores frequently can pass through a long resting period and are capable of germination at the end of this period, after germination has begun the spore usually cannot resist unfavorable conditions. After a consideration of these facts it becomes apparent that the fungi in general must necessarily be very prodigal of their spores, so that they are produced in enormous numbers.

The relation of the fungus to its host is a definite one. The question of the spores gaining entrance, however, is somewhat problematic. But few of even the parasitic fungi can gain entrance unaided through the bark which envelops the entire living trunk, since the fungal hyphæ are incapable of forcing their way through layers of cork. When uninjured, the bark therefore serves as an efficient barrier to the entrance of even the parasitic fungi. For its entrance to the living tree *Polyporus pargamenus* is dependent upon human, organic, or inorganic agencies, usually gaining entrance through mechanical injuries to the host. There is no reason to believe that the fungus studied here can gain entrance to a living tree unaided by one of these methods of entrance, since the writer's experience has shown that there must be some condition conducive to infection, such as a broken branch or other form of wound, a drying out and consequent death of the cambium as a result of fire. When the cambium of a tree is killed and the underlying sapwood exposed by a broken branch, blazing, or some other form of mechanical injury, the wood immediately underlying the wounded area soon becomes functionless and dead. The weathering action of the elements softens this wood, it retains moisture readily, and affords an ideal environment for the development of a spore. The spores that are blown there by the wind germinate and send out their mycelial filaments, which slowly penetrate the dead wood. Some plants, as the one studied here, seem to have acquired the ability to avail themselves of the parasitic habit, while during the greater part of their lives they are true saprophytes. In other words, at times in their development they may become parasitic, though nominally they are saprophytic.

Like many other fungi, *Polyporus pargamenus* possesses great adaptability, as shown by the fact that it attacks living tress as well as dead trees, stumps, and logs, thus showing that it may be either saprophytic or parasitic. Although it usually is found on dead wood, it may occur frequently on living trees where these have been severely wounded. This fungus is to be classed with the hemisaprophytes (the facultative parasites of DeBary). It is a plant that is wont to pass through its whole development as a saprophyte, its natural habitat being moist dead wood; under certain conditions, however, it may become a wound parasite.

The effect of such a parasite on the host may remain unnoticed for some time, since the growth of the mycelium is very slow at first and only a few wood cells are attacked. Upon becoming securely established within the tissues of the host, the mycelium spreads rapidly, permeating a larger volume of wood. After the mycelium penetrates the tissues of the host to a sufficient extent to be enabled to extract from them adequate nutrient materials for its sustenance, thereby causing what we call decay, it may produce fruiting bodies. The appearance of the fruit bodies often is the first noticeable indication of the presence of a fungous disease (Plate XXX.) The first appearance of the fruit-bodies on the bole of the infected tree, therefore, gives us an indication of the approximate development of the mycelium within the sapwood. As the vegetative part of the fungus increases in consequence of its age, so does the number of fruit-bodies increase. The dead portion of the sapwood is disintegrated slowly and, from contact with this, the adjoining living cells are reduced in vitality and ultimately die. When this stage is reached the effect on the host may be noticed in the dead branches at the top of the tree and the pale color of the remaining foliage. The fruit-bodies, like most annual ones, grow very fast, and, after attaining maturity, they are destroyed by insect larvæ or they die and decay. During this time the mycelium of the fungus spreads rapidly, attacking hitherto sound sapwood, and in the following year new fruit-bodies are produced which give further indication of the spread of the mycelium throughout the wood, and, consequently, of the extent of the decay. After building up considerable strength in its saprophytic life the fungus proceeds to attack the growing zone of the trunk, that is, where the sapwood joins the bark and where the living substance is produced by very thin-walled cells. Thus the host is slowly killed and the fungus continues to live on in its saprophytic way. The remaining sapwood soon becomes changed to a brittle substance having none of the properties of wood. These changes soon kill the tree by girdling it and eventually weaken the trunk so that it is only a question of time until the tree becomes broken by the wind. At this stage the basal portion of the trunk, up to a height of several feet, usually is surrounded entirely by a luxuriant growth of fruit-bodies froming a closely imbricated mass (Plate XXXI, Fig. 1.)

Polyporus pargamenus is one of the wood-rotting fungi which commonly appear on standing deciduous trees after forest fires have killed a portion of the cambium. One cannot help but take cognizance of the total destruction caused by a large forest fire, but few even apprehend the extent of damage done by a small surface fire which quickly consumes whatever superficial litter there may be lying on the ground at the time. Such fires, although they may not seem to have injured the trees at the time, usually generate sufficient heat to kill the inner, living bark and cambium over a considerable area at the bases of the trunks. The bark over such areas dries out and cracks, causing the death of the underlying sapwood. It is in such dead areas that fungi find a ready entrance. The injury thus caused apparently is slight, but in reality the damage done may continue during the entire life of the tree and eventually cause its death. Such small fire scars are responsible for a large amount of fungous decay and insect attacks in trees. The fire may have occurred many years ago and all signs of it been hidden by subsequent growth, but during the two or more years that it took the tree to heal over the scar insects and spores of fungi which produce rot in trees entered at this open wound on the butt and, in the case of the rots, have been at work ever since, gradually destroying the wood of the trunk (Plate XXXI, Fig. 2.) Thus it is that within a few months after the fire the sporophores *Polyporus pargamenus* are found growing on the dead bark and the decay caused by the fungus extends rapidly throughout the deadened area.

The small fire-scar may, and usually does, heal over so that within a few years no evidence of a fire or injury to the trunk can be seen from the outside. The rot, however, continues to grow for years, speedily causing the death of the tree upon the decay of the cambium and the sapwood. After the death of the tree the fungus continues its ravages of decay in the sound wood remaining, thus ruining the tree for most commercial purposes. Every time a tree is reached by a fire sufficiently hot to kill a small area of the inner bark and sapwood, an opportunity is given for attacks by this and other wood-destroying fungi.

There are, however, certain physical factors upon which the growth of fungi and the consequent destruction of the wood is dependent. For example, all fungi require a certain supply of nutriment, moisture, and air, the amount of each varying with the individual species and the environmental conditions for growth. If deprived of the requisite amounts of any one of these the fungus ceases to develop and eventually dies. It has been established that no chemical reaction takes place between substances except in the presence of water. As the decay of wood is largely dependent upon the chemical reaction of certain enzymes, secreted by the mycelium of the fungus, upon the various constituents of the cell-walls of the woody tissue, it follows that water must be present wherever there is decay. Water is essential for plant growth, and when there is no moisture no plants can develop, hence no decay can occur. Warmth also is conducive to the growth of fungi, the most favorable temperature being about 90 degrees F. They cannot grow in extreme cold, although no degree of cold that occurs naturally will kill them after they have become well established.[24]

Like all sap-rotting fungi, *Polyporus pargamenus* is especially dependent for its development upon the presence of a sufficient quantity of water and air. It usually grows with the greatest vigor close to the surface of the soil. Its fruit-bodies may therefore be looked for at the base of trees and at or near the ground line on ties, posts, and all timbers exposed to the soil. Where wood has time to dry partially on the outside after it has been cut, the spores will not germinate owing to the lack of moisture. Infection of such partially dried wood usually takes place through some season check.

Polyporus pargamenus may start development in a stick of wood within a few weeks after it has been cut, or, in other words, shortly after the wood becomes sufficiently dried on the outside to form season checks. After it has once gained entrance below the surface the mycelium will grow vigorously in the wood and give absolutely no macroscopic evidence of its presence on the outside until the mycelium has become sufficiently developed to form fruit bodies, which then usually form by growing out through the season checks to the outside air. It is on account of its ability to produce decay in the interior of the wood that this fungus is so very destructive, and it is for this reason that the greatest care should be taken to guard against its possible entrance. In moist climates the fruiting bodies will form above the ground on moist wood which may be several feet above the ground. Where wood has a chance to have air circulate around it continuously, however, the possibilities of its becoming infected with this fungus are remote.

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[24] Buller (1912) showed that the fruit bodies of *Schizophyllum commune* Fr., after having been kept dry and exposed to air for 2 years and 8 months, are able to retain their vitality when subsequently they have been dried in *vacuo* and subjected to the temperature of liquid air (— 190° C.) for three weeks. The retention of vitality was indicated by the fact that, upon being moistened, the fruit-bodies commenced to shed spores.

Polyporus pargamenus as a sap-rotting fungus is especially notorious for attacking those ties, timbers, and logs from which the bark has not been removed. The rapidity with which felled trees may be attacked and rotted by this fungus is a factor that must be taken into account when logging hardwoods, especially in the Southern Appalachian region. The destruction of the sapwood by this and other sap-rotting fungi often is so serious that unusual means often must be resorted to in order to get logs out of the woods before their value depreciates materially. Ordinarily the trees are attacked by a large number of sap-rotting fungi very shortly after they are felled, particularly if they are cut in the months from March to October. The rate of the destruction of the sapwood by these fungi varies greatly, however, according to the durability of the respective woods in question.

The decay which *Polyporus pargamenus* brings about in wood is usually confined for a year or more to the sapwood, and in many species it is largely confined to the sapwood. This is true of such trees that have their heartwood sharply differentiated from their sapwood as in the oaks. It is only after the sapwood is completely decayed that the heartwood is attacked to any great extent. Even then it is decayed far more slowly than the sapwood due to its greater durability. The manner and extent of the decay, of course, varies greatly not only with the species of tree, but also with the development of heartwood and its chemical and physical qualities. In the woods where the differentiation between the heartwood and sapwood is indistinct, as in the willows, poplars and birches, the fungus brings about the destruction of the sapwood with great rapidity and even destroys the heartwood with almost, if not equal, celerity. This variation is to be attributed to the greater durability possessed by the woods having a deep-colored heartwood and is due to the greater infiltrations of tannins, oils, and resins which render the wood more resistant to decay-producing fungi. The rate at which the sapwood of different dicotyledonous species decays presents little variation. The rate at which the heartwood decays, however, is proportional to the durability possessed by each species. It may be stated as a general rule that the sapwood of all trees is very susceptible to the attacks of *Polyporus pargamenus* and that where there is any difference in the resisting powers of such woods to this fungus it will be in favor of the heartwood.

A Reconnaissance Survey of a Recent Burn.

A reconnaissance survey was made in a region near State College, Pa., known locally as "The Barrens." This region was lumbered several years ago and since then parts of it have been burned over at frequent intervals by surface fires. It is characterized by having a dry, sandy soil, but the margin towards State College, where the survey was made, borders upon a limestone country, at which point the water is well underground except during the early months of the year.

In May, 1915, a surface fire swept over a portion of the Barrens that had thus far remained free from fire during the life of the stand of timber then present. As a result the trees on this area, with a few exceptions, were scorched so badly that they were killed outright. A few of the smaller trees were burned so badly near the base that some subsequently broke off. In August, 1916, the writer visited this area with the intention of securing some data relative to the rapidity with which fire-killed timber becomes infected with and deteriorates under the action of *Polyporus pargamenus.* In cruising through this area it was observed that a surprisingly large percentage of the fire-killed timber already (only one year and three months after the fire) bore sporophores of this sap-rotting fungus. Since the opportunity was so ably presented for securing valuable data in regard to the deterioration of standing timber after a forest fire, the writer decided to make a detailed reconnaissance survey of a portion of this burned area. A place was selected where the conditions were typical of the whole area that had been burned for the first time during the life of the stand and a rectangle, 100 by 500 feet, was laid off. This tract was fairly level — in fact no great variations in topographic conditions occur within this area. All trees along the inside of the compass line were chalked to mark definitely the boundary of the tract. The following data was secured for each standing tree within this tract: species, diameter (measured to the nearest inch) at breast height, condition (as to whether dead or living), and the species of fungi growing upon it as evidenced by the sporophores upon the trunk. The principal trees on this tract were white oak (*Quercus alba* Linn.) and scarlet oak (*Quercus coccinea* Muenchh.), the former being by far the more abundant, although its average size was much smaller. Other species in the order of their abundance were white pine (*Pinus strobus* Linn.), mocker nut hickory [*Hicoria alba* (Linn.) Britton], red maple (*Acer rubrum* Linn.), chestnut [*Castanea dentata* (Marsh.) Borkh.], and pitch pine (*Pinus rigida* Mill.).[25] The data obtained is given below, the trees being tabulated by diameter under the species. The coniferous trees (37 white pines and 1 pitch pine) have been omitted from the summary since the fungus in question rarely grows on coniferous timber and these two species were not considered to be possible hosts for it.

[25] A single pitch pine, the sole survivor of the previous generation, was the only representative of this species.

A Reconnaissance of a Burn One Year and Three Months Old.

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sphorophores.			
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*
Quercus alba[26]	2	....	*	*	....
Quercus alba	2	....	....	*	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	....	....	....
Quercus alba	2	....	*	....	....
Quercus alba	2	*	*	....	....
Quercus alba	2	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	....	*	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	*	....	....
Quercus alba	3	....	*	*	....
Quercus alba	3	....	*	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	*
Quercus alba	3	*	*	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	*	....	....
Quercus alba	3	*	*	....	....
Quercus alba	3	....	*	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	*	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	*	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....
Quercus alba	3	....	....	....	....

[26] All trees not indicated by (L) after their diameters are dead.

A Reconnaissance of a Burn One Year and Three Months Old—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sphorophores.			
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*
Quercus alba	3	...	*	*	...
Quercus alba	3	...	*	...	...
Quercus alba	3	...	...	...	...
Quercus alba	3	...	...	...	...
Quercus alba	3	...	...	...	...
Quercus alba	3	...	...	...	...
Quercus alba	3	*	*	...	...
Quercus alba	3	*	*	...	...
Quercus alba	3	*	*	...	...
Quercus alba	3	*	...	*	...
Quercus alba	3	...	...	...	...
Quercus alba	3	...	*	...	...
Quercus alba	3	...	*	...	...
Quercus alba	3	...	...	*	...
Quercus alba	4	*	*	...	...
Quercus alba	4	*	...	*	...
Quercus alba	4	...	*	...	...
Quercus alba	4	...	*	...	*
Quercus alba	4	...	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	*	...	...	*
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	*	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	...	...	...	*
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	*	...
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	*	...
Quercus alba	4	*	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	...	...	...
Quercus alba	4	*	*	...	...
Quercus alba	4	...	...	...	...
Quercus alba	4	...	...	...	...
Quercus alba	5	*	...	...	...
Quercus alba	5	*	*	...	*
Quercus alba	5	...	...	...	...

A Reconnaissance of a Burn One Year and Three Months Old—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sphorophores.			
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*
Quercus alba..............	5	....	....	*	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	*	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	....	....	....	....
Quercus alba..............	5	*	....	*	....
Quercus alba..............	5	*	*	....	....
Quercus alba..............	5	*	*	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alga..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	....	....	....
Quercus alba..............	5	*	*	....	....
Quercus alba..............	5	*	....	*	....
Quercus alba..............	5	*	....	*	....
Quercus alba..............	5	*	....	*	....
Quercus alba..............	5	....	....	....	....
Quercus alba..............	6	....	....	....	*
Quercus alba..............	6	....	....	....	....
Quercus alba..............	6	*	*	....	....
Quercus alba..............	6	*	*	....	....
Quercus alba..............	6	*	*	....	....
Quercus alba..............	6	....	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	....	....	....
Quercus alba..............	6	*	*	....	....

A Reconnaissance of a Burn One Year and Three Months Old—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sphorophores.					
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*	*Polyporus gilvus.*	*Schizophyllum commune.*
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	*
Quercus alba...	6	....	....	*	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba..	6	....	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	*	....	....	......	.....	....
Quercus alba...	6	....	....	....	......	.....	....
Quercus alba...	6	*	*	....	*	.....	....
Quercus alba...	6	*	*	....	......	.....	....
Quercus alba...	7 (L)	....	....	....	......	.....	....
Quercus alba...	7	....	....	*	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	*	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	*	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba..	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	7	....	....	....	......	.....	....
Quercus alba...	7	*	....	*	......	.....	....
Quercus alba...	7	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....
Quercus alba...	8	*	....	....	......	.....	....

A Reconnaissance of a Burn One Year and Three Months Old—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sporophores.				
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*	*Polyporus tulipiferus.*
Quercus alba...	8	*	......	......	......	*
Quercus alba...	8	*	......	......	......	......
Quercus alba...	8	......	......	......	*	......
Quercus alba...	8	*	......	......	......	......
Quercus alba...	8	......	......	......	......	......
Quercus alba...	8	*	......	......	......	......
Quercus alba...	8	*	......	......	......	......
Quercus alba...	8	*	......	......	......	......
Quercus alba...	8	*	......	......	......	......
Quercus alba...	9	*	......	*	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	......	......	......
Quercus alba...	9	*	......	*	......	......
Quercus alba...	10	*	......	......	......	......
Quercus alba...	10	*	......	......	......	......
Quercus alba...	10	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Quercus alba...	11	*	......	......	......	......
Total.....	237	164	......	......	......	......

A RECONNAISSANCE OF A BURN ONE YEAR AND THREE MONTHS OLD—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sporophores.			
		Polyporus pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*
Quercus coccinea	5				
Quercus cocciena	5	*			
Quercus coccinea	6				
Quercus coccinea	6				
Quercus coccinea	7	*		*	
Quercus coccinea	7				
Quercus coccinea	7				
Quercus coccinea	7	*			
Quercus coccinea	7				
Quercus coccinea	7	*			
Quercus coccinea	8	*			
Quercus coccinea	8				
Quercus coccinea	8				
Quercus coccinea	8				
Quercus coccinea	8				*
Quercus coccinea	8				
Quercus coccinea	8	*			
Quercus coccinec	9		*		
Quercus coccinea	9				
Quercus coccinea	9				
Quercus coccinea	9				
Quercus coccinea	9				
Quercus coccinea	9	*			
Quercus coccinea	10				
Quercus coccinea	10	*			
Quercus coccinea	10	*			
Quercus coccinea	10			*	
Quercus coccinea	10 (L)				
Quercus coccinea	10				
Quercus coccinea	10				*
Quecrus coccinea	10	*			
Quercus coccinea	10	*			
Quercus coccinea	10				
Quercus coccinea	10				
Quercus coccinea	10			*	
Quercus coccinea	10			*	
Quercus coccinea	10				
Quercus coccinea	10				
Quercus coccinea	10	*		*	
Quercus coccinea	11	*			
Quercus coccinea	11	*			
Quercus coccinea	11				
Quercus coccinea	11				
Quercus coccinea	11			*	
Quercus coccinea	11	*			
Quercus coccinea	11				
Quercus coccinea	11	*		*	
Quercus coccinea	11	*			
Quercus coccinea	12	*			
Quercus coccinea	12	*			
Quercus coccinea	12				
Quercus coccinea	12				
Quercus coccinea	12	*			
Quercus coccinea	12				
Quercus coccinea	12				

A RECONNAISSANCE OF A BURN ONE YEAR AND THREE MONTHS OLD—(*Continued*).

SPECIES.	D. B. H. inches.	FUNGI PRESENT AS EVIDENCED BY THE SPOROPHORES.			
		Polyporous pargamenus.	*Daldinia vernicosa.*	*Nummularia Bulliardi.*	*Hydnum ochraceum.*
Quercus coccinea...........	12	....	....	....	....
Quercus coccinea...........	12	....	....	....	....
Quercus coccinea...........	12	....	....	....	....
Quercus coccinea...........	12	*	....	....	....
Quercus coccinea...........	12	*	....	....	....
Quercus coccinea...........	13	....	....	....	....
Quecrus coccinea...........	13 (L)	*	....	....	....
Quercus coccinea...........	13	*	....	*	....
Quercus coccinea...........	13	*	....	....	....
Quercus coccinea...........	14	*	....	....	....
Quercus coccinea...........	14	*	....	*	....
Quercus coccinea...........	14 (L)	*	....	....	....
Quercus coccinea...........	15	....	....	....	....
Quercus coccinea...........	15	*	....	....	....
Quercus coccinea...........	16 (L)	....	....	....	....
Quercus coccinea...........	18	*	....	....	....
Total..............	71	30	....	....	....

A Reconnaissance of a Burn One Year and Three Months Old—(*Continued*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sporophores: *Polyporus pargamenus.*	*Daldinia vernicosa.*	*Hydnum ochraceum.*	*Schizophyllum commune.*	*Polyporus ulipiferus.*
Hicoria alba	1		*			
Hicoria alba	1					
Hicoria alba	1		*			
Hicoria alba	1					
Hicoria alba	1					
Hicoria alba	1					
Hicoria alba	1					
Hicoria alba	2					
Hicoria alba	2					
Hicoria alba	2					
Hicoria alba	2					
Hicoria alba	2		*			
Hicoria alba	2		*			
Hicoria alba	2					
Hicoria alba	2					
Hicoria alba	2			*	*	
Hicoria alba	2		*			
Hicoria alba	2		*			
Hicoria alba	2					*
Hicoria alba	3					
Hicoria alba	3		*			
Hicoria alba	3	*				
Hicoria alba	3	*	*		*	
Hicoria alba	3					
Hicoria alba	3	*				
Hicoria alba	4					
Hicoria alba	4					
Hicoria alba	4					
Hicoria alba	4					
Hicoria alba	4					
Hicoria alba	5					
Hicoria alba	5				*	
Hicoria alba	5					
Hicoria alba	6					
Hicoria alba	7		*			
Total.......	35	3				
Acer rubrum	1					
Acer rubrum	1					
Acer rubrum	1					
Acer rubrum	3	*				
Acer rubrum	3	*				
Acer rubrum	5	*				
Acer rubrum	5	*				
Acer rubrum	5	*				
Acer rubrum	5	*				
Acer rubrum	5	*				
Acer rubrum	6	*				
Acer rubrum	6	*				
Acer rubrum	7	*				
Acer rubrum	7	*				
Acer rubrum	11					
Total.......	15	11				

A Reconnaissance of a Burn One Year and Three Months Old—(*Concluded*).

Species.	D. B. H. inches.	Fungi Present as Evidenced by the Sporophores.		
		Polyporus pargamenus.	*Polyporus abietinus.*	*Polyporus volvatus.*
Castanea dentata	1	....	....	....
Castanea dentata	1	....	....	....
Castanea dentata	1	....	....	....
Castanea dentata	2	*	....	....
Castanea dentata	5	....	....	....
Castanea dentata	12	....	....	....
Total	6	1	....	....
Pinus strobus	1	....	*	....
Pinus strobus	1	....	....	....
Pinus strobus	2	....	....	....
Pinus strobus	2	....	....	....
Pinus strobus	3	....	....	....
Pinus strobus	3	....	....	....
Pinus strobus	3	....	....	....
Pinus strobus	3	....	....	....
Pinus strobus	4	....	....	....
Pinus strobus	4	....	....	....
Pinus strobus	4	....	....	....
Pinus strobus	4	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	5	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	6	....	....	....
Pinus strobus	7	....	....	....
Pinus strobus	7	....	....	....
Pinus strobus	8	....	....	....
Pinus strobus	8	....	....	....
Pinus strobus	8	....	....	....
Pinus strobus	8	....	....	....
Pinus strobus	9	....	....	....
Pinus strobus	10	....	....	....
Pinus strobus	11	....	....	....
Pinus strobus	11	....	....	....
Pinus strobus	11 (L)	....	....	....
Pinus strobus	12	....	....	....
Total	37	0	....	....
Pinus rigida	9	....	....	*
Total	1	0	....	....

SUMMARY OF TREES BEARING SPOROPHORES OF POLYPORUS PARGAMENUS BY SPECIES AND SIZE.

SPECIES.	D. B. H. inches.	Number of trees on area.	Number bearing sporophores of *P. pargamenus*.	Percentage bearing sporophores of *P. pargamenus*.
Quercus alba	2	12	1	8
Quercus alba	3	52	21	40
Quercus alba	4	37	21	57
Quercus alba	5	40	36	90
Quercus alba	6	33	27	82
Quercus alba	7	27	24	89
Quercus alba	8	19	17	89
Quercus alba	9	8	8	100
Quercus alba	10	3	3	100
Quercus alba	11	6	6	100
Total *Quercus alba*	....	237	164	69
Quercus coccinea	5	2	1	50
Quercus coccinea	6	2	0	0
Quercus coccinea	7	6	3	50
Quercus coccinea	8	7	2	29
Quercus coccinea	9	6	1	17
Quercus coccinea	10	16	5	31
Quercus coccinea	11	9	5	56
Quercus coccinea	12	12	5	42
Quercus coccinea	13	4	3	75
Quercus coccinea	14	3	3	100
Quercus coccinea	15	2	1	50
Quercus coccinea	16	1	0	0
Quercus coccinea	18	1	1	100
Total *Quercus coccinea*	....	71	30	42
Hicoria alba	1	7	0	0
Hicoria alba	2	12	0	0
Hicoria alba	3	6	3	50
Hicoria alba	4	5	0	0
Hicoria alba	5	3	0	0
Hicoria alba	6	1	0	0
Hicoria alba	7	1	0	0
Total *Hicoria alba*	....	35	3	9
Acer rubrum	1	3	0	0
Acer rubrum	3	2	2	100
Acer rubrum	5	5	5	100
Acer rubrum	6	2	2	100
Acer rubrum	7	2	2	100
Acer rubrum	11	1	0	0
Total *Acer rubrum*	....	15	11	73
Castanea dentata	1	3	0	0
Castanea dentata	2	1	1	100
Castanea dentata	5	1	0	0
Castanea dentata	12	1	0	0
Total *Castanea dentata*	....	6	1	17
Total all species of hardwoods	....	364	209	57

The figures given above are striking indeed and show that *Polyporus pargamenus*, as judged by the frequency of its occurrence, is the only wood-destroying fungus to be reckoned with as yet in this particular locality. The rapidity of the infection and growth of this pernicious sap-rotting fungus is remarkably well demonstrated by the fact that, out of the total (364) standing hardwood trees upon this tract, 57 per cent bore sporophores of *Polyporus pargamenus* within one year and three months after the area had been burned (Plate XXX). Here it may be mentioned that the weather was very dry during the two months prior to the survey so that practically all the growth of the fungus may be credited to thirteen months. Of the trees bearing no sporophores of the fungus a few were charred so badly near the ground that the chances for infection were materially reduced, owing to the fact that little or no sapwood was left near the ground, a place which offers the optimum moisture conditions for the growth of wood-destroying fungi. Moreover, many of the trees which do not yet bear sporophores are undoubtedly infected by this sap-rot so that, before many more months elapse, a much higher percentage of the trees will bear sporophores. In addition new trees are constantly becoming infected. The white oak is the principal tree on this tract, and, of the 237 white oak trees recorded, 69 per cent bore sporophores of *Polyporus pargamenus*. It is especially interesting to note that the smaller the trees were the less was the percentage containing sporophores of this sap-rot. Of the two-inch trees only 8 per cent bore sporophores, while of the three-inch trees 40 per cent bore sporophores. From this point on as the diameters of the trees increased so did the percentage that bore sporophores, until 100 per cent was obtained for the nine, ten and eleven-inch trees which were the largest present upon this particular tract. No apparent relations between the diameter of the trees and the percentage bearing sporophores were evident in the other species but there were more white oak trees on the tract than of all the other species combined, so that for this species better and more uniform comparisons are to be expected.

The majority of the fire-killed trees had sent up a good coppice growth but even this new growth will be subjected constantly to infection and as soon as any injuries occur to any of these new trees they will, without fail, be attacked by this sap-rotting fungus. The majority of the standing timber on this tract is too small to serve for anything but fence posts and cordwood, but even the possibility of profitable returns from these sources has been neglected by the owner. Thus will the infected timber remain standing for a number of years and continue to be a place of propagation and source of new infections, thereby endangering all other hardwood timber for miles around.

Control of the Sap-rot Caused by Polyporus Pargamenus

In forest pathology we have to deal with trees under two cultural types: First, the trees in the forest; second, shade, park, and ornamental trees. When we come to consider the question of commercial control, which is the principal aim and end of forest pathology, we can see that we have two very different lines of attack, which are governed entirely by commercial considerations. A shade or ornamental tree has great individual value and is under constant observation, or at least it should be. In this case we can employ in the prevention of disease the methods of control that have been evolved with such remarkable success in tree surgery practice.

When we consider diseases of the forest, however, commercial conditions are quite different. It is no longer possible to give the individual tree a large amount of attention. We must consider the forest *en masse*. This being the case, it is apparent that there is indicated for forest pathology a line of evolution quite distinct from that which characterizes the application of forest pathology in arboricultural practice. For the present this development will be comparable to what a physician would term "preventive medicine," as in the case of animal or human disease when we consider the species *en masse*. In the protection of forests the control of wood-destroying fungi therefore must be a matter of prevention rather than one of cure. In the control of such diseases as the sap-rots we have recourse only to slight modifications of silvicultural practice which will enable such diseased trees to be marked for removal when the forest is cut. There is one forest operation in which a timbered tract may be easily cleared of diseased stems at small cost. This is the repeated process of thinnings or of making improvement cuttings, during which all diseased and backward trees should be removed. In forests of high value, with high-priced timber located near towns or centers of industry, this cleaning out is comparatively easy and the value of the products sold usually suffices to pay for the improvement cutting. In remote forests, however, with a small working staff, deficient means of transportation, and little or no market for the thinned-out material, such methods are impracticable.

The sap-rot caused by *Polyporus pargamenus* is one of the most important sap-rots of deciduous trees. Suggestions made for its control will apply more or less to all of them. So long as fires are allowed to run through our woodlots and forests of deciduous trees, sap-rots will continue to be common. The loss of good, merchantable timber in lumbering operations due to wood-destroying fungi that have followed forest fires is enormous. Long (1913), in a study of the "Effect of Forest Fires on Standing Hardwood Timber," made in the Ozark Mountains of Arkansas, cites a case where on one stave sale area seventy-six trees out of every 100 felled had butt rot and twenty-seven trees in every 100 had wormholes of some kind in them. As the author states, this means that after going to the expense of felling 100 trees only twenty-four of them were perfectly sound and suitable for staves; not only was there a monetary loss from the cull of seventy-six trees, but the expense of felling unsound trees must be considered. For five widely separated areas in the eastern part of this forest Long states that an average of sixty-five trees in every 100 had butt rot and twenty-six had wormholes sufficient to cull some of the bolts. Most of this loss could be traced directly to the fires so common in this forest. The area where seventy-six trees in every 100 were found to have butt rot has been burned over regularly for years. Over areas where fires had not been so frequent the injury from butt rot was correspondingly less.

We find, then, that forest fires are a serious menace to hardwood timber since they open the way not only to wood-destroying fungi but also to wood-boring insects. Every fire, therefore, only increases the damage by providing conditions for a new crop of insects in the trees and giving another chance for fungi to enter through the new fire scars, thus increasing the quantity of unmerchantable timber and decreasing the amount of money received for the timber. This deterioration in the standing timber of any region is the direct source of a tremendous loss to the entire community of that region, for, as Long (*l. c.*) states, the timber itself is not only a total loss to the settlers and other owners, but by its presence it also increases the cost of lumbering and decreases the stumpage value of that timber which is merchantable; furthermore, it means a loss in wages to the laborer and a loss to the State in revenues from the sale of government timber.

The fact follows, then, that the continued burning of timbered lands in any region of the country is causing an annual loss of thousands of dollars — an absolute detriment to the welfare of the states involved. It is obvious that this loss can be almost entirely eliminated by the prevention of all forest fires, whether large or small — a matter which can be accomplished only by the hearty co-operation of all the residents with the fire protection work of the individual states or the government.

The practice of leaving standing all the badly diseased trees in our woodlots and of leaving them remain uncut in a lumbered area is radically wrong from the standpoint of proper forest sanitation, for this practice enables sap-rotting fungi to maintain themselves in the forest while the new generation of trees slowly develops and as soon as any become injured they thus become susceptible to the attacks of sap-rotting fungi. Trees effected with sap-rot should not be left for seed trees wherever it is possible to leave healthy ones for this purpose, since, having their vitality considerably reduced, they would not be good seed-producers, and moreover they undoubtedly would die within two or three years or even earlier. In deciduous forests it usually is unnecessary to leave seed trees, owing to the abundant production of sprouts and to the presence of young trees intermingled with the more mature ones.

Trees in the woodlot should be inspected annually and all diseased trees should be removed. The presence on a trunk of the fruiting bodies of *Polyporus pargamenus*, which may appear as early as a year from the time of infection, is the surest evidence of the existence of sap-rot and of the necessity of removing the tree. Such trees should be removed wherever found. Fire-scorched trees should be removed and marketed before decay sets in, for once the cambium is killed, decay invariably will follow quickly. In large forested areas it is not possible to personally inspect the trees every year, although the present prices of white oak nearly justify the expense necessary in a system of careful forest sanitation. It certainly will pay in lumbering large tracts of oak and other valuable hardwoods to cut out all unsound or diseased trees, remove the parts that can be used and burn the remainder. Under the present methods of lumbering many trees are left standing because they are decayed near the base of the trunk. The importance of utilizing such trees can not be too strongly exemplified, since, if used before the decay has spread for many months, the heartwood and all of the tree above the first log can be used, especially in those trees which have a durable heartwood, such as the white oak, for example. If cut down these trees will often be found to contain enough lumber to pay for the cost of the operation. Such a procedure will lead to a better and closer utilization of our gradually decreasing lumber supply of deciduous woods, especially of white oak. If, however, trees affected by sap-rot are left long in the forest they will deteriorate very rapidly and unless the merchantable timber which such trees may contain is utilized it will be a total waste and remain in the woods to furnish a means for the incubation of the fungus and the spread of the inoculum.

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Summary

Polyporus pargamenus is one of the most common wood-destroying fungi causing a sap-rot of most of the species of dicotyledonous trees occurring throughout its nearly cosmopolitan range. It is essentially a saprophytic organism, and as such is especially notorious for attacking dead wood, especially felled wood from which the bark has not been removed. It frequently becomes a wound-parasite, and as such is especially prevalent on fire-scarred trees throughout the hardwood forests of the eastern half of the United States.

The sporophores of *Polyporus pargamenus* are subject to wide variation in their morphological characters, and the various diverse forms are to be regarded as ecological adaptations of the fructification in response to varied environmental factors, particularly the moisture content of the substratum and the humidity of the air.

As a species *Polyporus pargamenus* consists of a number of more or less intergrading forms which often become sufficiently distinct as to constitute varietal forms or subspecies. It is advocated that these varietal forms be recognized for

practical purposes, particularly for the convenience of the critical worker.

The usual form of the fructification is distinct from that of its near relative *Polyporus abietinus*, with which it is often confused. These two species are to be distinguished definitely only by the combined use of their respective morphological characters, since the knowledge of the habitat (whether on coniferous or dicotyledonous wood), while sufficient in most cases, will not always serve as the deciding criterion.

The concentric sulcations, as well as the zones of color and pubescence, on the pilei are to be regarded as expressive of differences in the local climatological and atmospheric conditions existing at different times during the growth of the pilei.

The pores of the sporophores are evolved successively from the center of growth or point of attachment outward, the basidia and spores beginning to form while the pilei are still young, and continuing their development throughout the life of the pilei. As a result of this successive development of the basidia the spores are shed intermittently over long periods.

The extreme drouth resistance of the fructifications is indicated by the following criteria: (a) By the ability of the sporophores to resume growth after withstanding long periods of dessication; (b) by the ability of the sporophores to revive and shed viable spores after being kept in a state of dessication for at least a year; and (c) by the ability of the spores to germinate and produce infectious mycelium after having been shed and kept in a state of total dessication for as long as ten months.

Darkness is conducive to the most vigorous vegetative growth but retards sporophore formation. The dimidiate form of the sporophore is not to be ascribed either solely to the stimulus afforded by light, nor to that by gravity, but to the combined action of both. The formation of pores and the production of spores, however, depends entirely on light. No chemotropism of the mycelium could be detected; it seems to be non-specialized and secures its nutrient substances from the easiest available source.

Germination of the basidiospores occurs regularly in a great number of nutrient media, but the percentage of germination and subsequent growth of the mycelium is directly proportional to the suitability of the culture medium used. Germination also occurs in both tap and distilled water, thus showing that an external food supply is not necessary for the germination of the spores, although it greatly accelerates it. Germination was not stimulated, but was greatly retarded, by the use of slight quantities of alcohol and ether. In their germination the spores exhibited no especial preference for either acid or alkaline nutrient media.

The change in the mycelium from the short-lived primary mycelium, which is the product of the elongating germ tubes, to the typical secondary mycelium apparently is a regular occurrence not influenced by the nature of the culture medium or by other external factors.

The occurrence of two secondary spore forms, namely oidia and chlamydospores, as definite stages in the life cycle of this plant is here reported for the first time. Oidia were observed to form repeatedly on both primary and secondary mycelium; chlamydospores, however, were observed to form only on the secondary mycelium. The formation of oidia apparently can continue indefinitely or at least for several successive generations.

The basidiosporic hymenium has been developed from the basidiospore in petri dish cultures on nutrient agar, and also from the mycelium contained in a bit of birch bark when inoculated on sterile blocks of wood, thus completing the life-cycle of this fungus.

The decay of wood by *Polyporus pargamenus* consists of a series of chemical and physical changes brought about by the reduction of the woody substance by enzyme secretions of the vegetative mycelium. The dissolution of the cell-walls is to be attributed to the fact that they, as a potential source of food, are valueless to the fungus until broken down and reduced to a condition suitable for translocation and assimilation.

The enzymatic digestion and consequent decay of wood by *Polyporus pargamenus* is accomplished mainly by the exceedingly minute fungal hyphæ, which are the ultimate branches of the mycelial system. Upon the completion of the decay within any given area of the wood the older mycelium, which has fulfilled its purpose, causes to function in the enzymatic reduction of the woody substance, although it still may prove useful in the translocation of the elaborated food materials. When the final stage of the decay is reached the mycelium itself apparently is dissolved together with the woody substance in areas of the wood where the decay is most intense.

The decay of wood by *Polyporus pargamenus* is characterized by its habitual tendency to produce a minute pocket type of decay, which, while not very pronounced in the early stages of the decay, becomes a conspicuous feature of the later stages. As a result of the intensity of the decay in these innumerable pockets the destruction of the woody elements becomes completed in these initial centers of the decay before the wood lying between these areas is materially destroyed. Within the individual pockets the decay progresses mainly in a direction parallel to that of the woody elements, the central elements becoming reduced rapidly to pith-like consistency. In the late stages two or more adjoining pockets may coalesce into one, the resulting pockets becoming quite empty of contents and separated by almost membranous layers of less decayed wood. The largest pockets observed were in yellow birch wood, where they attained a maximum diameter of three mm. in diameter and three cm. in length.

The first chemical change brought about by the action of this fungus is that of delignification. The decay begins at the interior of the cell-wall and destroys it progressively from the internal or last-formed layer to the middle or primary lamella between two adjoining cells, first removing the lignin constituents and then the remaining cellulose. The tertiary and secondary layers are entirely dissolved before the delignification of the middle lamellæ commences.

The results obtained from the study of the decay by *Polyporus pargamenus* establish the fact that the minor variations in the decay of different woods by this fungus are much more dependent upon the dissimilar structure of the respective woods than has been generally supposed.

The results of the microscopic study of the decay of five woods of diverse structure, of the macroscopic study of the decay in twenty-eight other species of wood, indicate that the decay progresses to varying extents in different woods before reaching completion and that the decay of any given species approaches completion long before the woody substance is entirely destroyed. The ratio between the amounts of chemically resistant by-products accumulated in the woody tissue and the potential food supply still remaining available for assimilation by the fungus automatically constitutes itself an index of the completion of the decay.

The anatomical and microchemical observations on the decays of the five woods studied indicate that the vegetative mycelium of *Polyporus pargamenus* secretes diastatic, proteolytic, and cytohydrolytic enzymes, among the latter being pectinase, cellulase, and ligninase.

The metabolic by-products most frequently encountered in wood decayed by *Polyporus pargamenus* are the extremely chemically resistant brown humic products which infiltrate portions of the wood, causing them to appear as brownish discolored areas, or which more often collect in narrow zones between the decayed and undecayed portions, causing the wood at this point to appear as a blackish zone of varying thickness. These zones are not constant in position since they keep pace with the advance of the decay in any part of the stem and ultimately disappear upon its completion within that part.

The partially decomposed material of woody plants forms a particularly vague and indefinite group of substances containing all the non-volatile products of fungal, enzymic, and oxidative actions on the plant residues. The physical appearance and chemical composition of the brown humic by-products of decomposition vary greatly according to the extent to which they have been reduced. The chief characteristic of this series of degradation products of plant tissues is the accumulation of carbon at the expense of oxygen and hydrogen. The cell contents and certain other substances, particularly the hemicellulose xylan (wood gum), that originally were combined with the cellulose to constitute the cell-wall, furnish the formative material which coagulates to thick drops and gives rise to the humic by-products of decomposition which ultimately infiltrate certain portions of the wood, causing them to appear as blackish zones.

By the action of a strong oxidizing reagent on fresh sap-wood a brown humic product can be prepared artificially, which is essentially like that occurring naturally in wounded areas of living trees, dead wood, or as the result of their decay by *Polyporus pargamenus* and other wood-destroying fungi.

The properties of the extracts obtained respectively from sound and decayed hickory wood indicate that in the course of the decomposition a portion of the carbohydrate substance, particularly the hemicellulose xylan, becomes converted into humic substances of two principal groups, namely humic acid and humin. It is the accumulation of these humic substances which give rise to the dark brown decomposition products which are of such common occurrence in decaying wood.

The chemically resistant by-products often forming blackish zones in wood decayed by *Polyporus pargamenus* have proven to be a group of substances analogous to the humic products which arise under certain circumstances in wounded parts of living trees or in fallen woody parts that may be entirely free from fungous attack and which have been known under the name "wound gum." In wood free from fungous attack the formation of the brown decomposition product is mainly dependent upon the concurrence of three factors: (a) The presence of dead cells; (b) an optimum supply of moisture; and (c) a supply of oxygen sufficient to promote oxidation. The formation of the brown product in this case is likewise a sign of the humification which sets in gradually when their walls and contents undergo decomposition.

In general the manner and extent of the decay varies greatly, not only with the species of tree, but also with the development of the heartwood and its chemical and physical qualities. The rate at which the sapwood of various dicotyledonous species decays presents but little variation; the rate at which the heartwood decays, however, is slower by reason of being proportional to the superior durability of the heartwood over the sapwood exhibited by each species.

For its entrance to the living tree, *Polyporus pargamenus* is dependent upon human, organic, or inorganic agencies, usually gaining entrance through mechanical injuries to the host. Ordinarily this organism exists as a saprophyte but may, when favorable conditions present themselves, become a wound parasite. In the latter case it exhibits in its life-cycle two rather distinct phases — pathogenesis and saprogenesis.

The practice of allowing fires to run through our hardwood forests can not be too strongly condemned, since even trees but slightly scorched on one side furnish admirable infection courts for the entrance of *Polyporus pargamenus* and other sap-rotting fungi. The subsequent deterioration of the standing timber of any region incident to fire is a direct source of loss to the entire community of that region.

In a study of fire-killed timber made one year and three months after the burning, out of 364 standing hardwood trees occurring on an area 100 by 500 feet in central Pennsylvania, 57 per cent already bore sporophores of *Polyporus pargamenus*. Of the 237 white oak trees recorded, this being the principal tree on the tract, 69 per cent bore sporophores, the largest diameter classes containing the largest proportion of sporophore-bearing trees. This indicates the importance of the fungus in causing timber deterioration.

Under the conditions on this area the incubation period of *Polyporus pargamenus* was less than fifteen months, and, in all probability more nearly twelve months. In the case of artificial cultures the length of the entire life-cycle varied from four months in agar plate cultures to eighteen months in cultures on blocks of wood.

In the protection of our forests the control of *Polyporus pargamenus*, as well as other sap-rotting fungi, must be a matter of prevention rather than one of cure. Prevention involves forest sanitation as carried out in such slight modifications of silvicultural practice as will enable diseased trees to be marked for removal when the forest is thinned out or cut. Such procedure, in addition to improving the woodlot, will lead to a better utilization of our gradually waning lumber supply of deciduous woods, particularly of white oak.

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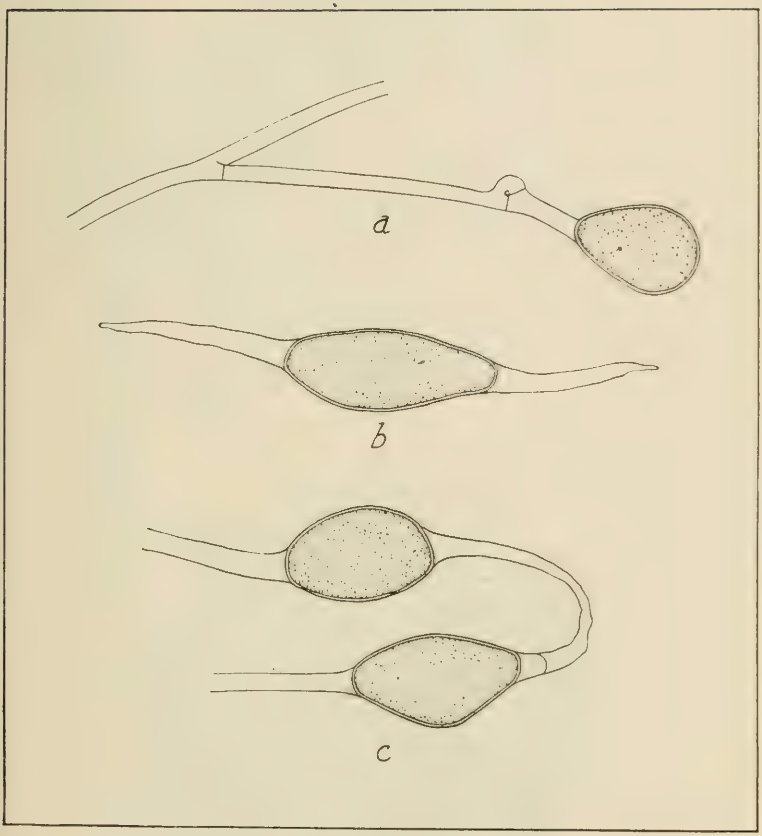


PLATE XVII.

Camera lucida drawings showing chlamydospore formation in old mycelium after it had passed through the oidial stage. X 1,500. *a*, a terminal chlamydospore; *b*, an intercalary chlamydospore, showing how it is set free by the disintegration of the empty portion of the parent hypha; *c*, two intercalary chlamydospores formed near together, showing the disintegration of the parent hypha. The lower chlamydospore has abandoned its original end wall, the protoplasm having contracted further and formed a new limiting membrane about itself at this point.

Fig. 1.

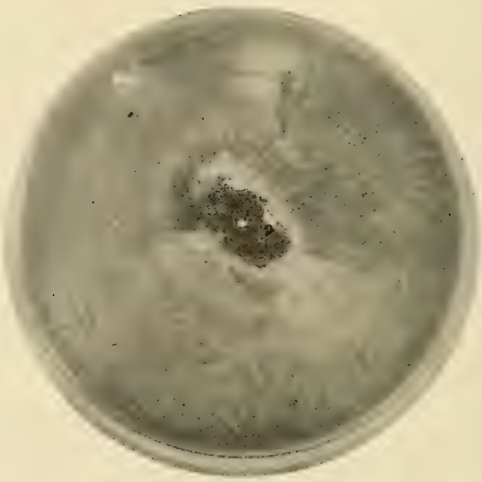


Fig. 2.

Plate XVIII.

Fig. 1.—A 3-week's old culture of *Polyporus pargamenus* secured by transferring oidia from a culture on malt extract agar to a new plate of the same medium, two-thirds natural size. The mycelial growth resulting was indistinctly zonate and again broke up into oidia.

Fig. 2.—A 3-week's old culture of *Polyporus pargamenus* on malt extract agar secured by transferring to a plate a portion of the agar containing yellowish mycelium from an old oidial growth. The mycelial tissue transferred quickly developed into a brownish hydnoid hymenium while an oidial growth spread over the agar from this nearly to the side of the dish.

PLATE XIX.

A group of sporophores of *Polyporus pargamenus* that have revived and made a new growth the second year. The sporophores in the left hand row show the formation of a new hymenial layer over the old one, which, in the sporophore at the bottom of the row, has not only entirely obliterated the old sporophore but has grown out beyond the margin of it, thus increasing the size of the pileus. The sporophores in the right hand row show the formation of a new mold-like growth over the upper surface of the sporophores and the marginal additions to the old pilei resulting from the new growth.

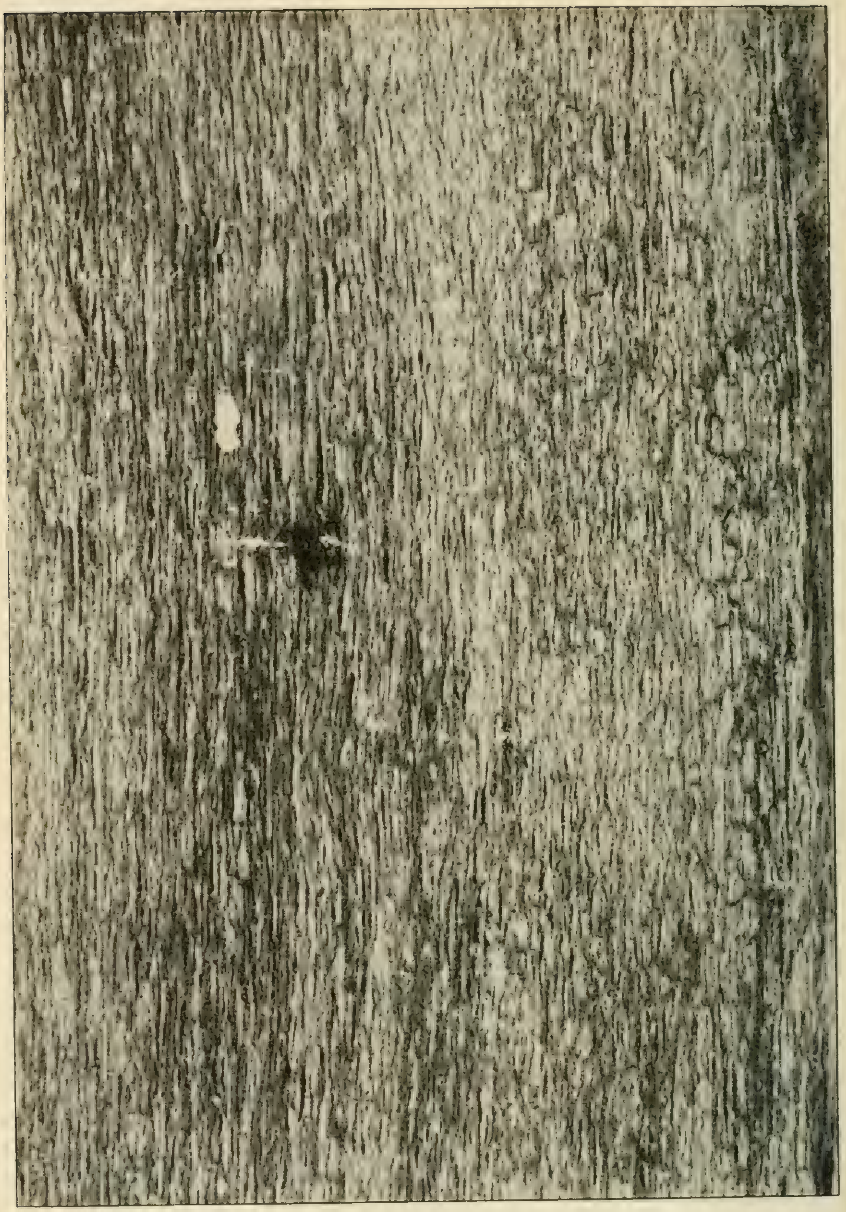


PLATE XX.

Wood of *Betula lutea* decayed by *Polyporus pargamenus*, showing initial stages in the formation of pockets — tangential surface — natural size.

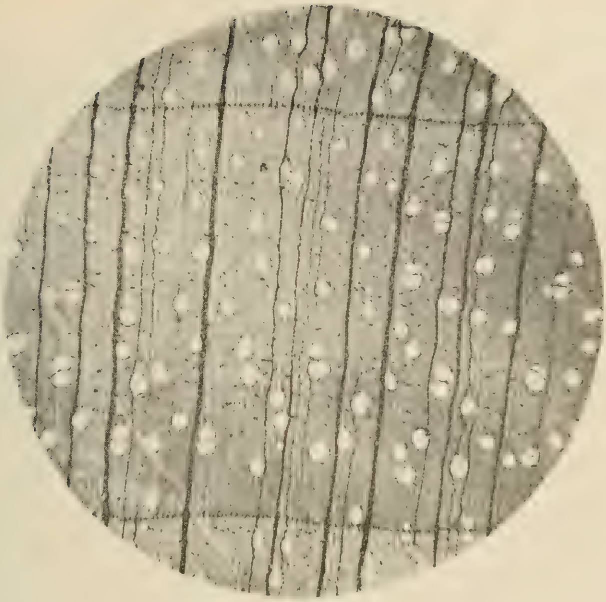


Fig. 1.

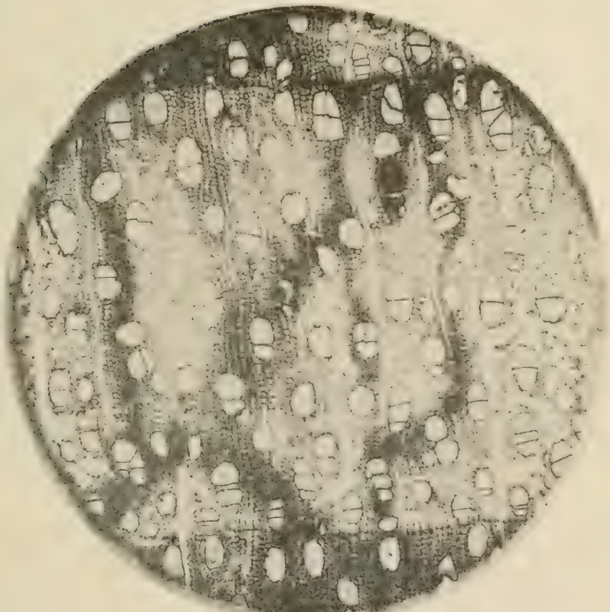


Fig. 2.

PLATE XXI.

Fig. 1.—Photomicrograph of a transverse section of normal yellow birch (*Betula lutea*) wood, X 20.

Fig. 2.—Photomicrograph of a transverse section of yellow birch (*Betula lutea*) wood decayed by *Polyporus pargamenus*, X 35.

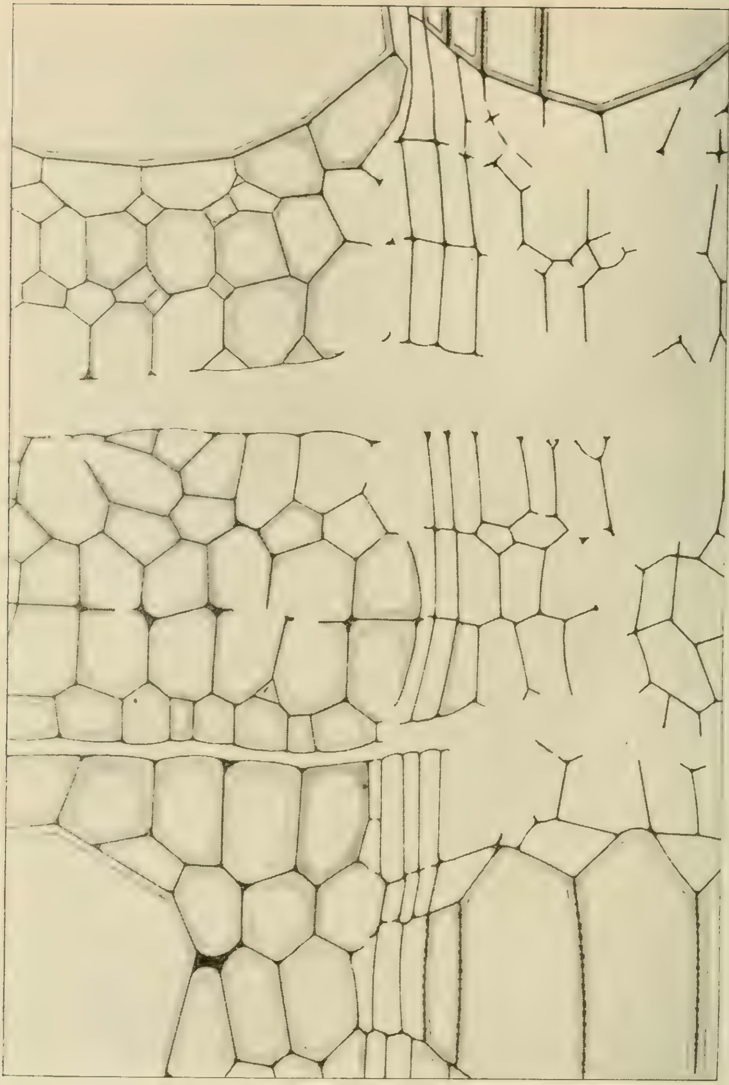
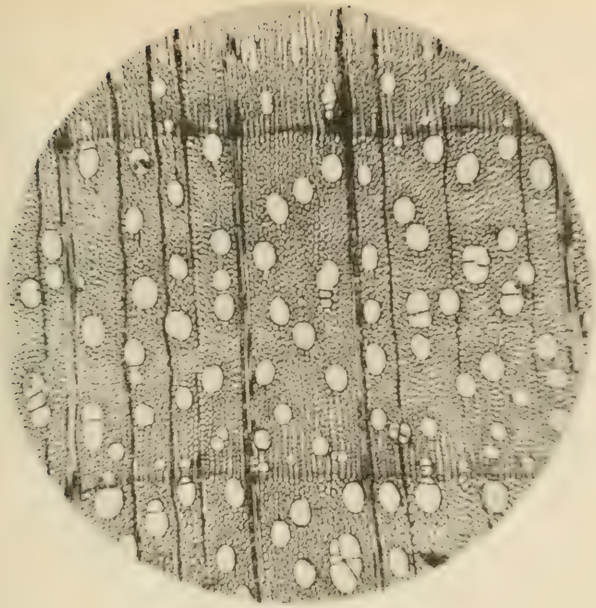


PLATE XXII.

Camera lucida drawing of transverse section of wood of yellow birch (*Betula lutea*) wood decayed by *Polyporus pargamenus*. X 800. The section, which was taken through two adjoining growth rings, shows the late wood on the left side and the early wood on the right side, with a group of vessels in each corner, and two pith-rays running horizontally through the center. The cells of the lower pith-ray have been completely dissolved out while the adjoining prosenchyma elements of the summer wood remain unaffected. The layers of secondary thickening of the elements in the early wood have been completely dissolved out, leaving only the middle lamellæ, a condition which gives the wood a skeletonized appearance.



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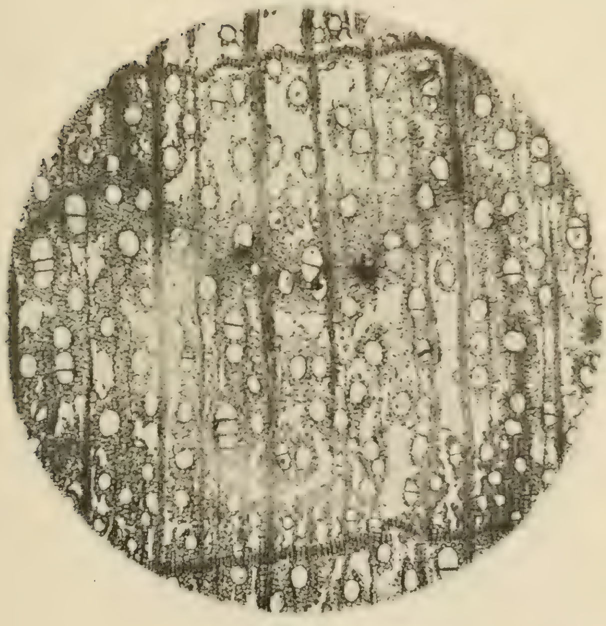

Fig. 2.

PLATE XXIII.

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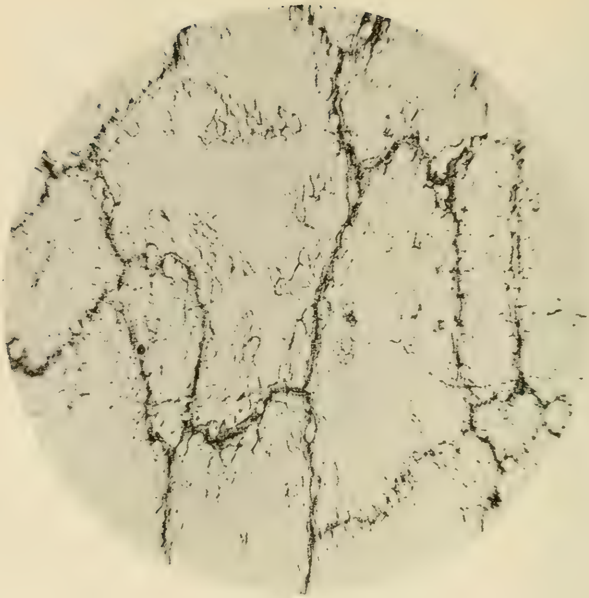


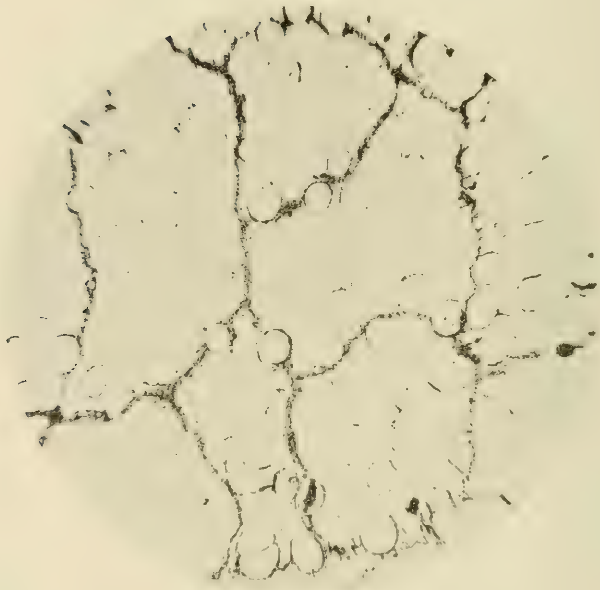
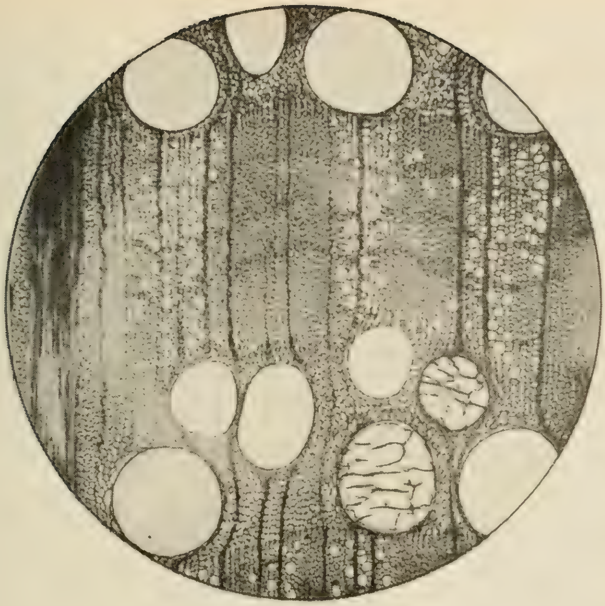


Plate XXIV.

Fig. 1.— Photomicrograph of a transverse section of yellow birch (*Betula lutea*) wood showing the final stage of the decay, X 15.

Fig. 2.— Photomicrograph of a transverse section of bitternut hickory (*Hicoria minima*) wood showing the final stage of the decay, X 15.



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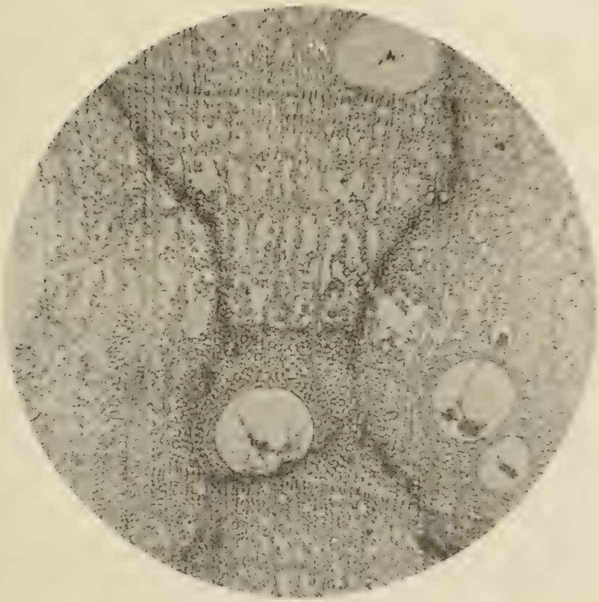


Fig. 2.

PLATE XXV.

Fig. 1.— Photomicrograph of a transverse section of normal chestnut oak (*Quercus prinus*) wood, X 35.

Fig. 2.— Photomicrograph of a transverse section of chestnut oak (*Quercus prinus*) wood decayed by *Polyporus pargamenus*, showing a reticulum of matted hyphæ bounding the original pockets or decayed areas, X 30.

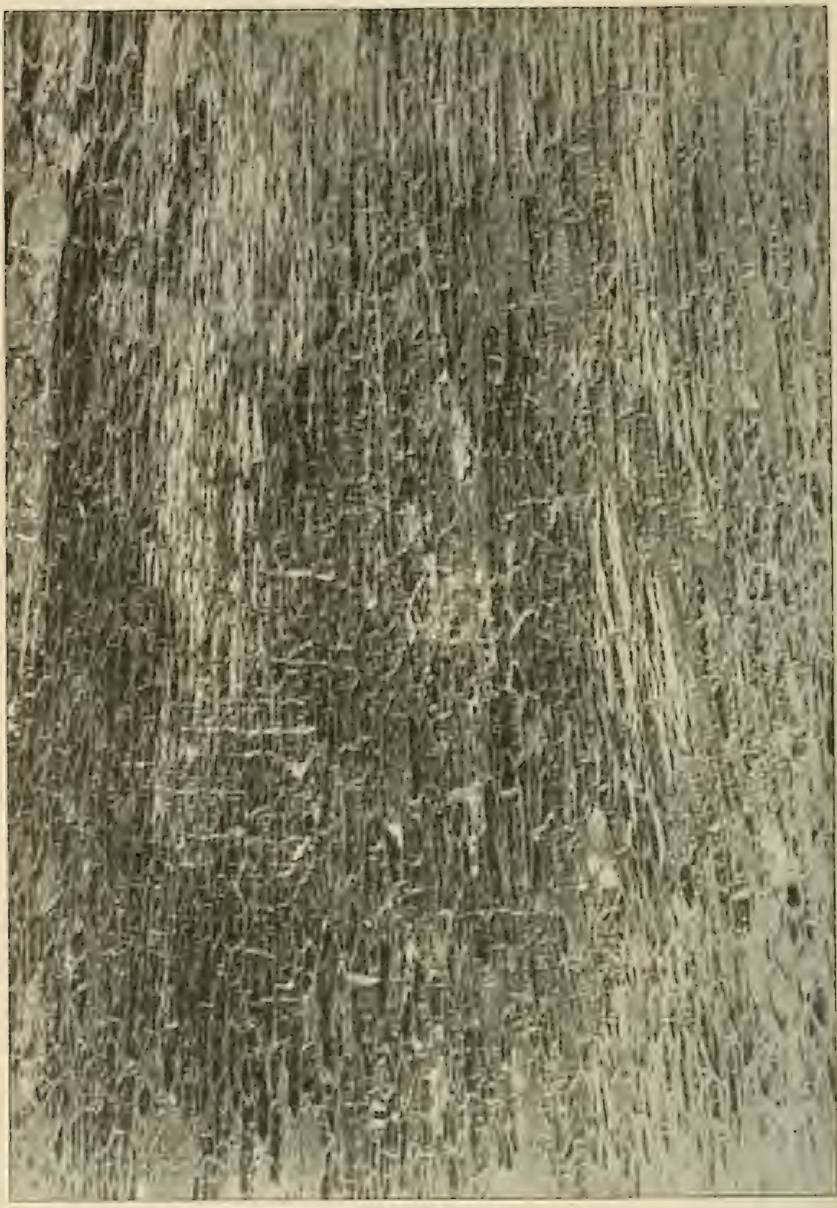
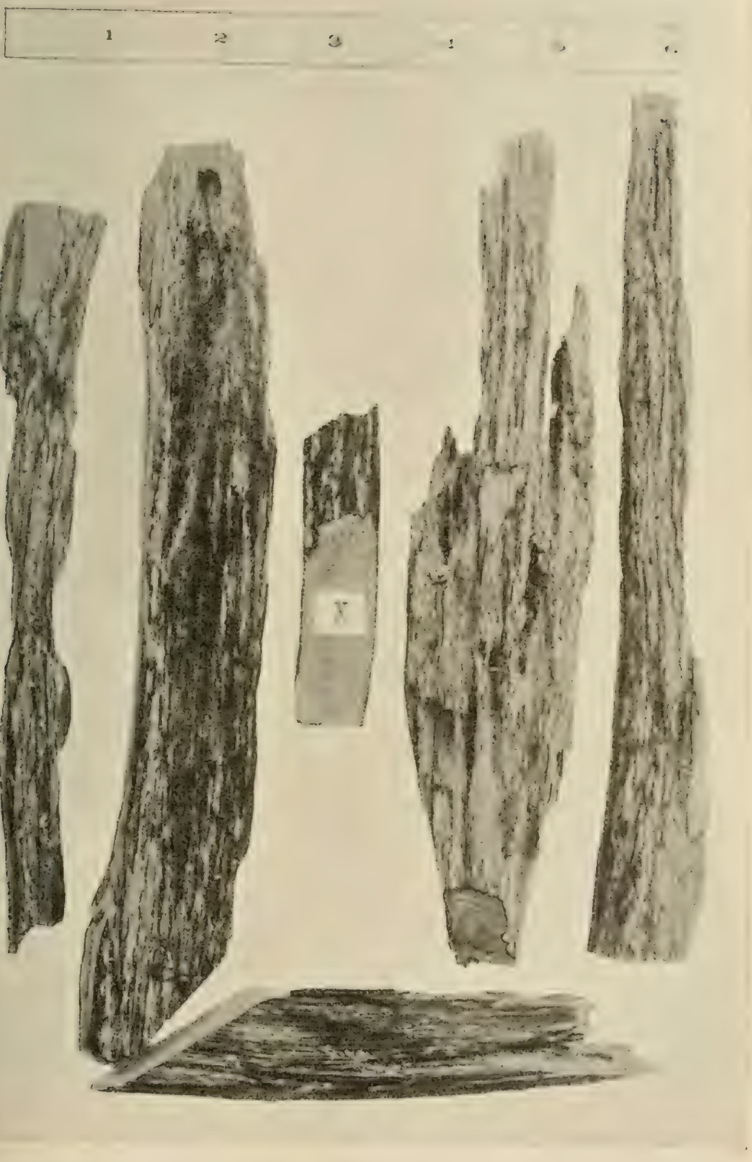


PLATE XXVI.

Wood of hemlock (*Tsuga canadensis*) decayed by *Polyporus pargamenus*, showing the peculiar localization of the decay into small pockets — tangential surface — natural size. This shows the characteristic appearance of the wood in the late stages of decay.



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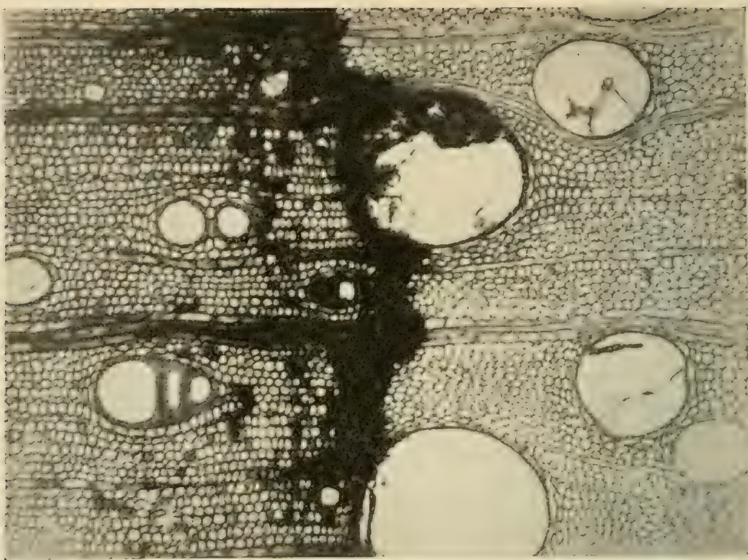

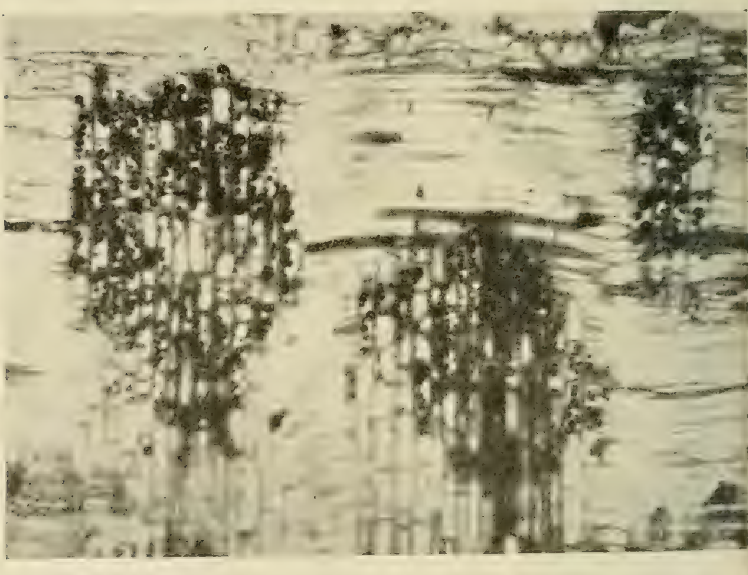

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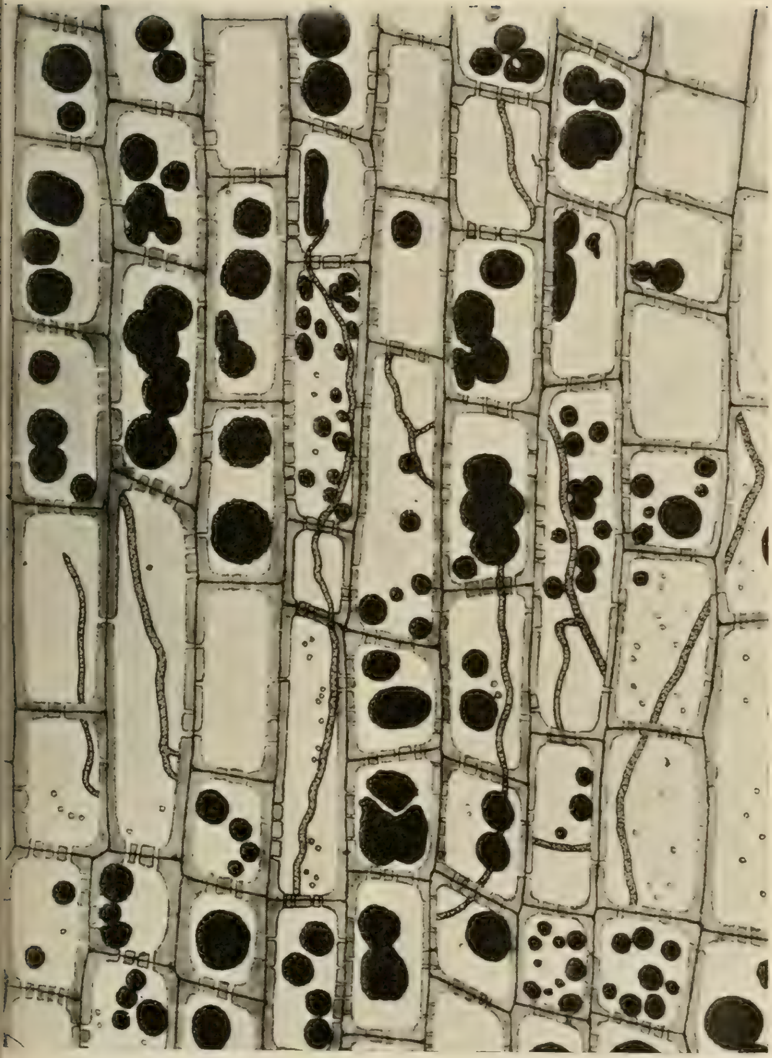

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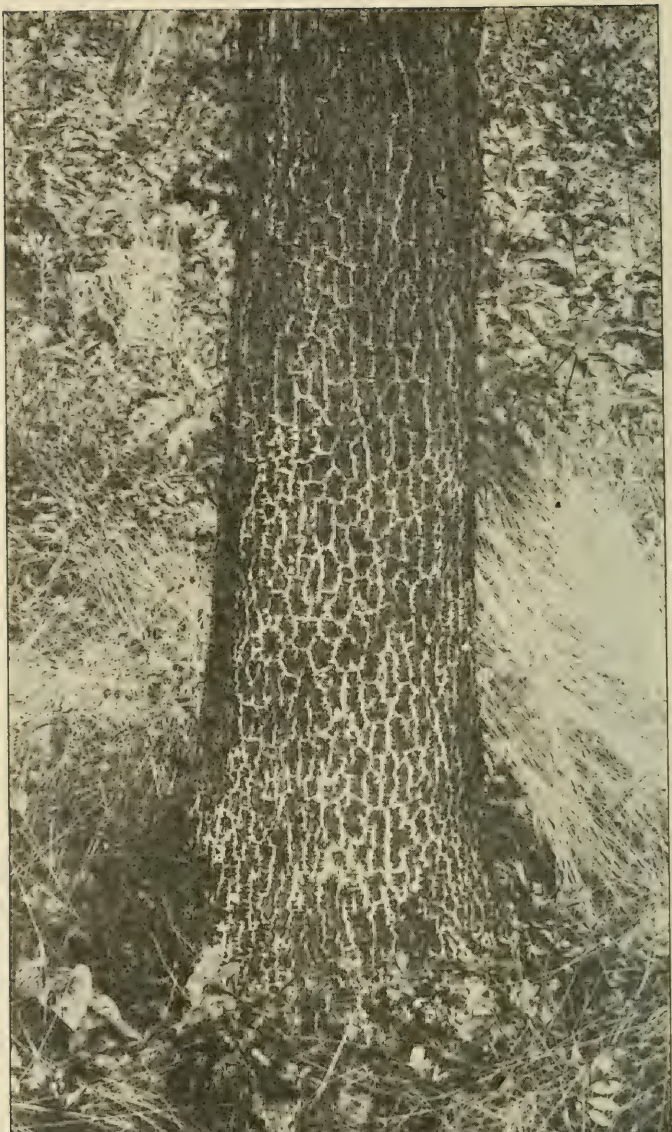

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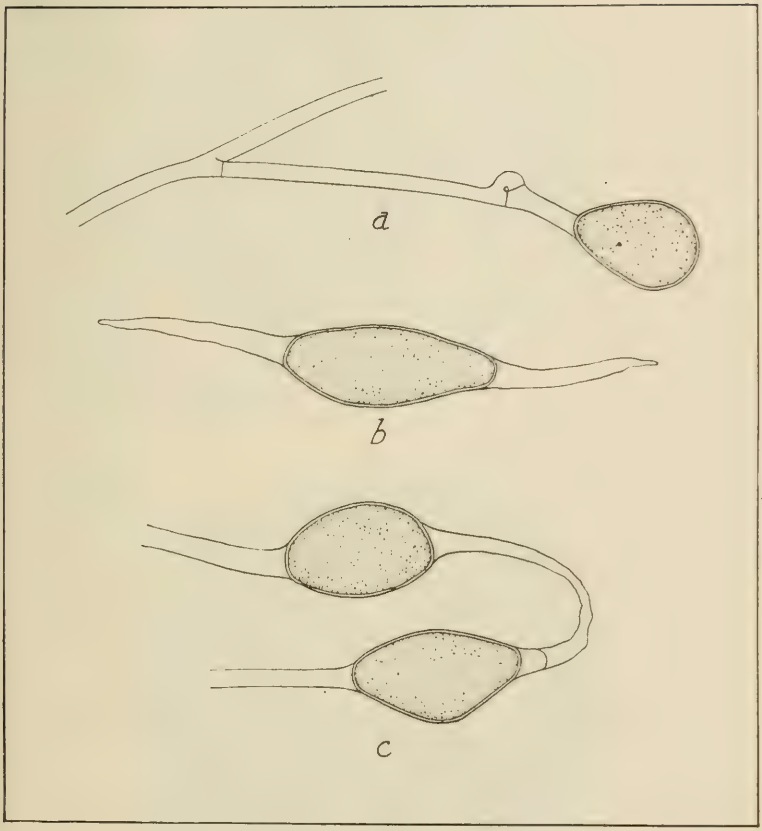

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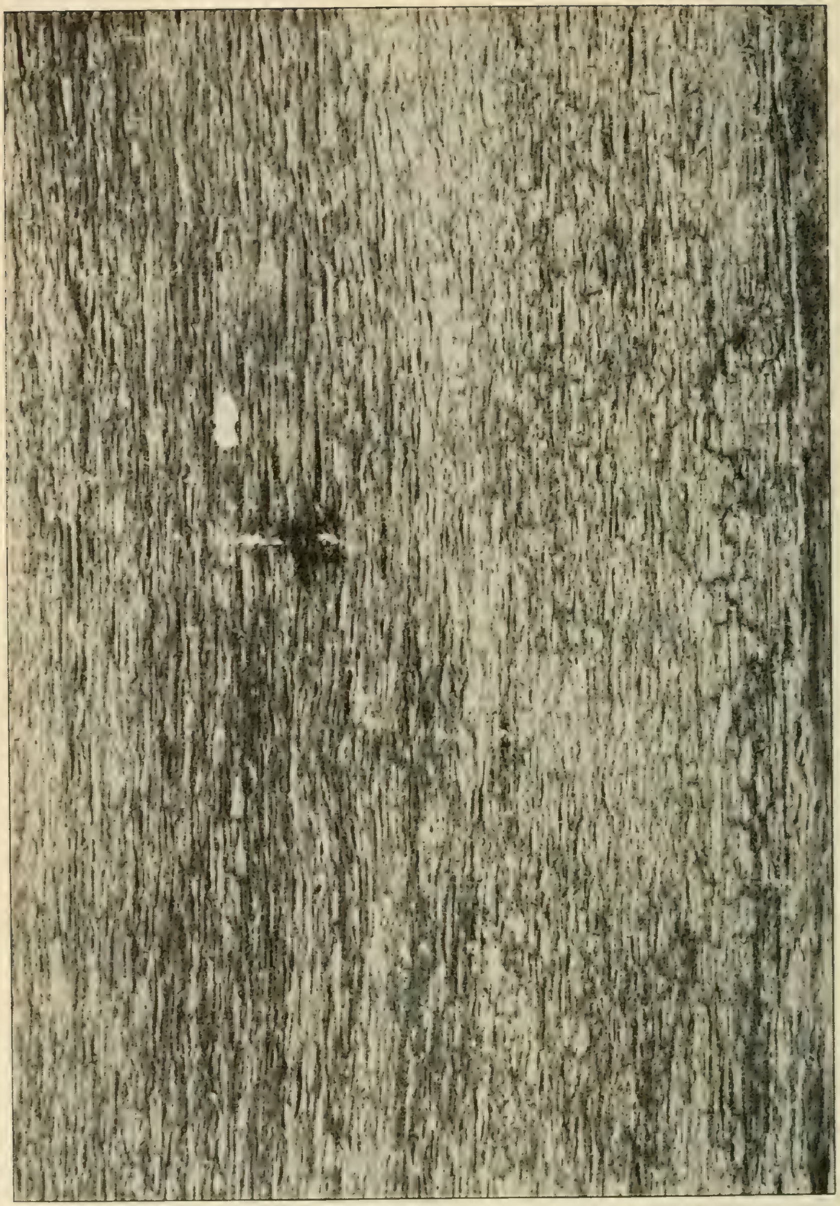

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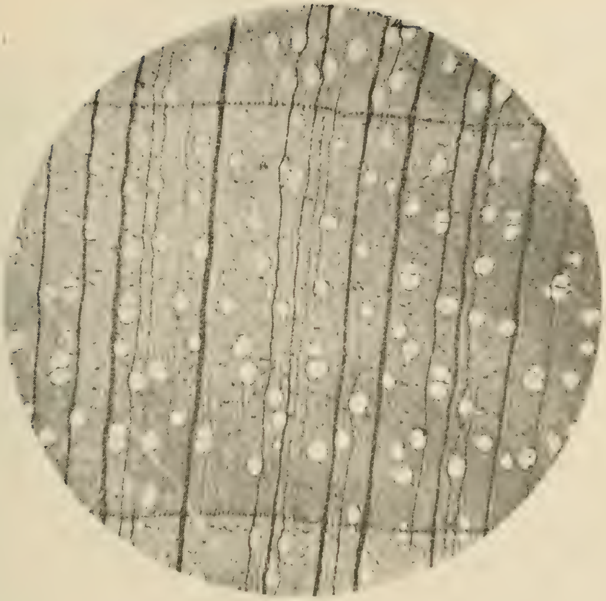

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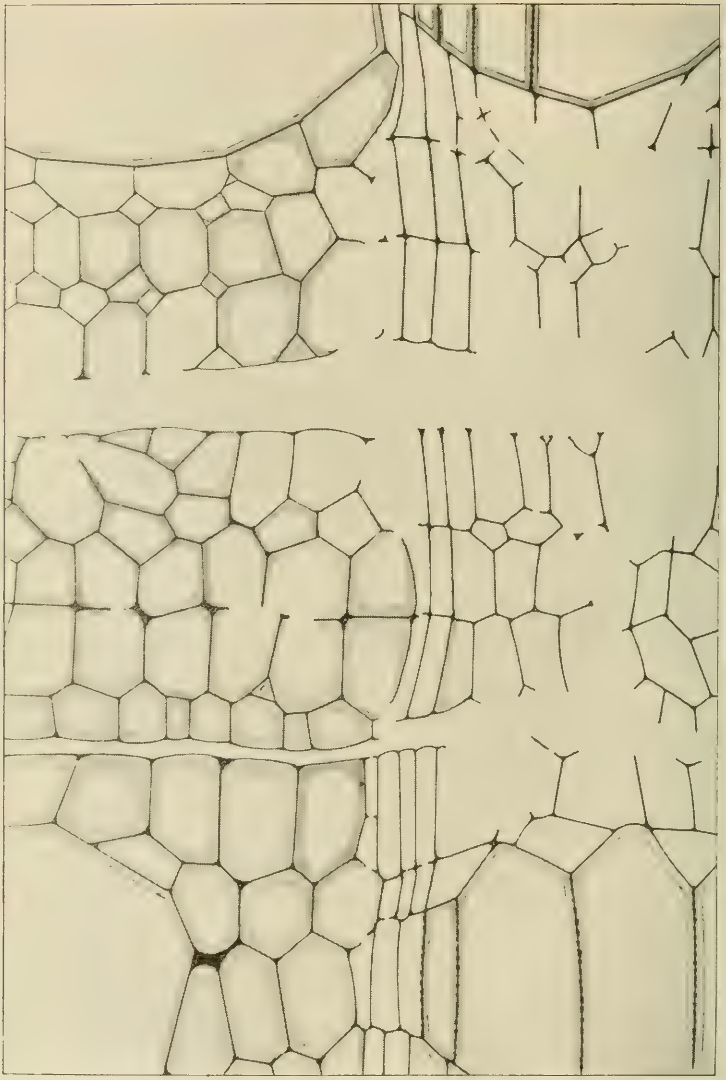

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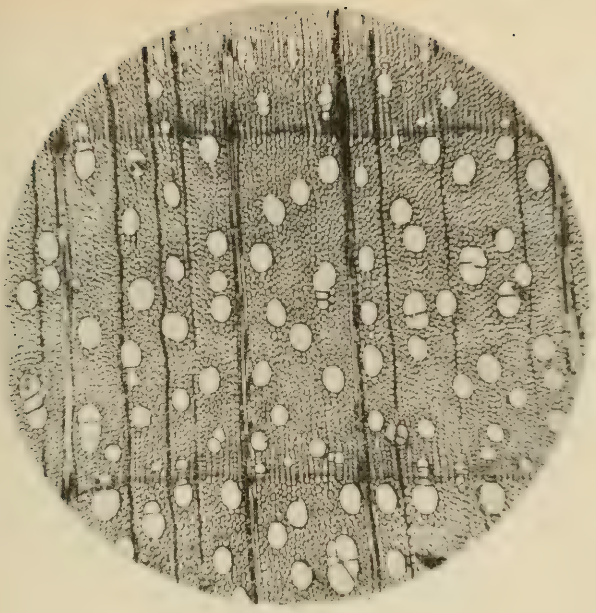

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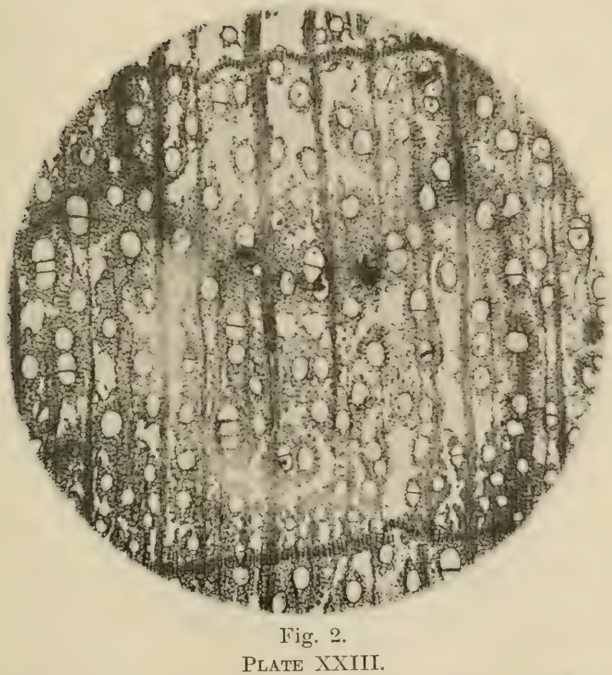

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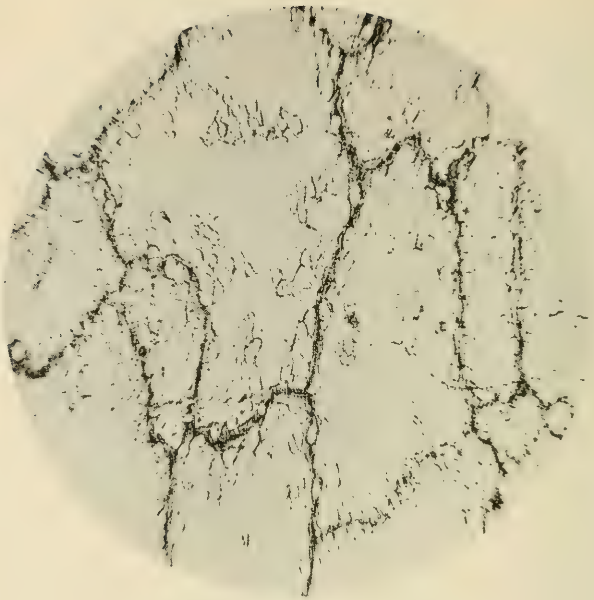

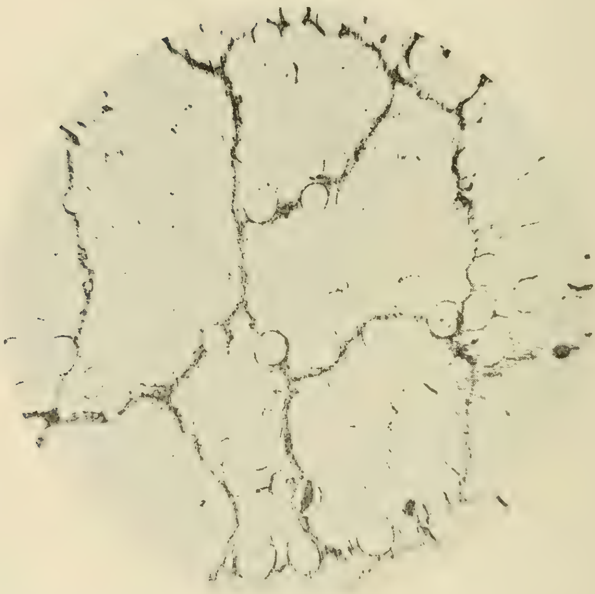

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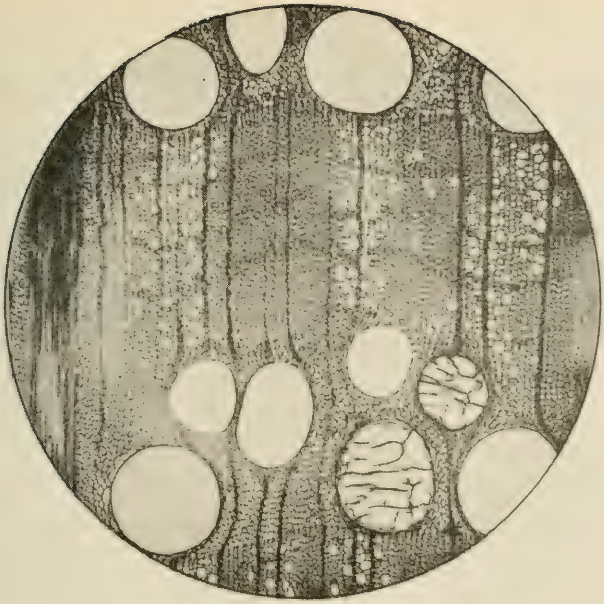

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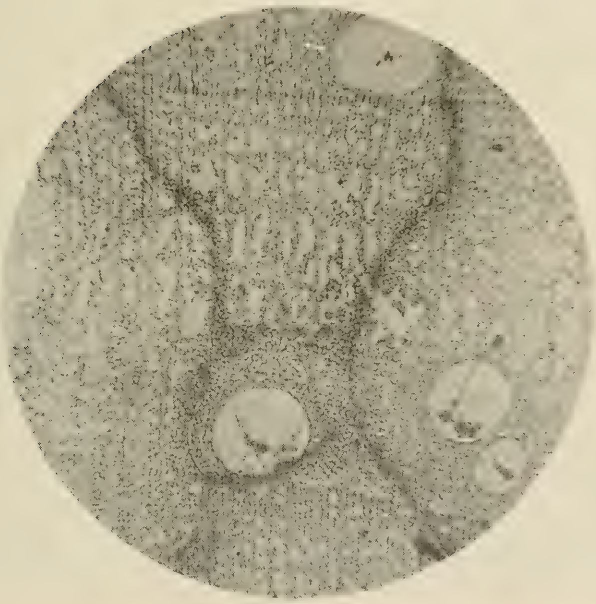

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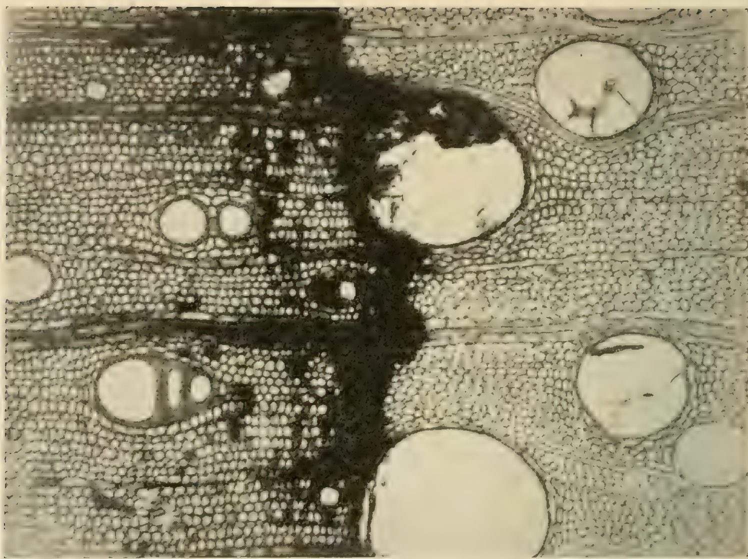

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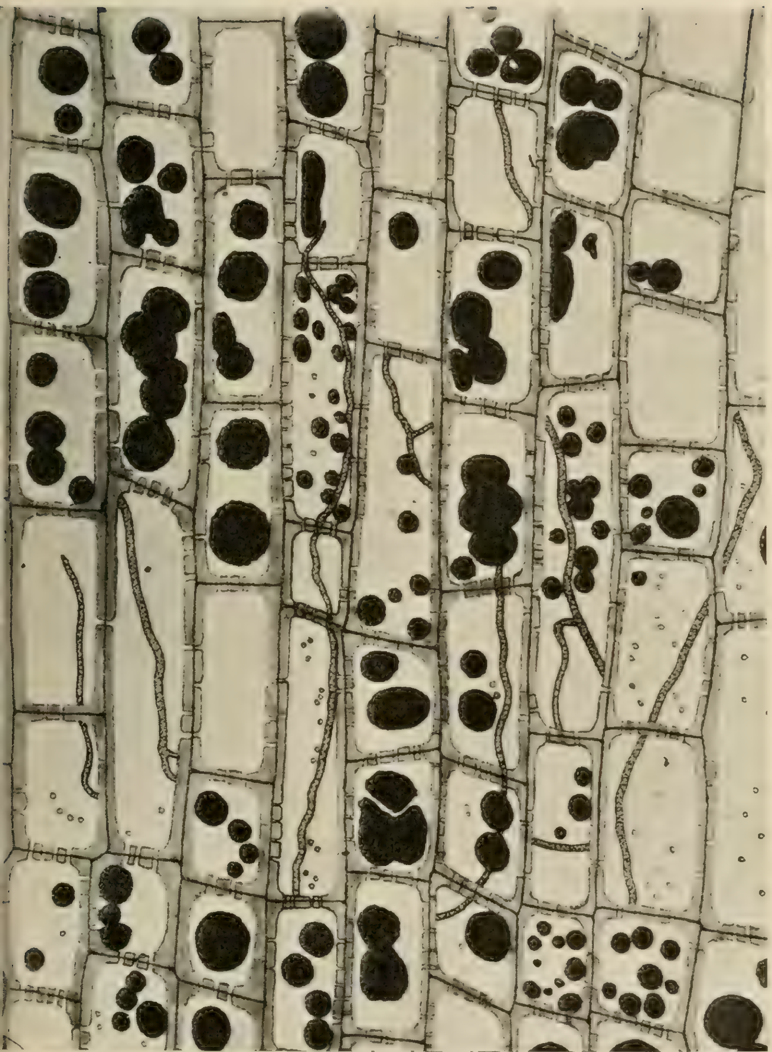

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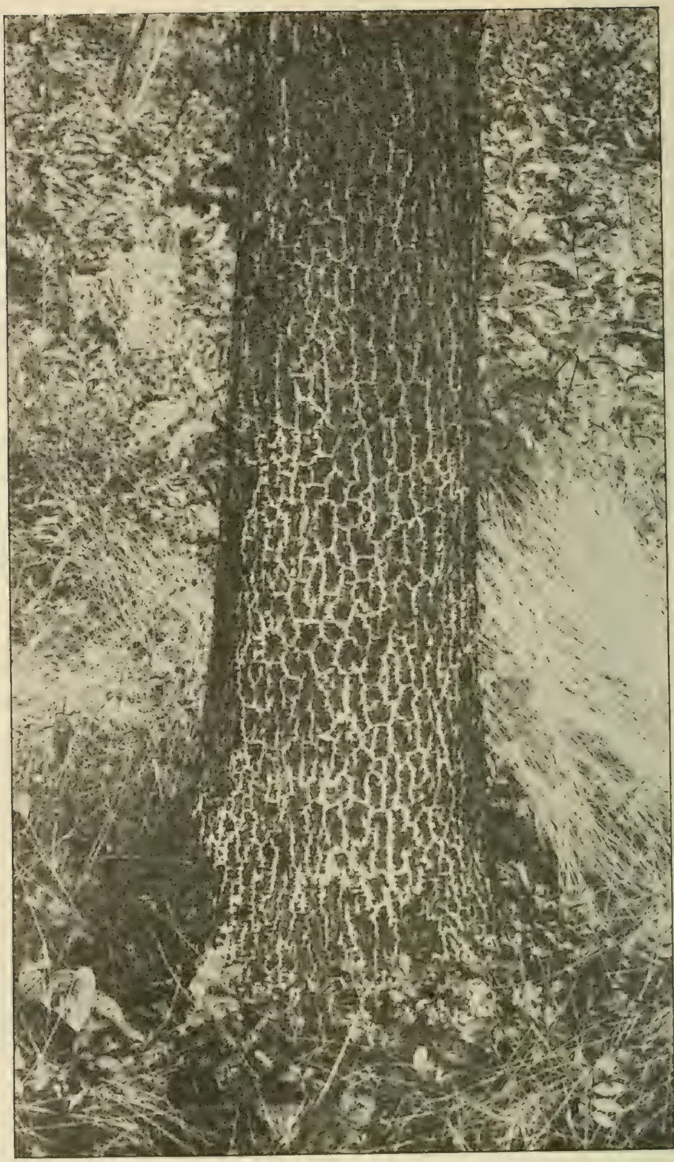

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Fig. 1. Fig. 2.

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FIGURE 1
Mature yellow birch grown on hardwood land under virgin conditions

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YELLOW BIRCH AND ITS RELATION TO THE ADIRONDACK FOREST

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YELLOW BIRCH AND ITS RELATION TO THE ADIRONDACK FOREST

The importance of hardwood in the Adirondack forest mixture when establishing plans for management was early recognized by Dr. B. E. Fernow, and active steps were taken to bring into the Adirondack regions industries that could utilize the hardwoods. The present study of yellow birch was undertaken to better acquaint us with its relation to the future forest crop. While it is but one of the four important hardwoods found in the Adirondack forest mixture, it has been selected for study for reasons which demand for it first consideration in the judgment of those members of faculty of the College of Forestry who have undertaken the work.

A complete study of the yellow birch (*Betula lutea*) was planned by the Research Committee of the College, and the work was started by several departments. This report covers the investigations of a field party of five men during the summer of 1919, together with some data previously collected. The results substantiate the previous judgment of the committee as to the importance of an inclusive study of this species.

This report includes a fundamental discussion of the types and conditions found in the Adirondacks, and presents comparative data to show the silvicultural relation of the birch to the other species native to the region. Since the study is a part of a larger work on the birch, it is all presented under the title heading of yellow birch.

The conditions which give rise to the importance of the yellow birch are due to the complex nature of the Adirondack forest and the changing values in its utilization. While the birch is not found throughout the virgin forest, it is found in the major portion and the important types. With this statement in mind, the facts that led to the study may be enumerated, and a specific discussion of its relation to types presented later.

Facts Leading to the Study:

The following premises are the result of close study of the published reports, constant observation of the forest of the western Adirondacks for a period of three years, and intermittent observation covering eight years. All types and conditions of the forest were under observation during all seasons for the three years mentioned. The measurements made during 1919 are in accord with the observations previously made, and with the following premises:

1. Yellow birch is the most generally distributed hardwood species in the true northern forest of the Adirondack region. Not only is it preponderant among the mature hardwoods on the average Adirondack acre, but it extends most widely through the range of types.

2. Yellow birch possesses certain advantages over the three important competing hardwoods—beech, sugar maple, and red maple—in seizure of devastated areas.

   Its seeds are more motile.

   Its seed crop occurs in quantity annually, and has few enemies.

   Its seeds can germinate on deep humus or partially decayed wood, and take root successfully through deep layers of such material to the mineral soil.

   The species in its seedling and young sapling stages grows with sufficient rapidity to compete with tolerant hardwoods and assure the tree of a dominant place in the ultimate stand of trees of the same age.

3. The crown of the birch intercepts less light than those of the maples and beech, so that it allows a better growth of the understory of softwoods by reason of this and other factors of tolerance.

4. Cut over lands are observed to have dense stands of young birch, and it is believed that the ultimate forest will have a larger percentage of birch than the virgin forest, which will increase its importance in the industries, and further enhance its value.

Type

The Fundamental Importance of Type:

Division of a forest area into types is quite as necessary, for purposes of management, as it is to obtain facts that can be converted into working principles. Operations on any extensive Adirondack area, even in logging, bring out the differences in forest composition and topography, and these differences have been used to define the major types of the region. Any study which ignores these differences will cause to be lost, by the law of averages, the facts that might be developed into rules of management. While this publication recognizes the four major types of the region for the sake of common understanding, very little intensive work can be accomplished until a *more minute division* is made and the physical factors which create the minor differences are recognized and studied. Changes in soil depth and composition, drainage, depth of humus, forest composition and even shrub and herbaceous cover all react to cause differences in forest reproduction within a type.

While the four major types are used as the basis of this study, other types are mentioned and described, and minor differences are pointed out.

Swamp:

This type is of small importance in a study of yellow birch in virgin forest, since birch does not enter into the forest as a merchantable tree in the true type. Any study which reports birch as part of the swamp type in its tables does so because the tree appears on the margin of the type and on knolls, or well-drained spots where the small size of the area prevents elimination from the type. The area of swamp will be reduced in the second growth forest on cleared areas by encroachment of both birch and red maple from the margins.

The true swamp type of the Adirondack region is a balsam and spruce mixture on flat, poorly drained land. There may be areas along streams and lake margins where cedar and hemlock are prominent. Tamarack, as the temporary species of such swamps, was once plentiful, but the mature trees are now dead, and tamarack occupies only bog margins in the virgin swamp type. White pine as a member of the swamp mixture is found occasionally due to slight variation in topography and soil site.

The soil may be deep or practically lacking, as on some boulder formations, but the permanent water table is generally so high as to make natural swamps a poor site for tree growth. The floor of the forest is spongy with common occurrence of sphagnum.

Effect of Drainage on Swamp Mixture:

The typical tree of the undrained swamp is black spruce, and any appearance of balsam in the mixture is evidence of a flow of water in that area, either by seepage or direct stream drainage. The margins of bog swamp areas may have balsam in mixture and may be as wet to all appearances as the spruce section of the bog, yet there is doubtless movement of water from the higher land through the balsam section of the swamp which brings about the change of mixture commonly observed.

The Stunted Spruce and Open Bog:

Open heath covered bog with stunted growth of black spruce occurs over considerable areas of the undrained swamp type.

A slight rise of the water table in such swamps is soon apparent in the loss of vigor and death of the spruce, while an equivalent lowering of the water table will result in a distinct recovery of the stunted trees and more rapid growth. This variation of the commercial swamp type offers possibilities of drainage in many places which will react favorably in introduction of species from the higher ground. Young birch trees often invade this type where drainage permits, but these fail to mature or produce dwarfed specimens. The swamp type has a normally high percentage of windfall due to the poor root support, so that the existing forest is usually young as compared with the upland types. The outer margin of the swamp may be defined as the line at which a soil layer of depth sufficient to sustain mature hardwoods exist above the water table, and where the floor of the forest loses its spongy character. Yellow birch appears in commercial size at about this line, and is surpassed by the red maple only in ability to take a wet site.

Graves (1) gives the number of birch on swamp land among trees ten inches and over in diameter at breast height as thirteen per acre, or 18.33 per cent of the total stand. This was an average of 225 acres.

Hosmer and Bruce (2) similarly give 2.72 birch trees per acre, or 7.44 per cent of the total number on an average of ninety acres.

Tables I and II show the composition of two typical swamp areas. Hardwoods were marked cull in case they had no present merchantable value, or, if small, had reached such a condition that they would never become merchantable. The reproduction count was made on square rod sample plots well distributed over the areas.

These are given to show the composition of the swamp type in its relation to birch. Birch reproduction was found farther in from the swamp margin than the mature trees.

TABLE I

Virgin Stand in N. W. ½ Twp. 1—Macombs Great Tract No. 2

Represents the average of 11.4 carefully run acres. Softwoods calipered to inch classes and hardwoods to even inch classes.

Swamp Type, Virgin

Number of Trees per Acre by Species and Diameter Classes

D. B. H. ob.	Spruce	Wind-fallen spruce	Balsam	Wind-fallen balsam	Sound yellow birch	Cull yellow birch	Sound soft maple	Cull soft maple
2..........	37.98	0.09	26.00	0.44	0.35	.....	0.09	......
3..........	45.90	0.09	35.80	1.40	.....	.....	.....	......
4..........	39.60	1.30	35.20	0.62	2.11	1.14	0.09	0.96
5..........	37.10	0.18	35.20	0.79	.....	.....	.....	......
6..........	25.60	1.23	32.90	1.40	3.60	1.84	0.62	0.18
7..........	22.70	0.35	23.10	1.93	.....	.....	.....	......
8..........	14.70	0.61	12.40	1.66	3.77	1.23	0.26	0.35
9..........	12.70	0.44	9.40	1.14	.....	.....	.....	......
10..........	8.30	0.44	5.90	1.40	3.25	0.53	0.96	0.44
11..........	6.80	1.05	1.93	0.17	.....	.....	.....	......
12..........	6.60	0.26	1.32	0.35	2.11	0.61	0.62	0.09
13..........	3.60	0.09	0.90	0.18	.....	.....	.....	......
14..........	2.60	0.44	0.17	.....	1.06	0.53	0.44	0.09
15..........	2.02	0.09	0.35	0.09	.....	.....	.....	......
16..........	1.58	.....	0.09	.....	1.06	0.18	0.35	......
17..........	1.28	.....	0.09	.....	.....	.....	.....	......
18..........	1.31	.....	.....	.....	0.32	.....	0.18	......
19..........	0.35	.....	.....	.....	.....	.....	.....	......
20..........	0.26	.....	.....	.....	0.18	.....	.....	......
21..........	0.17	.....	.....	.....	.....	.....	.....	......
22..........	0.26	.....	.....	.....	0.09	.....	.....	......
23..........	0.09	.....	.....	.....	.....	.....	.....	......
24..........	0.09	.....	.....	.....	0.09	.....	.....	......
25..........	.....	.....	.....	.....	.....	.....	.....	......
26..........	.....	.....	.....	.....	.....	.....	.....	......
Total....	271.59	6.66	220.75	11.57	11.49	6.06	3.61	2.11

Tamarack, total number per acre all diameter classes......	10.50
White pine, total number per acre all diameter classes.....	0.45
Cedar, total number per acre all diameter classes.........	4.40
Hemlock, total number per acre all diameter classes.......	2.58

Result of Count of Reproduction Less Than 1.5 Inches D. B. H. on Thirty-six Sample Plots Scattered Over 11.4 Acres of Swamp Recorded in Table I

Number of seedlings per acre	Species	
1,775	Balsam	Majority less than one foot high. All grown under dense shade and not vigorous.
1,480	Spruce	Larger number of seedlings one and two feet high than in case of balsam. Majority ten inches or less in height. None counted which did not show branching.
252	Yellow birch ..	Found near the edge of the swamp and on logs and stumps in windfall openings. Not thrifty.
584	Soft maple	Found along the drainage channels and near the swamp edge.
27	Hard maple ...	Will probably not mature.
12	Hemlock	Seed found favorable site near swamp edge.
8	Beech	
31	Cedar	No evidence of larger saplings to give proof that these will mature.

TABLE II

VIRGIN STAND IN N. W. ¼ TWP. 1—MACOMBS GREAT TRACT NO. 2

Represents the average of 16.5 acres taken from a swamp of smaller area than that represented in Table I. Hardwoods taken to even inch classes. *Swamp Type, Virgin*

NUMBER OF TREES PER ACRE BY SPECIES AND INCH CLASSES

D. B. H. ob.	Spruce	Wind-fallen spruce	Balsam	Wind-fallen balsam	Sound soft maple	Cull soft maple	Sound yellow birch	Cull yellow birch
2..........	34.18	0.12	25.47	0.12	.....	.....	0.33	......
3..........	29.45	0.06	36.27	0.06	.....	.....	.....	......
4..........	25.27	0.30	31.76	0.36	0.18	0.18	0.85	0.24
5..........	25.25	0.24	32.18	0.42	.....	.....	.....	......
6..........	20.75	0.48	24.90	0.73	1.15	1.03	1.27	0.61
7..........	20.24	0.12	21.45	0.54	.....	.....	.....	......
8..........	15.76	0.06	16.27	0.73	0.85	1.03	1.23	0.75
9..........	14.42	0.18	7.09	0.30	.....	.....	.....	......
10..........	11.76	0.24	4.42	0.36	0.91	1.09	0.61	0.18
11..........	8.66	0.18	1.76	0.18	.....	.....	.....	......
12..........	6.16	0.12	0.55	0.06	0.55	0.55	0.24	0.06
13..........	4.60	0.12	0.73	.....	.....	.....	.....	......
14..........	2.48	0.06	0.18	.....	0.24	0.24	0.06	......
15..........	1.64	0.06	2.24	.....	.....	.....	.....	......
16..........	1.82	0.06	0.06	.....	0.12	.....	.....	......
17..........	0.91	0.12	0.06	.....	.....	.....	.....	......
18..........	0.79	0.12	.....	.....	.....	.....	.....	......
19..........	0.31	0.12	.....	.....	.....	.....	.....	......
20..........	0.42	.....	.....	.....	.....	.....	.....	......
21..........	0.12	.....	.....	.....	.....	.....	.....	......
22..........	0.12	.....	.....	.....	.....	.....	.....	......
Total....	225.11	2.82	203.39	3.86	4.00	4.12	4.59	1.84

Pine (white), total of all diameter classes per acre.......	0.84
Hemlock, total of all diameter classes per acre...........	2.36
Tamarack, total of all diameter classes per acre..........	2.12
Black ash, total of all diameter classes per acre..........	0.48

RESULT OF COUNT OF REPRODUCTION LESS THAN 1.5 INCHES D. B. H. ON NINETY SAMPLE PLOTS SCATTERED OVER THE 16.5 ACRES RECORDED IN TABLE II

SPECIES	Seedlings per acre
Spruce	1,772
Balsam	1,571
Red maple	1,300
Birch (yellow)	182
Pine	18
Hemlock	11
Tamarack	9
Beech	5

Spruce Flat:

This type has been effectively described by Graves (1), and the chief purpose of discussing it here is to designate its limits so that it may be identified on cut and burned land. The type may be crowded out in some places by the abrupt approach of steep hardwood slopes to the edge of a swamp, and again the spruce flat may cover extensive areas around the swamps on the flats, knolls, and lower ridge slopes. The lower margin extends to the edge of the swamp, stream, or lake and is marked by the appearance of soft maple and birch on a moist soil covered with humus and lacking the spongy characteristic of the swamp.

The upper margin is marked by the disappearance of balsam and appearance of beech in the mixture. The soil loses its humus covering, and there appears instead a shallow layer of hardwood leaf mould with a firm, well-drained soil beneath. Sugar maple is not commonly found in this type. The characteristic species are red spruce, balsam, hemlock, birch and red maple. Graves (1) gives 12.7 birch trees nineteen inches and over in diameter* per acre which is 19.71 per cent of all species on an average of 106 acres. Birch exceeds in number all other hardwood species in the type. The predominance of softwood species, and moist condition of soil when shaded, and extreme dryness when not shaded, influence to a marked degree the reproduction in this type.

Hardwood:

This type has been defined as to its lower margin, and needs only general characterization. While that zone of the ridge slopes having comparatively deep soil may be defined as hardwood type up to the point in elevation where spruce again appears as the dominant, there is still a wide variation in hardwood areas. The amount of moisture and soil depth both influence the composition. The lower, moist hardwood land will have more birch than the better drained parts. Knolls with deep humus are usually covered to larger extent by softwoods.

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* Diameter is used to mean diameter at breast height outside bark.

Areas of several acres may be found covered by stands of pure* sugar maple, while shallow soils on exposed ledges are pure softwood, largely hemlock.

The age of these stands makes marked differences in the forest composition and in the management. Some comparatively even aged stands that are old or decadent show great gaps that are filling again with even aged second growth. Cutting of hardwoods on such areas amounts practically to a clean cutting. Other areas are dense stands of all aged forest suitable to selective cutting without opening the forest to the destructive action of wind and sun.

The hardwood type has reproduced itself by natural selection mainly, yet the characteristic of windfall and even aged growth is common on small areas. Variation in the type is wide, and the composition of the forest changes in the several sections of the Adirondack region. The number of yellow birch per acre ten inches in diameter and over on 442 acres of Nehasane Park is given by Graves (1) as fifteen or 19.06 per cent of the total stand. Table III is taken from N. Herkimer Co., west of Nehasane, and shows an uncommonly large percentage of beech.

TABLE III

Average Number of Trees Ten Inches and Over D. B. H. per Acre on 70 Acres Distributed Over 700 Acres—Northern Herkimer County

Virgin Hardwood Type

Pine	0.53	Beech	26.10
Hemlock	8.47	Maple	8.94
Red spruce	27.30	Yellow birch	13.04
Balsam	1.34	Black cherry	0.56

Upper Spruce Slope:

Yellow birch is the most widely distributed and best developed hardwood tree of this type. It can thrive better than maple or beech on the thin soils, and can reproduce best of all hardwoods in the deep humus found under the type. Birch is given by Hosmer and Bruce (2) as 18.07 per cent, and by Graves (1), 19.52 per cent of the stand. This percentage of

* Term pure used to mean 80 per cent or more of given species.

birch will not increase if the type is managed as a selection forest.

Influence of Logging on the Forest

The early logging operations may be designated as a selection method, in which the amount of timber removed was not enough to interfere with the crown of the forest, or to make any greater change in its composition than the removal of mature timber itself. In this way the white pine and spruce saw timber was cut and in some localities the large hemlock. Subsequent cutting may be classified under three heads:

1. Cutting of softwood to a diameter limit.
2. Cutting of all merchantable soft wood.
3. Cutting both hard and soft wood as far as it is merchantable.

Cutting of Soft Wood to a Diameter Limit:

The condition of forest resulting from this method of management varies with the lower limit of cutting, the type, and the period in which cutting was done. Such management is the outcome of early agitation for conservative methods following studies made some twenty years ago. The first cut of spruce for pulp was made to a diameter limit of twelve inches at four and one-half feet from the ground, while a later limit of ten inches at the stump height has resulted in removal of practically all merchantable soft woods. Some of the early cutting left the swamps intact and also the hemlock stands. These were then removed in a later cut at a considerable profit resulting from increased stumpage values. Results from this method of cutting have shown after a lapse of twenty years:

1. Heavy windfall of soft woods in the swamps and on thin soiled ledges.
2. Failure of medium diameter classes to recover under the closure of hardwood crowns.
3. Complete depletion of soft wood seed trees on some hardwood acres.

Reproduction is shown to be largely hard maple and beech on the hardwood type at the expense of the yellow birch where the light cutting was not enough to open up the crowns to allow birch to succeed. This characteristic is so pronounced and important that a table is given to show reproduction under these conditions as compared with clear cutting:

TABLE IV

SHOWING THE NUMBER OF SEEDLINGS AND TREES LESS THAN 1.5 INCHES IN DIAMETER AT BREAST HEIGHT, PER ACRE, BY SPECIES

Hardwood Type

SPECIES	NUMBER PER ACRE	
	Logged to diameter limit	All merchantable timber logged
Pine	0	0
Hemlock	13	2
Spruce	185	454
Balsam	21.4	13
Sugar maple	3,779	83
Red maple	793	900
Beech	1,036	578
Yellow birch	224	2,530
Black cherry	0	36
Fire cherry	0	404
Totals	5,051.4	5,755

Column No. 1 taken from ninety-seven sample plots distributed over thirty-seven acres in northwest ¼, township 35, Totten and Crossfield purchase. This, a portion of the Whitney estate, represents hardwood type which was logged in 1898 to a ten-inch diameter limit, as discussed in F. S. Bul. 26.

Column number 2 taken from 181 sample plots distributed over 680 acres in the southeast ¼, township 15, Macombs Great Tract number 3 (southern St. Lawrence county). Represents same natural type of mixed hard and softwood, logged for both hard and softwood without diameter limit, about 1907.

Cutting all Merchantable Softwoods:

The size of softwoods considered merchantable has varied to such an extent that no standard of result is attainable. On swamps, trees are now cut in some cases to four inches on the stump. This is clear cutting to an extent not known in the Adirondack forest before. On flats and hardwood lands, the removal of merchantable softwood will make the resulting forest more largely hardwoods, but will not exclude softwood reproduction. Some spots will be clear cut, and others will have a comparatively complete crown cover of birch and red maple. When the forest is opened severely, there will be a large mortality due to windfall and exposure.

Table V shows the result of cutting softwood on the hardwood type. This area, cut over about ten years previous to the study, was covered by a 10 per cent strip survey.

TABLE V

PERCENTAGE OF SPECIES SHOWING CONDITION ON 28.8 ACRES ACTUALLY MEASURED—HARDWOOD TYPE—CUT FOR MERCHANTABLE SOFTWOOD—WEBSTER TRACT—VICINITY OF CRANBERRY LAKE

SPECIES	Condition	Percent of stand
Beech	Sound	33.10
	Cull	12.10
Birch	Sound	18.90
	Cull	2.40
	Windfall	0.50
Maple	Sound	15.10
	Cull	1.70
Spruce	Live	9.50
	Windfall	0.40
Hemlock	Live	6.00
	Windfall	0.13
Balsam	Live	0.15
	Windfall	0.00

Clear Cutting Hard and Softwoods:

In the true use of the term "clear cutting," there has been no removal of this nature carried on in the larger logging operations, since hardwoods of small diameter and cull trees are left standing. Data are presented on a study of hardwood type cut for all merchantable hard and softwoods.

Hardwood Type:

A caliper record of all trees one-half inch D. B. H. and up was taken on strips one chain wide over 20 per cent of the area. A total of 12.2 acres was calipered. In addition, plots one rod square were laid out at two-chain intervals, and all trees less than one-half inch were counted. Height growth was measured on dominant trees of mean diameter over one-half inch. In this way, the average growth of the dominant reproduction in each species was determined. A special study was made on spruce by measurement of the growth of the last twelve years on trees one to ten feet high twelve years ago. The results are recorded in Tables VI, VII, and VIII.

Attention is called to the important facts brought out.

1. The numerical predominance of hardwood reproduction.

2. The importance of yellow birch in the young stand.

3. The failure of hemlock reproduction.

4. The prevalence of fire cherry and absence of the aspen.

   (This area had not been burned and fire cherry came on softwood knolls where humus is deep.)

5. The change of the mixture from sugar maple on the higher and drier land to birch on the lower zone in the type where seepage is a more important factor.

6. The more rapid growth of hardwoods than spruce during the first eleven years, the former reaching a height from the seed in the least instance of 10.1 feet as against 5.16 feet in the case of the spruce advanced growth.

There is evidence, as shown in Curve 2, Figure 2, that the spruce has already been checked by the shade of the young hardwoods, and must pass through a period of suppression and await the removal of the hardwood second growth crop. In comparison with Curve 1 which represents the rate of growth of spruce under pole stand of yellow birch, Curve 2 shows a slow rate of height growth for four years after cutting, followed by a sharp recovery exceeding that of Curve 1.

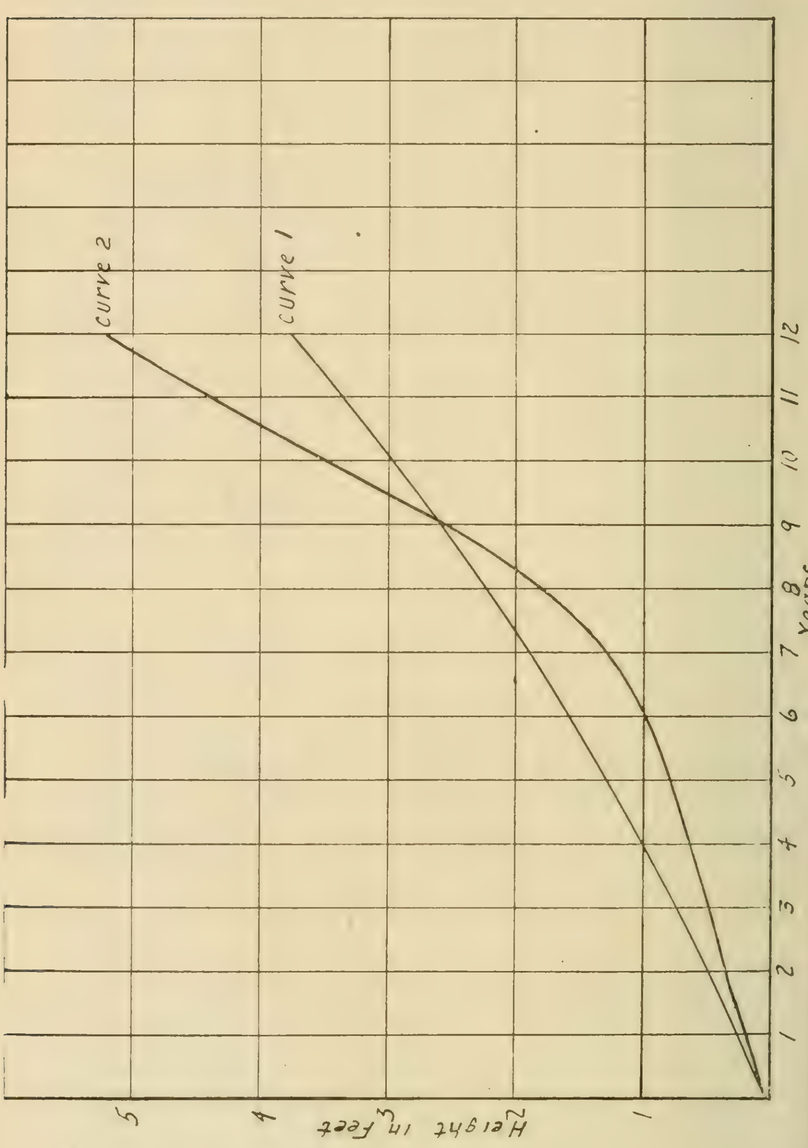
Curve 2
Curve 1
1
2
3
4
5
6
7
8
9
10
11
12
Years
1
2
3
4
5
Height in feet

FIGURE 2

Height growth of red spruce for last twelve years, on trees one to ten feet high twelve years ago.

Curve 1 — One hundred and fifty-three trees in northern Herkimer County, grown under sixty-year old dense pole stand of yellow birch.

Curve 2 — Ninety-three trees on 12.2 acres near Wanakena—logged eleven years ago and now competing with second growth hardwoods.

TABLE VI

Number of Trees per Acre by Species and Diameter Classes (Average of 12.2 Acres Actual Caliper Record), Hardwood Type, Cut About Eleven Years Previously for Hard and Soft Wood, Near Wanakena, in Southeast St. Lawrence County, N. Y.

D. B. H. inches ob.	Yellow birch	Red spruce	Sugar maple	Beech	Hemlock	Balsam	Red maple	Fire cherry	Black cherry	Aspen	Black ash
0*	1696.00	96.00	1294.00	1092.00	25.00	14.00	834.00	148.00	78.00	8.00	37.00
1	145.90	23.60	111.40	92.30	....	24.00	128.40	196.00	22.10	2.13	....
2	7.78	11.10	2.70	6.73	....	....	3.28	174.40	5.00	0.24	....
3	2.56	9.03	0.738	6.90	0.082	0.082	....	31.62	0.24	....	....
4	2.03	7.95	0.41	4.75	0.164	0.082	0.082	1.72	....	....	....
5	2.95	3.04	0.24	2.05	0.41	....	0.24	....	....	....	....
6	1.38	3.12	0.903	2.00	0.903	....	0.082	0.082	....	....	....
7	7.38	1.72	0.82	2.05	0.903	0.082	0.164	....	....	....	....
8	1.23	0.903	0.164	2.62	0.49	....	0.082	....	....	....	....
9	1.14	0.24	0.33	1.80	0.903	....	0.41	....	....	....	....
10	0.738	0.082	0.49	1.31	0.082	....	....	....	....	....	....
11	0.82	0.082	0.164	0.98	0.082	0.082	0.164	....	....	....	....
12	0.57	....	0.082	0.57	0.082	....	0.082	....	....	....	....
13	0.41	....	0.164	0.49	....	....	0.24	....	....	....	....
14	0.41	....	0.164	0.74	0.082	....	0.33	....	....	....	....
15	0.24	....	0.164	0.33	....	....	....	....	....	....	....
16	0.164	....	....	0.082	....	....	....	....	....	....	....
17	0.164	....	....	0.24	....	....	0.164	....	....	....	....
18	0.41	....	....	0.082	....	....	....	....	....	....	....
19	....	....	....	0.082	....	....	....	....	....	....	....
20	0.164	....	....	....	....	....	0.082	....	....	....	....
21	0.082	....	....	....	....	....	....	....	....	....	....
22	0.41	....	....	....	....	....	....	....	....	....	....
23	....	....	....	....	....	....	....	....	....	....	....
24	0.082	....	....	....	....	....	....	....	....	....	....
25	0.33	....	....	....	....	....	....	....	....	....	....
26	0.41	....	....	....	....	....	....	....	....	....	....
27	0.24	....	....	....	....	....	....	....	....	....	....
29	0.082	....	....	....	....	....	....	....	....	....	....
32	0.164	....	....	....	....	....	....	....	....	....	....
33	0.082	....	....	....	....	....	....	....	....	....	....
[illegible]	0.082	....	....	....	....	....	....	....	....	....	....
Total	1874.404	156.867	1412.933	1218.106	29.177	38.328	967.802	551.822	105.340	10.370	37.000

* Reproduction less than one-half inch D. B. H. counted on square rod sample plots five per acre.

TABLE VII

TOTALS BY ZONES ON SAME AREA FOR TWO SPECIES ONLY (AVERAGE OF 12.2 ACRES)

	Lower Zone		Middle Zone		Upper Zone	
	Birch	Sugar maple	Birch	Sugar maple	Birch	Sugar maple
Average number per acre.....	168.8	36.3	135.3	100.0	100.9	338.7

TABLE VIII

HEIGHT OF TREES ON SAMPLE PLOTS AND AVERAGE DIAMETER TAKEN FROM SAMPLE PLOTS ON 12.2 ACRES NEAR WANAKENA, N. Y.

Hardwood Type

Species	D. B. H. inches ob.	Height in feet
Yellow birch..........................	0.8	11.0
Sugar maple..........................	0.67	10.8
Red maple	0.85	11.0
Beech	0.8	10.1
Fire cherry..........................	1.45	*Not taken
Black cherry.........................	1.0	14.0

* Not regarded as of sufficient economic value for consideration.

In Connection with Table VIII:

The total height growth of red spruce during the eleven years preceding the study was 5.16 feet. During the first four years the growth shows little acceleration over that of virgin forest conditions, but after that time a rapid recovery was made. The mean annual growth in height for the last four years was 0.83 of a foot which shows some inclination to lessen, due probably to shade of the hardwoods. The measurements were made on trees 1 to 10 feet high at the time of cutting.

Spruce Flat:

A typical area was selected and permanent sample plot established to show the history of this type under this condition. The area was logged eleven years previous to the time of the study. This acre will be remeasured at periodic year intervals, so care was taken to establish permanent corners and lines. Trees above four inches in diameter were numbered and recorded, while all others down to the one-inch class were calipered. Brush piles and waste areas were mapped, stumps, stubs and windfallen trees calipered and mapped. In this way a complete restoration of the original forest was effected, also the stages of its destruction.

This permanent sample plot is one of two established in cooperation with the New York Section of Society of American Foresters. The entire plan incorporates all types and conditions of the Adirondack forest, and will establish important facts in regard to its natural replacement.

The history of this acre is shown graphically in Figure 3. While the area is too small to claim that it represents average conditions, some important facts are obvious:

1. The brush piles cover areas shown in shade, and still prevent, after eleven years, the reproduction of forest on these spots (Figure 3a). Camparison of Figures 3d and 3f show the natural change in the forest due to windfall and death from exposure since the logging operation. The crown cover at the present time is open, and the ground covered largely by red raspberry bushes. Over the entire acre, a layer of soft wood humus covers the soil in a depth varying from a few inches to one foot. Figure 3e may be called the mortality record. The count of reproduction showed less than 8 per cent of softwoods, and among hardwoods, soft maple held the dominant place followed by yellow birch. The presence of deep humus and the fact that this dries severely on exposure to the sun prevents tree seeds from germination and checks the growth of seedlings. Although the influence of this condition is most marked on burned lands, its effect appears on cutover lands wherever the soil is exposed to direct sunlight. The first cover is raspberry bushes, and these are not in foliage early enough to protect the germinating softwood seedlings. The ultimate shade of fire cherry and aspen brings about establishment of other reproduction.

FIGURE 3

a. Map of sample acre marked out for study; shaded area is waste land, largely covered with brush; reproduction strip in the center. *b.* Original forest. *c.* Trees logged from the area. *d.* Forest after logging. *e.* Trees that have died since logging. *f.* Standing living trees June, 1919; softwoods shaded; hardwood not shaded.

Planting on Cutover Land

The discussion thus far has tended to define the types of the Adirondacks and the conditions created by logging operations. Because of the need of softwood to supply the established industries, production of the maximum amount of softwood consistent with good forest economy is a principle of management in this region. Observation of the general tendency of cutover lands to increase their percentage of hardwood led to an examination of plantations to determine their success.

The oldest of plantations within the region studied is about twenty years, placed largely on open or burned over land. Such plantations have demonstrated their success in many instances and covering a wide range of species. The difficulty presented is that of getting cutover land free from slash, bushes, and hardwood young growth without running fire over the land first. No single instance could be found where clear cut hardwood land had been planted without first burning and had lived to reach a size suitable to show results. Such a plantation had been made along the Tupper Lake-Wawbeek road but was subsequently burned. The nearest approach to the required condition was found near this same road, on an area planted in 1904 in accordance with experimental plan of the New York State College of Forestry. It is located north of the Tupper Lake-Wawbeek road about three-quarters of a mile west of Wawbeek, and behind a shelter belt of uncut timber. The type is hardwood having a small number of spruce in the mixture. The soil is glacial boulder till and of good depth except for one ledge outcrop. The slope is of medium grade and faces northerly, extending down to spruce flat type on the north edge. All of the old stand of timber was removed, even to the cordwood, and the brush was burned in small piles. Judging from the number of fire-scarred stumps, the burning destroyed a large amount of potential hardwood reproduction.

Strips were run at an angle of forty-five degrees to the plantation rows, four chains apart, so as to include 5.2 acres of measured area. All trees were calipered down to one-half inch, D. B. H., in inch classes.

Table IX shows the caliper record reduced to an acre basis not curved. The planted species are white pine, red pine, Scotch pine, Norway spruce and blue spruce. The species that have reproduced naturally are red spruce, balsam, sugar maple, red maple, black cherry, fire cherry, aspen, beech and yellow birch.

The comparative numbers of trees planted could not be determined with accuracy since several spacings were included in the study. Blue spruce was not planted in quantity. The presence of red spruce and hardwoods was general over the tract but more prevalent on approaching the timber belt mentioned.

The preponderance of hardwood species, combined with the greater height of any given inch class makes the competition with the planted softwood very keen. Heights were taken at random over the plantation to get the relation of height to diameter for each species in each inch class. They are recorded in Table X with the number of trees measured beside each.

The general impression, created by the plantation and the compiled data, is that the method here used of clean cutting in its true sense with burning of brush has resulted in producing *a mixed hardwood and softwood forest*, and as such is successful. This does not answer, however, the problem of planting hardwood land as ordinarily cut for all merchantable species, nor does any other plantation thus far found in the Adirondacks.

From Table IX, it is worth noting that the number of trees per acre, fifteen years after the establishment of the plantation, is 1,540.79. Of these, 553.33 are planted stock, all softwoods. There are in addition 44.63 native red spruce and balsam, naturally reproduced. The striking thing to be noted is the invasion by natural reproduction into a prepared and planted site, of the great numbers of native hardwoods. These total 942.83, or 61 per cent of the numerical value of the stand per acre. The occurrence of a large number of aspen and fire cherry in this stand is of temporary consideration only, as they are expected to play but a small part in the future forest, whose typically mixed character seems already indicated.

TABLE IX

NUMBER OF TREES PER ACRE OF PLANTATION, PLANTED 1904 NEAR WAWBEEK, FRANKLIN COUNTY, N. Y., BASED ON 5.2 ACRES OF CALIPERED STRIP

D. B. H. ob. inches.	White pine	Red pine	Scots pine	Norway spruce	Blue spruce	Red spruce	Balsam fir	Sugar maple	Red maple	Black cherry	Fire cherry	Aspen	Beech	Yellow birch
0*......	17.31	.....	0.39	75.00	7.12	10.58	13.08	.....	.....	.....	.....	.....	.....	......
1.......	50.90	0.576	0.19	124.50	0.96	4.62	5.95	95.10	47.50	9.81	73.40	74.40	28.63	61.90
2.......	50.40	0.576	20.79	78.50	.....	0.77	1.34	29.20	22.80	15.58	95.10	91.40	6.54	49.60
3.......	24.80	0.769	22.05	20.29	.....	0.58	1.54	3.27	3.46	15.39	54.00	72.10	0.77	16.70
4.......	9.60	1.155	16.72	5.57	.....	0.39	0.77	.....	.....	9.81	6.15	36.80	.....	1.34
5.......	1.54	1.920	11.70	0.39	.....	0.58	0.77	0.19	.....	2.89	0.77	8.84	0.19	0.38
6.......	.....	1.155	5.38	0.19	.....	0.77	0.58	0.19	.....	0.39	.....	0.77	0.38	......
7.......	.....	0.190	0.96	0.19	.....	0.39	0.19	.....	.....	.....	.....	.....	0.38	0.38
8.......	.....	.....	.....	.....	.....	0.58	.....	.....	.....	.....	.....	.....	.....	0.38
9.......	.....	.....	.....	.....	.....	.....	0.19	.....	.....	0.39	.....	.....	0.38	......
10.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.38
11.......	.....	.....	.....	.....	.....	0.19	0.19	.....	.....	.....	.....	.....	0.38	......
12.......	.....	.....	.....	.....	.....	.....	0.19	.....	.....	.....	.....	.....	0.38	0.38
13.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......
14.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.38	......
15.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......
16.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......
17.......	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	......
18.......	.....	.....	.....	.....	.....	.....	0.19	.....	.....	.....	.....	.....	.....	......
Total..	155.35	6.331	78.99	304.63	8.08	19.45	25.18	128.15	76.73	54.26	229.42	284.31	38.41	131.55

* Softwoods less than 4 feet 6 inches in height.

TABLE X

HEIGHT* IN FEET BY DIAMETER CLASSES FOR THE PRINCIPAL SPECIES ON 1904 PLANTATION, NEAR WAWBEEK, FRANKLIN COUNTY, N. Y., MEASUREMENTS TAKEN JULY, 1919

SPECIES	D. B. H. (ob) INCH CLASSES													
	1		2		3		4		5		6		7	
	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured	*Height in feet	No. of trees measured
Scotch pine	8.75	20	11.65	20	14.25	20	14.80	20	18.70	20	19.95	20	21.75	4
White pine	10.55	20	13.90	20	16.20	20	20.70	20	21.80	9	.....	..	.....	..
Norway spruce	10.35	20	14.55	20	17.60	19	22.00	5	.....	..	.....	..	.....	..
Yellow birch	14.00	20	16.85	20	21.55	20	.....	..	.....	..	.....	..	.....	..
Sugar maple	13.10	20	19.25	20	21.25	14	.....	..	.....	..	.....	..	.....	..
Red maple	14.70	20	19.15	20	21.40	14	.....	..	.....	..	.....	..	.....	..
Black cherry	13.85	20	19.50	20	23.05	20	25.30	20	.....	..	.....	..	.....	..

* Mathematical averages only; not curved.

Influence of Burning on the Forest

Reproduction on burns is influenced by the size of the area, the severity or number of times burned, and the amount and size of reproduction started at the time of the fire. Type also influences the time necessary for reclaiming such an area.

A large burn on the College forest near Wanakena in St. Lawrence county, was selected for study. The fire occurred in the fall of 1908, and followed the logging operation by about five years. This gave opportunity for hardwood reproduction to start. An area varying in width from eight to twenty chains was covered by strip survey, with square rod sample plots at two-chain intervals. The fire had killed all vegetation except a few large trees in wet spots, but did not destroy the humus except on the outcropping ledges. The area faces in a gentle slope to the southward, and is intersected by one dry watercourse. On the north boundary, near the top of ridge, the fire was checked, and left untouched a stand of hardwood timber. From this a zone of young growth had started, having a width of three to five chains along the edge of the live timber. This zone was not included in the study, although it represents the common condition along the edge of burned areas adjacent to standing hardwood timber.

The presence of such a large number of permanent hardwoods, which is a pronounced feature of this burned area, is probably due to the period of time elapsing between the cutting and burning. A period of about five years elapsed between the logging and the time of the fire. The area was burned but once without serious destruction of the soil cover. It is very doubtful if any appreciable amount of this reproduction is due to storage of seed, since the softwoods are noticeably lacking. In some few places on thin soils over outcropping ledge rock the only tree found is the fire cherry, which exceeds the aspens in ability to endure a dry site. A plantation established on this area with Norway spruce, white pine, and Scotch pine, is only partially successful, due to competition of trees and ferns.

TABLE XI

Number of Trees per Acre on Burned Hardwood Land (Burned 1908), Based on 20.2 Acres of Caliper Record—Wanakena, 1919

D. B. H. Class	Spruce	Balsam	Hem-lock	Big tooth aspen	Trem-bling aspen	Black cherry	Fire cherry	Red maple	Sugar maple	Yellow birch	Beech	Miscel-laneous	Total
1	0.89	......	......	38.90	118.30	51.50	746.00	144.95	59.75	130.00	12.85	1.83	1304.97
2	0.28	......	......	15.80	47.40	26.75	50.45	18.75	29.45	13.07	0.83	0.83	203.16
3	0.11	0.05	......	2.95	8.85	6.67	2.87	3.89	0.05	1.31	0.11	......	26.86
4	......	......	......	0.40	1.21	0.28	0.83	0.05	0.05	0.28	0.28	......	3.38
5	......	......	......	......	0.05	......	......	......	......	......	0.05	......	0.10
6	0.05	......	......	......	......	......	......	......	......	......	......	......	0.05
7	......	......	0.05	......	0.05	......	......	......	......	0.05	0.05	......	0.20
8	......	......	......	......	......	......	......	......	......	......	0.11	......	0.11
9	......	......	......	......	......	......	......	......	......	......	0.05	......	0.05
Total	1.13	0.05	0.05	58.05	175.86	85.20	800.15	167.64	89.30	144.71	14.33	2.21	1538.88 checked

Average D. B. H. in Inches and Height in Feet

	Spruce	Balsam	Hem-lock	Big tooth aspen	Trem-bling aspen	Black cherry	Fire cherry	Red maple	Sugar maple	Yellow birch	Beech	Miscel-laneous	Total
D. B. H. inches	......	......	......	1.5	1.3	1.0	0.09	0.09	0.8	1.0	0.8	......	......
Height in feet	......	......	......	13.3	12.9	10.6	11.1	11.3	10.9	11.3	9.4	......	......

Influence of Type on Natural Reproduction of Burned Areas:

The marginal line between spruce flat and hardwood areas can often be traced as the lower line of hardwood reproduction, and examination of soil cover shows a deep, dry humus on the lower type. Aspen and fire cherry, with some sprout soft maple, are the first forest cover of the spruce flat type, except on approach to unburned swamps, where balsam establishes itself on the wetter parts.

Heavily burned swamps are very slow in recovery when remote from standing swamp timber areas, and soft maple displaces some of the original spruce and balsam.

Range of Effective Seed Distribution:

The study of the burned area on the College forest was made with the intention of determining the range of effective seeding, but the results showed other factors that made conclusions difficult. Isolated seed trees, change of type with dry humus cover, and most important, sprouting from young fire-killed seedlings which were established by trees now dead, all tend to confuse the original purpose.

Dense stands of young hardwoods extend out for ten chains, in some instances, from the belt of live timber, yellow birch reaching the farthest of the tolerant hardwoods. This is probably the outer limit of effective seeding unless very favorable conditions of grade, wind, and surface prevail.

Growth of Hardwoods

In addition to determining the average number of young trees per acre for the important types and conditions, a comparative study of growth was made to determine their natural competition. Even aged stands along the edge of the land burned in 1903 were selected, the dominant trees of the stand were cut, and complete stem analysis made. While all trees were taken at random, all species were taken from the same local area to get a fair comparison. The exception to this is fire cherry, which does not grow in mixture with tolerant hardwoods, and represents a drier site than that occupied by the other species. All grew on hardwood type of land and in dense stand, so that the soil and forest floor conditions were favorable to good growth. The trees are all plotted to fourteen years of age, and diagrams of the same scale are presented for comparison. Height, diameter and form are shown on the diagram in straight lines drawn to points determined by mathematical averages.

The two aspens represent the fastest growth of the temporary stand. The interesting point in comparison of these two is the faster early growth of big-toothed aspen, which later slowed down. At fourteen years the trembling aspen is still increasing its rate of growth. While the two maples and yellow birch have reached a fairly uniform development at fourteen years, the present speed of growth gives hard maple the advantage, and next to this the yellow birch. The development of black cherry is quite remarkable, and would exert an important influence on the subsequent forest if present in sufficient numbers in the production, as in the case of yellow birch. The larger of these black cherry trees will persist and appear in the mature stands as dominants. The growth of beech was very slow in the early ages of its life, and, since the establishment of good forest floor conditions, it is now increasing its rate of growth in spite of it being ten feet less in height than the other competing hardwoods. Many of these beeches are started from root sprouts although they have all the appearance of trees of seed origin. The beech will persist to the final stand and occupy in it eventually a high percentage of crown space. It will, however, be overtopped by several other species of hardwoods.

The fire cherry shows ability to occupy the driest sites in burned over land, and, because of its wide seed distribution and growth in the first few years, seizes land ahead of other species. It does not create a dense shade, but, in thickets, is capable of killing Scotch pine. This is probably due as much to its competition for water as for light. The trees may be ignored in consideration of the final stand, since it loses its dominance and dies quickly on being overtopped.

Pole Stands of Yellow Birch:

In order to determine the growth rate of yellow birch in comparatively pure stand where it is not suppressed in competition by other hardwoods, an attempt was made to find the

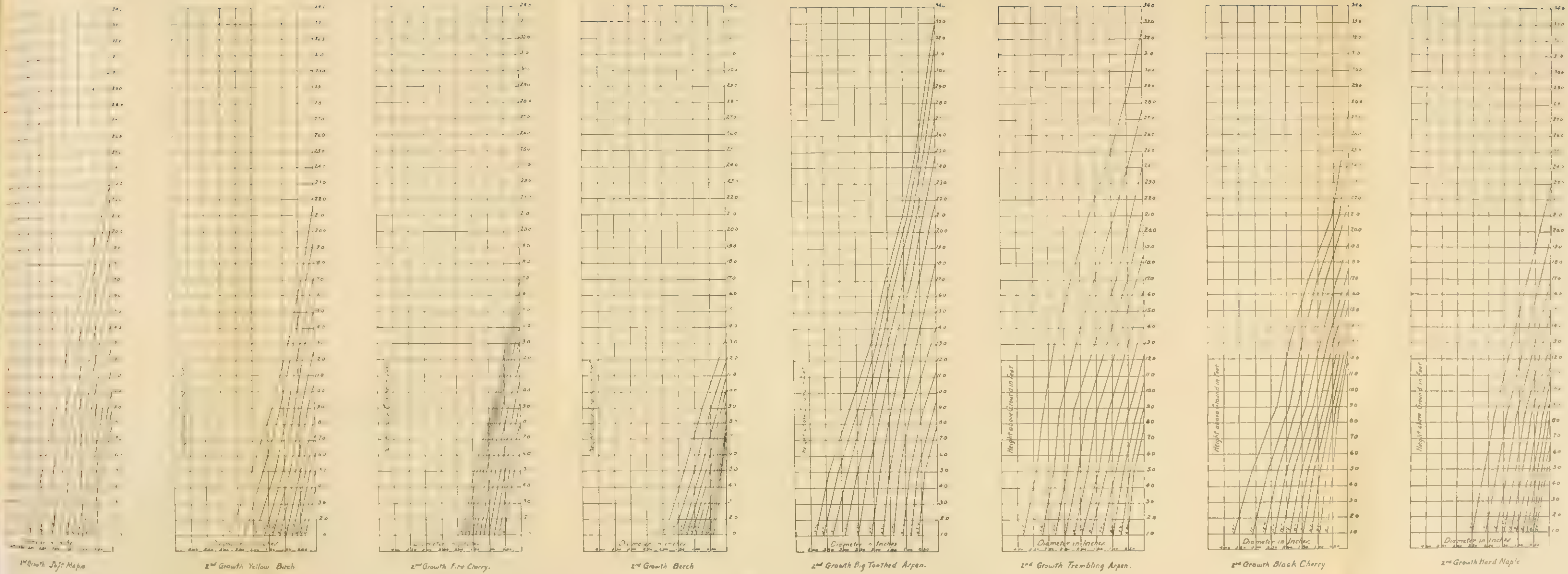

FIGURE 4

Growth of principal species during the first fourteen years on burned over land. Mixed hardwood, upland type, Wanakena, N. Y., June, 1919 oldest cuttings available in the Adirondack region. After an extensive inquiry it was found that the oldest clear cuttings of hardwood land dated back about twenty years on the larger logging operations. In three instances, however, pole stands of yellow birch were found which had resulted from fire, and in one case from the clear cutting of hardwoods for charcoal manufacture.

Second Growth Birch at Lake Ozonia:

Such a stand was found near Lake Ozonia in the northwestern Adirondacks, and complete stem analyses were made on trees cut in this stand. While the birch in this instance has grown without overhead competition, at an age of about sixty years, there is a considerable slowing down of volume growth in the last ten years. This is due to some extent to the crowding of trees on the area, and might possibly have been overcome by thinning, but is probably due in a larger measure to a natural tendency of the birch to slow down its growth at about this age. The rate of volume growth would doubtless have been better if the birch had not been forced to contend with the aspen, and had the support of a larger percent of beech and maple in the mixture. A complete statement of existing conditions is given to increase the value of the study for comparative purposes.

Type — Hardwood.

History — Burned over between 1886 and 1880.

Soil — Medium to deep with boulders; drainage, good.

Forest floor — Humus two to three inches, formed from hardwood leaves and litter which is 1½ to 2½ inches deep. No brush or dead wood.

Ground cover — Mountain maple, striped maple, witch hopple and ferns.

Exposure — West to northwest.

FIGURE 5
Natural reproduction sixty years of age following fire. Upper story aspen followed by yellow birch with an understory of spruce.

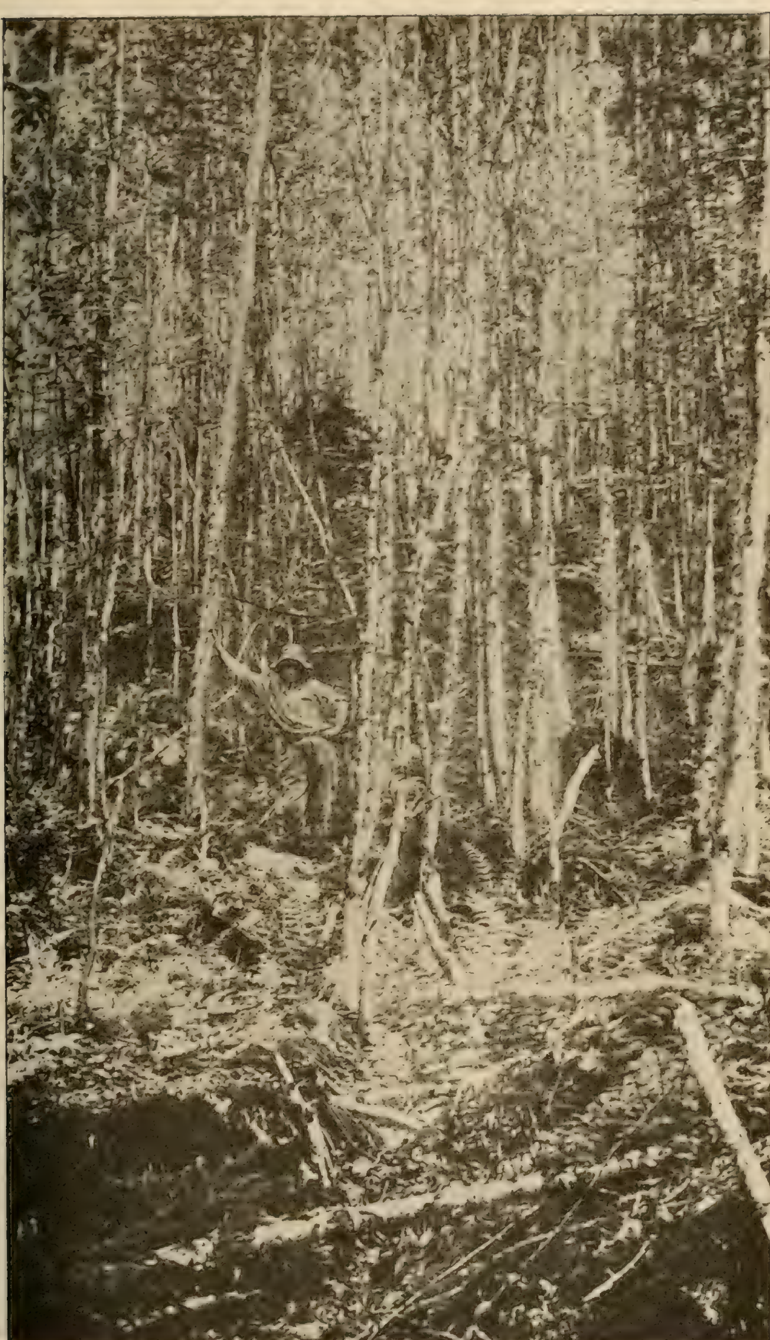

Figure 6
Pole stand of yellow birch following fire. Subsequent ground fire has destroyed understory of soft woods.

Number of trees per acre below one and one-half inches D. B. H.: Hemlock, 140; spruce, 640; white pine, 19; Sugar maple, 5,000; red maple, 1,440; yellow birch, 320; trembling aspen, 480; beech, 140.

This table was computed from eight sample plots scattered over 4.9 acres. Its chief value to show the encroachment of tolerant hardwoods under the shade of yellow birch and other species shown in the attached stand table.

TABLE XII

NUMBER OF TREES PER ACRE, LAKE OZONIA, FRANKLIN COUNTY, N. Y., SETEMBER, 1919 (BASED ON 4.9 ACRES)

D. B. H. CLASS	White pine	Hem-lock	Spruce	Balsam	Sugar maple	Red maple	Trem-bling aspen	Big tooth aspen	Yellow birch	Beech	Fire cherry	Total of all species
1	0.75	29.16	52.20	2.56	47.76	6.12	......	......	135.98	12.34	......	286.87
2	2.28	21.66	16.98	2.56	17.16	1.20	......	1.29	222.90	16.34	......	302.28
3	......	5.32	8.36	......	5.30	3.66	3.82	1.28	223.30	7.58	2.72	261.34
4	......	0.75	2.46	......	2.46	......	6.58	2.56	127.22	3.72	2.72	148.47
5	......	......	......	......	......	1.28	16.44	3.72	79.62	1.20	2.72	104.93
6	......	......	......	......	......	......	14.80	2.42	33.30	2.56	1.30	54.38
7	0.75	......	......	......	......	1.28	8.68	7.58	10.50	1.20	......	29.99
8	......	......	......	......	......	......	2.46	7.68	10.04	......	......	20.18
9	......	......	......	......	......	......	2.46	3.82	......	......	......	6.28
10	......	......	......	......	......	......	......	......	1.20	......	......	1.20
11	0.75	......	......	......	......	......	......	1.20	......	......	......	1.95
12	......	......	......	......	......	......	2.46	......	......	......	......	2.46
13	......	......	......	......	......	......	......	1.28	......	......	......	1.28
14	......	......	......	......	......	......	1.20	......	......	......	......	1.20
Total	4.53	56.89	80.00	5.12	72.68	13.54	58.90	32.71	844.06	44.94	9.46	1222.81

TABLE XIII

Yellow Birch, Height, Diameter, and Volume Growth, Lake Ozonia, Franklin County, N. Y., 1919

Age	Total height	D. B. H.	Total volume in cubic feet
10	13.8	1.3	0.14
20	28.1	2.9	0.64
30	38.4	4.3	1.96
40	44.6	5.1	2.52
50	49.7	5.9	3.78
60	53.6	6.5	4.66

A study of birch growing under shade of adjoining hardwoods shows at sixty years of age about 50 per cent of the height and diameter development found in the trees of the same age grown in the open.

Height growth studies made on 170 spruce trees grown under shade of yellow birch at Lake Ozonia shows an annual height growth of about two-tenths of a foot. While this is relatively slow, it is faster than that of spruce under mixed hardwoods. Stands of this type can be profitably thinned to allow increased growth of the spruce understory.

Birch, second growth — St. Lawrence County:

A second area of pole stand of yellow birch and aspen was found in southeast St. Lawrence county, and data are submitted to show the result of slightly different conditions. This area of some twenty-five acres is found on spruce flat type, and was burned about forty years ago, followed by reproduction and a light ground fire about ten years ago on part of the area. Strips and sample plots were run on twenty-three acres of the area, and the results shown in four tables (14, 15, 16 and 17). The effect of the second ground fire was to kill a number of the smaller birch, hasten the destruction of the aspen, thin the crown of the stand, and allow considerable reproduction of intolerant species. The amount of soft wood reproduction was doubtless reduced in number. It can be readily seen that the aspen is decadent, and was once the dominant tree on the area.

A third area was studied and results found comparable to the preceding two, which makes it obvious that small burns sur-

TABLE XIV

NUMBER OF LIVE TREES PER ACRE POLE STAND OF YELLOW BIRCH, SOUTHEAST ST. LAWRENCE COUNTY, NEAR CRANBERRY LAKE, 1919

D. B. H. Class ob.	White pine	Spruce	Balsam	Sugar maple	Red maple	Trembling aspen	Big tooth aspen	Yellow birch	Beech	Fire cherry	Total of all species
1	0.22	7.12	1.33	0.22	3.15	14.20	....	10.55	....	13.85	50.64
2	0.44	8.23	0.22	0.22	0.67	....	....	82.89	2.00	....	94.67
3	0.44	1.55	0.22	....	0.44	....	....	131.50	0.89	....	135.04
4	0.44	2.44	0.22	0.22	0.44	....	1.11	123.10	0.67	....	128.64
5	0.89	0.67	....	....	0.67	....	1.77	69.45	0.22	0.22	93.89
6	0.67	1.33	....	....	0.89	0.22	2.22	34.25	....	....	39.58
7	0.44	0.67	....	....	0.89	1.11	2.89	10.88	....	0.22	17.10
8	0.89	....	....	....	0.22	0.67	5.34	6.89	0.44	....	14.45
9	1.55	0.22	0.22	....	....	0.67	3.33	0.89	0.44	....	7.32
10	0.89	....	0.22	....	0.22	1.55	6.23	0.44	0.22	....	9.77
11	0.67	0.22	....	....	....	1.55	4.01	0.67	0.22	....	7.34
12	0.89	....	....	....	....	0.67	5.34	0.22	....	....	7.12
13	0.22	0.22	....	....	....	0.22	3.15	....	....	....	3.81
14	0.44	....	0.22	....	0.22	0.44	2.00	....	....	....	3.32
15	0.22	....	....	....	....	0.44	1.55	0.22	....	....	2.43
16	....	....	....	....	0.22	0.44	0.89	....	....	....	1.55
17	....	....	....	....	....	0.22	....	....	....	....	....
18	....	....	....	....	....	....	....	....	....	....	....
19	....	....	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....	....	....
Total	9.31	22.67	2.65	0.66	9.03	22.40	39.83	471.95	5.10	14.29	586.89

TABLE XV

NUMBER OF DEAD TREES PER ACRE, SAME STAND AS TABLE XIV

D. B. H. Class ob.	Species									
	White pine	Spruce	Balsam	Yellow birch	Trembling aspen	Big tooth aspen	Red maple	Sugar maple	Fire cherry	Beech	Totals
1	....	1.00	....	31.50	....	....	....	....	....	0.50	33.0
2	0.50	3.00	....	141.50	0.50	....	1.00	....	0.50	0.50	147.5
3	....	2.00	....	79.50	3.50	....	....	....	2.50	1.00	88.5
4	0.50	1.50	....	36.00	1.50	....	....	....	1.50	....	41.0
5	1.00	1.50	....	15.00	3.00	....	....	....	2.00	....	22.5
6	0.50	1.50	0.50	6.50	1.00	....	....	....	....	1.00	11.0
7	....	1.00	....	....	1.00	0.50	....	....	....	....	2.5
8	....	0.50	....	....	1.50	2.50	0.50	....	....	....	5.0
9	....	....	....	0.50	2.50	0.50	....	....	....	....	3.5
10	0.50	....	....	....	1.50	....	....	....	....	....	2.0
11	0.50	....	1.00	....	1.50	0.50	....	....	....	....	3.5
12	....	0.50	....	....	0.50	....	....	....	....	....	1.0
13	....	....	....	....	1.50	0.50	....	....	....	....	2.0
14	....	....	0.50	....	1.00	....	....	....	....	....	1.5
15	....	....	....	....	....	....	....	....	....	....	....
16	....	....	....	....	0.50	....	....	....	....	....	0.5
Total	3.50	12.50	2.00	310.50	21.00	4.50	1.50	....	6.50	3.00	365.0

rounded by standing timber may be expected to reproduce readily to birch in addition to the aspen, and that these two form a nurse crop under which the more tolerant hardwoods and softwoods enter. The subsequent history is not clear since areas burned more than sixty years ago were not found.

TABLE XVI

REPRODUCTION PER ACRE LESS THAN ONE-HALF INCH IN DIAMETER BASED ON REPRODUCTION COUNT OF TWENTY-THREE PLOTS ON TWENTY-THREE ACRES, SOUTHEAST ST. LAWRENCE COUNTY, NEAR CRANBERRY LAKE, 1919

Species	No. per acre	Species	No. per acre
White pine	14	Big toothed aspen	175
Spruce	202	Yellow birch	2805
Balsam	243	Fire cherry	153
Sugar maple	335	Black cherry	27
Red maple	3995	Beech	291
Trembling aspen	222		
		Total number per acre	8462

TABLE XVII

COMPARISON OF DEVELOPMENT OF YELLOW BIRCH AND ASPEN, SAME AREA AS IN PRECEDING THREE TABLES

D. B. H. Class ob.	Yellow Birch			Big Tooth Aspen		
	Average values (curved)			Average values (curved)		
	D. B. H. outside bark	Cl. length	Total height	D. B. H. outside bark	Cl. length	Total height
1	....	4.0	11.0	....	6.0	9.0
2	2.0	7.5	19.0	....	9.5	16.5
3	3.1	10.3	26.0	....	13.0	22.5
4	3.9	12.7	31.5	....	16.0	28.0
5	5.0	15.0	36.0	....	18.5	33.5
6	5.7	16.5	40.0	6.0	20.5	38.0
7	7.0	18.0	43.0	7.0	22.0	42.0
8	....	19.0	44.5	8.1	24.0	45.5
9	8.7	19.5	46.0	....	25.5	48.5
10	....	....	....	10.3	26.5	51.0
11	....	....	....	11.0	27.5	53.5
12	....	....	....	11.7	28.5	55.0
13	....	....	....	13.0	29.5	56.5
14	....	....	....	14.1	31.0	57.7
15	....	....	....	14.9	32.5	58.5
16	....	....	....	15.9	34.0	59.7

FIGURE 7
Natural reproduction on clean cut land yielding thirteen cords per acre in twenty-three years. Northern Adirondacks.

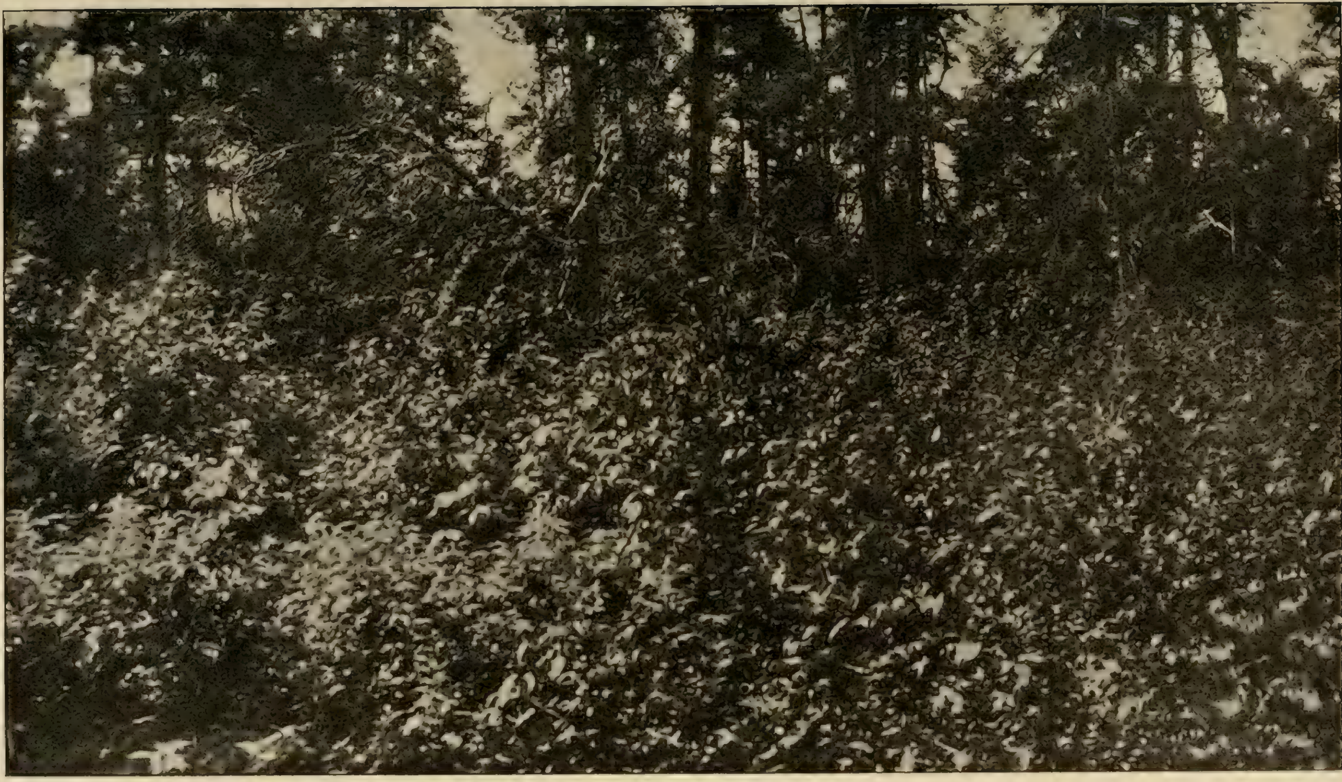

FIGURE 8

Reproduction in second year following hard and softwood logging operation of Emporium Forestry Company land.

A study was made of the volume of mature yellow birch on the logging operations of the Emporium Forestry Company in southeastern St. Lawrence county. Trees were measured as cut in the regular logging operations of the Emporium Forestry Company, and scaled in the log lengths found by Scribner Rule. Utilization in the tops approximated eight inches and long logs up to twenty feet were cut. The close utilization in length of the logs tended to decrease the volume for individual diameter classes.

This table is submitted as showing the volume ruled of an actual logging operation under present conditions of utilization.

Growth, height, diameter and volume were computed by complete stem analyses of the trees.

TABLE XVIII

VOLUME TABLE FOR YELLOW BIRCH BASED ON MERCHANTABLE CONTENTS IN BOARD FEET, SCRIBNER RULE, ON MEASUREMENTS ON 351 TREES, TOWN OF COLTON, COUNTY OF ST. LAWRENCE, N. Y.

D. B. H. outside bark	Volume in Board Feet—Scribner Rule						
	Number of sixteen foot logs						
	1 log	1½ logs	2 logs	2½ logs	3 logs	3½ logs	Number of trees
10	32	43	55	...	...	....	2
11	36	48	60	72	...	....	5
12	41	53	66	80	...	....	27
13	47	60	75	95	...	....	24
14	54	67	86	106	...	....	38
15	51	77	97	122	145	168	23
16	68	84	107	140	166	198	133
17	76	96	123	158	193	229	31
18	84	108	139	175	217	262	18
19	93	121	157	200	246	300	27
20	102	136	177	224	281	345	23
21	112	150	198	254	317	392	21
22	123	169	222	285	357	445	18
23	135	186	245	317	400	496	9
24	148	206	271	350	441	550	18
25	162	223	296	385	495	621	10
26	177	243	324	418	538	678	4
27	193	264	351	452	590	750	9
28	210	286	382	500	645	830	5
29	229	310	420	549	710	920	5
30	250	336	452	598	775	1050	8
Total	...	...	...	...	...	....	351

TABLE XIX

YIELD TABLE

YELLOW BIRCH, TOWN OF COLTON, ST. LAWRENCE COUNTY, N. Y. (BASED ON 208 TREES)

AGE IN YEARS	D. B. H. ob in inches	Total height in feet	Clear length in feet (curved)	Merchantable length in feet (2′ stump)	Yield in board feet, Scribner Rule (to 8″ top d. i. b.)
10	0.25	5.5	2.7	..	...
20	1.1	13.5	5.1	..	...
30	1.9	19.5	7.5	..	...
40	2.9	26.8	9.8	..	...
50	3.8	33.1	11.8	..	...
60	4.9	38.5	13.7	..	...
70	5.9	43.8	15.6	..	...
80	6.8	48.2	17.3	..	...
90	7.7	50.9	19.0	..	...
100	8.9	53.3	20.5	8	10
110	9.1	55.7	22.0	12	25
120	11.1	58.0	32.4	16	44
130	12.3	60.3	24.9	24	64
140	13.4	62.5	26.0	30	87
150	14.5	64.6	27.1	32	112
160	15.6	66.6	28.2	32	139
170	16.6	68.6	29.2	40	175
180	17.7	70.5	30.2	42	210
190	18.7	72.3	31.1	48	250
200	19.8	73.9	32.0	50	295
210	20.8	75.1	32.8	52	345
220	21.7	76.1	33.6	54	399
230	22.6	77.0	34.3	56	450
240	23.6	77.9	35.0	56	500
250	24.4	78.7	35.7	58	553
260	25.2	79.4	36.3	58	600
270	25.9	80.1	36.9	60	637
280	26.6	80.7	37.5	60	668
290	27.2	81.2	38.0	60	695
300	28.8	81.7	38.5	62	720

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Volume XXI June, 1921 Number 2

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OF

The New York State College of Forestry

AT

SYRACUSE UNIVERSITY

FRANKLIN MOON, Dean

HISTORY OF FOREST DEVELOPMENT ON AN UNDRAINED SAND PLAIN IN THE ADIRONDACKS

BY

WILLIAM L. BRAY, Ph. D.

Published Quarterly by the University, Syracuse, N. Y.
Entered at the Postoffice at Syracuse as second-class mail matter


Lilypad Pond
Hardwood Island
Bostwick Pond
Town Line Pond
Grass River
1528
1520
1561
1607
Dead
River
Wheeler Mtn
1800
1700

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THE HISTORY OF FOREST DEVELOPMENT ON AN UNDRAINED SAND PLAIN IN THE ADIRONDACKS

BY WILLIAM L. BRAY, Ph.D.

Introduction

In a previous bulletin, (2) the writer has discussed in a general way the development of the vegetation of New York State. The bulletin attempted to show, and the use of the word development was meant to imply, that the history of the occupation of the land by plant life is in more or less obvious reality the history of the establishment of plant societies, or, more exactly, plant associations in the course of which one association succeeds another until a more or less stable type of vegetation or plant society is established which is spoken of as the climax association. So far as New York State is concerned, conditions of rainfall and humidity are such as to insure the presence of a forest as the final type of vegetation, as contrasted, for example, with grassland of the "short grass" type which inevitably forms the stable vegetation cover under the sort of rainfall and humidity conditions which prevail in the Great Plains region of western North America.

In the bulletin above cited it was pointed out that even if the lands of New York State were wholly occupied by the final stable or climax forest, this would not be uniform as to its associated species. In the milder region of the lower Hudson with its less severe winters, and especially its long frostless season, such species as Liriodendron, sweet gum, chestnut and many species of oaks and hickories form the dominant elements of the forest, while in the Adirondacks generally none of these species figures in forming the forest cover, but instead, the well-known associates, hard maple, yellow birch, beech, white pine, hemlock, red spruce, and sometimes balsam, form the controlling or characteristic elements of the climax forest, at least up to 3,000 feet elevation. Now, of course, New York State, even before the coming of Europeans, was not all forest.* Even the Adirondack region, with which we are here especially concerned, was not wholly forest land though very generally so, and the forest cover was not all of the climax type composed of

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* This statement is not to be taken as intimating that any considerable area of New York State was not heavily forested at the beginning of the period of colonization by European nations. As a matter of fact the State was really a vast forest wilderness in common with the Atlantic region generally. The forests were regarded in those days as the great obstacle against colonization, since the land had to be cleared of this dense growth in order to extend the farming areas and in establishing sites for homes and villages. Rightly to understand the situation one should bear in mind that climatically considered, the region comprised in the present area of New York State was all potentially forest and that the natural trend of vegetation development was to culminate in a forest stand as rapidly as the lowlands were built up by depositions of plant growth and other agencies, or as soon as the rocky uplands, notably mountain slopes and summits had been covered by a humus blanket.

During the centuries preceding the coming of white men the course of vegetation development had been carried forward to the point where not only nearly all of the valley and upland areas were in the final or climax forest stage, but large areas of swamp and marshland, even many of the shallower lake basins, had been filled to a level which could support swamp and bog forest. There were still stretches of marsh meadow notably near the coast (see Van Derdonk's New Netherlands, 1656) and vlaies and "beaver meadows" along certain streams and on the borders of glacial lakes. It must be remembered that the influence of man was felt even in these prehistoric days, for the Indian tribes had their cleared cornlands and their hunting grounds which in some sections at least they periodically burned over (Van Derdonk speaks of them as "bush burnings"). A noteworthy instance of this sort seems to be implied in the existence of open grass lands studded with groves of oak in Erie county back of the escarpment bordering the Erie basin (see E. H. Perry Hist. Buffalo and Erie Co.). It appears to be confirmed that the Buffalo ranged eastward along the lake region into Western New York (see Hornaday, Extermination of the Buffalo: Smithsonian Report, 1887). Sometimes these fires gained such headway as to become vastly destructive forest fires which not only destroyed the forest stand but the humus blanket, thus entailing conditions with which in more recent times we have become all too familiar. Forests were destroyed then as now also by fires set by lightning, by fierce windstorms, by fungus and insect pests as in these days, so that there were always areas where the forest cover was broken or destroyed. In the normal course of events, however, these losses and setbacks were replaced generally with surprising rapidity, so that the "high tide of vegetation," the virgin climax forests, may really be said to have covered the whole area of New York State. As to the several types and zonal boundaries of these forests see Bray's Development of the Vegetation of New York State, above cited.

the associated species above listed. Present conditions in the Adirondacks abundantly illustrate this diversity of vegetation, though in surveying the region one has constantly to bear in mind that with difficulty do we find a vegetation type wholly unmodified by the hand of man. Every one who has traversed the Adirondacks is familiar, for example, with beaver meadows, alder thickets, peat bogs covered by sphagnum and heath shrubs or by black spruce and tamarack; with balsam swamps, with spruce covered mountain sides, with vast areas of nearly pure hardwoods from which pine, hemlock, and spruce have been removed and with more nearly virgin tracts in which many soft woods are still left; and finally with the apparently endless tracts of popple and fire cherry, of bracken and blueberry, of red raspberry thickets, which with blackened snags and stumps and bare granite, mark the path of lumbering followed by burning or of greatly destructive fires in virgin tracts. Theoretically, the Adirondack forest should, from the standpoint of climate and with the lapse of centuries, be of the stable climax type. Actually and quite independent of human agency, it showed, when white men first entered it, the varied types of vegetation above mentioned, for there was diversity of soil and topography, and of course, even in areas of climax forest, fires and disease and storms wrought their destruction before man became a competitor in forest devastation.

The causes of this diversity of vegetation types in a region which climatically favors the establishment of a stable, more or less uniform forest are to be sought chiefly in the nature of the ground which vegetation is seeking to occupy. Looking at it as a static phenomenon, a peat bed, a shallow lake bottom, a deposit of sand, an area of bare granite, a precipitous mountain side, a cover of easily dried out duff and a rich, moist substratum of leaf mould is each sufficient cause to explain the presence severally of a bog heath, a bed of water weeds and rushes, a cover of bracken or blueberry, a patch work cover of rock mosses and lichens, a stand of red spruce, of red pine, and finally of the mixed hardwood and conifer climax forest. But exactly the point to be emphasized is that the phenomenon is not static but dynamic, i. e., it is a "moving picture"— a matter of social evolution so to speak. The bog heath will presently (speaking in terms of decades or centuries maybe) become a dwarf forest of black spruce and tamarack. The bed of water weeds and rushes will become perhaps a beaver meadow, a balsam swamp and possibly utimately a climax forest. The bare granite will ultimately be covered by a moisture holding blanket laid down by the vegetation itself and capable of supporting a forest growth.

The expression "development of vegetation" therefore is meant to suggest the progressive steps or stages by which vegetation comes to occupy the land. Vegetation is essentially a social organization and the sequence of plant associations from the pioneer state — for example a shallow lake bottom — on through the successive stages to the climax forest — its mature stage — has been compared to the life history of an individual organism. (3, page 3.)

While theoretically the ultimate type of vegetation in this climate should be a climax forest of certain hard woods and conifers, actually the continuing, though decreasing, diversity of soil conditions will perpetuate the diversity of vegetation types. But this theoretical consideration should not be allowed to obscure certain very practical considerations; namely, that all the energy and momentum of plant life in this region tends toward the establishment of a forest; that the process of forest establishment is a more or less fixed course of development starting in widely differing situations and following different sequences but all tending to converge toward a uniform type; finally, and more especially important, that during the course of its development vegetation itself brings about changes in the soil which cause or contribute to the succession of one type of vegetation by another and which lead to the uniformity of soil conditions — the thick blanket of forest humus — which is able to support the stable, more or less uniform climax forest.

One must not conclude from this that the lumbered and burned areas of the Adirondacks are speedily returning again to the desirable status of climax forest. In some cases where the balanced association of species has not been too greatly broken up and where the soil blanket has been preserved, the return, speaking in terms of tree growth, will be prompt. Large areas are coming to what seems a stable condition with only hard wood species in the association. It may be that the soft wood species are starting under the present close crown and will endure until some veteran hardwoods fall and thus opening the canopy give them a chance to assert their place as associates in the forest stand. This, of course, is a question of too great economic concern to remain in the field of mere speculation. As foresters have shown, the forest policy for the Adirondacks rests very largely on the question as to whether the soft woods will reappear under present methods of cutting.

Then there remain those vast areas where lumbering and especially severe fires have destroyed both forest stand and the humus blanket. For such lands the return to climax forest through the slow stages of the normal course of vegetation development involves a time schedule beyond any except mere academic interest of present generations. With such lands the way lies through shortening the period of development by human agencies.

The Development of Vegetation on Peat Beds

The present bulletin gives an account of certain investigations having for their object to determine some of the conditions under which peat beds are formed and especially to follow the course of vegetation as it develops upon and contributes to the formation of peat. Such a study cannot be said to have any very great economic bearing as compared with investigations of conditions under which the more valuable commercial forests develop, for even when peat beds or bogs become covered with forest growth this forest consists chiefly of dwarfed black spruce and tamarack of relatively little commercial value. This investigation seems to show, however, that in the long run the vegetation on peat soils may build the soil up above the water table so that with better drainage and aeration the substratum becomes transformed in such a way as to support not only a better growth of the black spruce and tamarack but to allow the entrance of species — balsam for example — of greater value. In any event such an investigation serves to add to our knowledge of the phenomena of forest development. There are also these considerations that the peat itself has a very large potential fuel value and that where drainage is feasible, peat beds may become valuable agricultural soils. The agricultural value is, however, of uncertain status in the Adirondack region because of the prevalence of killing frosts late in spring and early in fall. The season of probable freedom from killing frosts would apparently not exceed sixty days and in many situations would fall below that. Before Adirondack peat lands are exploited for agricultural purposes it will be necessary to determine the extent of risk of killing frosts and to find what crop plants would be suitable for the conditions which obtain in the low lying areas where peat beds occur.*

Bog areas, that is, areas where peat beds are formed and consequently where bog vegetation occurs, constitute a very considerable percentage of the total area of the Adirondacks. That is to say, the Adirondack region is a part of the large area in the northern States and Canada where conditions of climate and topography and possibly also the postglacial status of plant species favor bog development. The vast scale on which glacial leveling and filling occurred which resulted in interrupted drainage and in a multitude of lakes resulted also in low lying poorly drained areas where, either at the beginning of vegetation invasion or after the pioneer vegetation had wrought certain changes in the substratum, the peat mosses — Sphagnum species — entered and thenceforth dominated the

* While it is not within the scope of this bulletin to consider in detail the agricultural utilization of peat lands, the extensive areas of such lands not only in the Adirondack region, but throughout New York State, offers a field of agricultural development whose profitable outcome is being demonstrated by numerous truck gardening projects outside the Adirondacks. In the further expansion of this reclamation of peat lands, it is, of course, only a matter of time when the peat soils of the colder Adirondack districts will come into consideration. Readers interested in this aspect of the subject will find a valuable reference in a recent bulletin by F. J. Alway on Agricultural Value and Reclamation of Minnesota Peat Soils, The University of Minnesota Agricultural Experiment Station Bulletin 188, pp. 1–136, 1920, with its extended list of references.

situation, resulting in peat formation and in the elimination of all except a meager list of species tolerant of the uncongenial conditions incident to peat soils and ordinarily designoted as bog plants. As just stated, the list of species is not long and the uniformity with which nearly all of them occur in bogs throughout northern North America arouses speculation as to their history and of the nature of their preference for or tolerance of bog conditions. Recent investigations (15) seem to show that among the conditions thus to be endured and as a result of which many wet land inhabiting species are eliminated from bogs, the most notable and controlling item lies in a condition of toxicity of the bog water.

It is generally assumed that the sum of edaphic conditions present in a bog results from a situation attended by lack of free drainage. A comparison of thiee units described in this bulletin seems to support this view. It must be noted, however, that so far as New York State is concerned the tendency toward bog development as contrasted with marsh and swamp is more pronounced in the Adirondack region than elsewhere and that the species eliminating factors are more potent, resulting more frequently in what may be designated as extreme types of bogs where not only are the tolerant species few, but they show marked dwarfing effects as well. This suggests that temperature conditions play an important role in determining the tendency to bog formation on the one hand and marsh formation on the other. Again, those regions in New York State outside the Adirondacks where the tendency toward bog development is pronounced are areas of sand beds such as prevail over the old Iroquois lake basin between Syracuse and Oswego. Since Adirondack bogs also are very generally formed upon sand beds it seems obvious that the nature of the original substratum plays likewise a role in determining whether a bog sequence or a marsh and swamp sequence — i. e. a toxic water as contrasted with fresh water sequence of associations — shall develop in a given basin or on low flat terrain. Rowlee (16) has called attention to the acidity or softness of water occupying basins in sand deposits as contrasted with the alkalinity or hardness of water in basins in limestone areas of New York. He has shown that marl formation is abundant in the ponds and lakes of the limestone region and states that marl formation is lacking in most of the peat bogs of the Adirondacks. My observations confirm these statements, and they also show that marl formation indicates the agency of a heavy growth of submerged water plants (vascular plants like Potamogetons accounting for quite as much marl as Chara). The marsh and swamp sequence in my observation tends to persist upon marl beds and as I have shown (2) in the case of Tully Lake Bogs only after the vegetation has created a situation involving lack of free movement and areation of the water does peat formation set in upon a marl bed.

On the whole, my observations would indicate that the dominance of marsh and swamp plants in certain situations and of bog plants in topographically similar situations, is to be accounted for on the basis of factors now operative rather than as phenomena of post-glacial floristic relations. (17.)

The Grasse River Bog

The area here dealt with is locally known as the Grasse River Marsh.* It is a tract comprising several hundred acres lying along the south fork of the Grasse River some ten miles east of Cranberry Lake Village. It is traversed by the Grasse River railroad and is thus easily accessible. It is within easy walking distance of Grasse River Club station, Silver Brook stop, and Shurtleffs. Massawepie Lake lies adjacent to the bog at its northeast limit so that Massawepie Park offers easy access to the bog region by auto and to the bog itself by boat or easy trail. The road from Massawepie Park to Conifer, and especially the branch to Grasse River Club passes just back

* These details of location and accessibility are given with the idea that this area in common with many other special features in the Adirondacks may become the object of closer study by those who spend seasons of recreation in the North Woods. It will add to the satisfaction of such experiences if one can gain a closer understanding of the region and its different types of vegetation.

of the crest of the sand ridge which forms part of the eastern boundary of the bog. At its nearest point it is only a few steps from this road to a fine outlook above Town Line Pond. From this outlook nearly the whole of the bog may be seen as well as the relation topographically of Town Line Pond to the bog. (Map, fig. 1.)

By the courtesy of the Emporium Forestry Company, the students of the New York State College of Forestry Summer Camp of 1919 were permitted to establish camp on, and conduct a survey of the Grasse River bog. From this survey two maps were made, one showing contours and two lines of levels across the eastern section of the bog, the other a plotting of the vegetation types. These maps are used in this bulletin. (See Maps 1, 2.) The section of the bog west of Grasse River was not surveyed. The writer is personally indebted to Mr. W. L. Sykes, President of the Emporium Forestry Company for personal co-operation and facilities, to Director W. E. Sanderson of the Summer Forestry Camp at Cranberry Lake, and to Mr. H. S. Andrews who was in charge of the survey.

The Grasse River bog region differs from the usual types of bog areas in the Adirondacks which are commonly associated with glacially filled valleys and shallow undrained basins. Physiographically it is to be classed as one of the sand plains of which there are striking examples on larger or smaller scales in New York State. Thus, as pointed out in a previous bulletin (2) the Hudson–Mohawk sand plains in the Schenectady–Albany region, the sand plains of the Saranac at Plattsburg, and of the Black River below Carthage (Pine Plains) are major features of this type while within the Adirondacks the plains at the junction of Benedict Creek with the south branch of Moose River several miles east of Lime Kiln Lake and "The Plains" of the Oswegatchie south of Wanakena in the vicinity of High Falls are fairly well known examples of the smaller sand plains. The last formed the subject of a report by the State Botanist (12) and was also described in the bulletin above cited (2, page 144). In all the above cited cases, the sand plains lie well above the water table and are subject therefore to extreme drying. In such cases the vegetation is of the dry heath types. In the case of Grasse River bog, the sand plain lies so low that if one could see the original sand bed, now of course covered by its peat blanket and the living vegetation growing thereon, it would be seen to be covered by water much of the season, emerging only during dry periods of midsummer. Thus, in August, 1918, and again in 1919, borings in the shallower parts of the bog showed no free water at the sand level, though, of course, the peat was wet. In October of the same season, nearly all of this sedge meadow part of the bog was flooded. This relation to the water table insuring constant wetness is the primary cause of the bog vegetation as contrasted with the characteristic dry heath type of the better drained sand plains.

As above stated, the Grasse River bog lies in part along the course of the upper Grasse River where this small stream emerging from narrow valleys in the hills follows a slowly meandering course across the sand plain, and escapes through a narrow gorge with rapids at Shurtleffs. (Fig. 1.) It is somewhat as if a lake had been interposed in the river's course, and with but a few feet less of cutting in the gorge at Shurtleffs this would actually be the case. A low, temporary dam at the latter point makes still water as far up as Burnt Rock — about two miles. This is the Grasse River Flow. The stream has done very little cutting through this portion of its valley — i. e., the bog — in post glacial time, its actual channel being a low banked sinuous cut with a flood plain of only a few hundred feet in width. The sand plain itself is not merely river valley. It occupies a peculiar relation to a series of ponds and lakes lying along its eastern and northeastern margin. The largest of these, Massawepie Lake, represents a basin of considerable maximum depth, said to be more than 100 feet, whose southwest shore line is the border of the bog itself. (Fig. 3.)

The outlet of Massawepie Lake skirts the northern edge of the bog being almost flush with its surface, escapes through

Fig. 2. Part of Grasse River Bog seen from ridge above Town Line Pond. At high water the pond spills out over the bog in an ill defined seepage from the bog at right of figure.

Fig. 3. The bog seen in relation to Massawepie Lake. The outlet is the channel at right of figure. Most of this portion of the bog is covered by an open black spruce-tamarack association, but a tall shrub association lies adjacent to the lake at this point. The sand plain is about level with or slightly lower than the lake surface.

a channel behind Hard Wood Island, and joins Grasse River to the northwest of this granite ridge. Town Line Pond is a small lake occupying a basin at the base of the sand ridge which forms part of the eastern boundary of the bog. This pond also lies flush with the bog, and indeed, spills over upon it at high water. Boot Tree Pond lies on the bog side of the sand ridge, but its surface is about 15 feet above the bog and of Massawepie Lake. Deer Pond and Horseshoe Pond lie on the opposite side of this sand ridge. (Figure 1.)

It should be noted that the water of these ponds and of Massawepie Lake is very clear, in sharp contrast with the brown bog water of the peat beds and mountain streams and ponds of the Adirondacks generally, and notably of Cranberry Lake.

The salient physiographic features of this project embrace then the above described items together with certain others all briefly specified in summary as follows: (1) The sand plain whose area generally is very low and flat but with occasional slight ridges traversing its eastern section (indicated by islands of balsam and other non-bog species) and larger "island" areas (see contours of map figure 1) of low but still fairly well drained undulating surface (indicated by stands of willow and alder and by remnants of a former forest stand of apparently the balsam swamp type); (2) The meandering stream and its narrow flood plain covered by beaver meadow grasses and alders. (Figure 25.) (3) Massawepie Lake and outlet and Town Line Pond parts of whose shore lines is the bog itself; (4) Finally, and most significant as a controlling topographic feature, a low sand ridge paralleling the Grasse River on the east and just outside its flood plain. This ridge (see contours and trail Figure 1) is apparently a glacial esker whose position and elevation are such as virtually to constitute a dam holding back, or at least intercepting, the drainage of the bog. In October 1919 when the project was visited after heavy fall rains, the intercepted water of the marsh was spilling over this eskerlike ridge at certain low points. Slight channels were thus being cut in the dam. A well defined drainage has been established adjacent to Hard Wood Island. (Figure 1.) The intercepting barrier at this point has been cut away by a wide channel quite down to the river level. It is interesting to note as bearing on the causes of vegetation types that about the head of this established drainage and quite within the bog area, thickets of alder replace the bog vegetation proper. It is assumed that this difference is associated with the freer drainage.

In order to emphasize the role which edaphic factors play in determining types of vegetation, we may specify three edaphic units as follows: (1) The flat undrained sand plain; (2) The low, but well drained sand mounds and ridges including the eskerlike ridge. (3) The flood plain of Grasse river. Of these, only the first bears any relation to the development of bog vegetation though all constitute features of the Grasse River Marsh as locally known. It must be borne in mind also that while historically considered the origin and early course of vegetation on the low sand plain is the most important aspect of the problem of the development of vegetation with which we are here dealing, at the present time this originally flat, undrained substratum of sand is covered by a blanket of peat, and that this peat substratum rather than the original sand substratum determines the plant associations which form its present vegetation cover. In describing the relation of the present vegetation to edaphic conditions, therefore, we shall speak of the peat beds rather than of the original wet sand plain.

The Peat Beds of the Grasse River Sand Plain

The main area of the sand plain on the east side of Grasse River and abutting on Massawepie Lake and outlet and Town Line Pond is covered with a peat blanket varying in thickness from more or less eighteen inches at the south end to seven or eight feet over the center of the north east third of the bog.* The smaller section of the plain west of the river appears to be covered with a rather uniform depth of peat averaging about

* At the southern end of the marsh the peat becomes very shallow and finally disappears as the sand bed rises into the bordering eskerlike ridge.

three feet. This section, however, was not so thoroughly surveyed, soundings having been made only along the line of the railroad and from this southward to the bordering ridge in the heavily timbered zone. Two lines of levels were run with the transit at right angles to each other across the east section. These are indicated on the survey map. (Map 1.) The E-profile runs from the river at Burnt Rock to Town Line Pond; the F-profile from the south western end of the marsh to its northeast limit at Massawepie outlet very near the lake. The elevations are indicated at stations 180 feet apart. It will be noted that E-profile shows a difference of elevation between the river at Burnt Rock and the edge of the peat covered sand plain of about seven feet, the approximate depth of the drainage cut shown in Figure 27. It shows also that the surface of Town Line Pond is about twelve feet above the river level at Burnt Rock. There is an obscure drainage from Town Line Pond to the well defined channel of Figure 27, whose location is indicated by such marsh species as *Carex stricta, Calamagrostis canadensis* and alders. F level shows a rise from 1,617 feet at the south end to 1,622 feet at station F40. Peat soundings were made with a Davis peat sampler at each station along the lines of level. Along the F level these indicated a depth of peat of only 3 or 4 inches at station F1 but of 8 feet at station F41 in the center of the northerly third of the bog. It seems evident, therefore, that the increase in elevation northward is due to the peat cover. Thus while the sand plain is a uniformly flat, level floor (except for certain slight ridges rising above the peat forming level, see Figures 1, 22, 23) the peat forming vegetation has built up a raised bog upon the northerly half of this section of the plain. In general the peat blanket is a typical bed of sphagnum peat varying from the fully preserved dead sphagnum under its living cover, to the finally disintegrated brown peat of the bottom. It varies, however, with the type of vegetation upon it as will be shown, being blacker and quite compact under a pure sedge cover (Figures 5, 6) where the sedge binds it into a firm sod; coarser and with more woody material under the shrub cover where the surface is built up in tussock like mounds. Under the heaviest forest cover of the bog the peat is more decomposed, being blacker and mucklike. Important as bearing on the history of the vegetation cover is the fact that throughout the marsh under the present sedge cover, as well as under the shrub and conifer associations there are buried logs and the stumps of black spruce and tamarack. (Figure 13.) All of these so far as examined, showed the charred effects of burning. In some places fire charred snags still stand (Figure 14), showing that a conifer bog forest formerly occupied the area.

As in typical basin peat bogs the peat blanket is ordinarily water soaked and the living sphagnum cover reeking wet. The free water table fluctuates, however, so that after long summer drouth the surface of the bog, especially in the sedge zone, becomes dry and crisp. That is, the dead but not disintegrated sphagnum layer becomes dried out and then, of course, the top layer of living sphagnum is more or less completely killed by drying. No doubt this recurrence of summer droughts materially checks the aggressiveness of sphagnum in what appears to be its tendency to smother out the sedge and shrub species.* On the other hand, in wet seasons, as observed for example in late October after heavy fall rains, the water table is high enough to lie free above the sphagnum surface throughout the sedge zone and between the mounds in the shrub zone. Borings made at the end of a severe drought period and again at the same locations after heavy rains showed that the whole peat blanket shrinks and swells with the fluctuations of the water content or of the water table. Thus at station 10 on the F profile (see Map 1) the peat depth on August 12, 1919, after more than two weeks of hot dry weather, was 24 inches; on August 19 after a heavy rain, 30 inches, and on Novem-

* It should be noted that as the bog surface becomes built up so that it is permanently above even flood water level, the moisture demanding *Sphagnum recurvum*, generally dominant in the open bog, becomes replaced by the more xerophytic species, *S. capillaceum* var. *tenrellum* and *S. fuscum*. On the other hand, during flood water periods the habitually submerged *Sphagnum cuspidatum* enjoys a season of notable vegetative activity apparently becoming dormant as the water subsides.

Fig. 4. View of the southern portion of the east section of Grasse River bog. Sphagnum-sedge association is dominant but some dwarf heath shrub colonies occur. The conifer forest here occupies slightly higher non-peat covered ground.

Fig. 5. A plug of peat sod showing how firmly it is bound by the rhizomes and roots of the sedge. The sphagnum matrix may be seen at base of sedge shoots and especially in separate specimens held in left hand.

ber 1 after continuous fall rains resulting in areas of open water on the marsh, 33 inches.

The Plant Associations on the Peat Beds

While the vegetation complex seems diversified and of more or less haphazard occurrence, it may on closer inspection be referred to a few aspects or stages constituting a developing sequence with pure sphagnum sedge meadow as the apparent pioneer association and the old stand of black spruce and tamarack forest as the temporary, edaphic climax. It should be remembered, however, that in speaking of the sphagnum sedge meadow as the pioneer association, it is not to be inferred that this was the pioneer vegetation of the original sand plain, but only of the peat blanket which covers the sand and which is itself a vegetation product. Moreover, the evidences of a former bog forest as shown by the presence of fire charred logs, stumps and occasional standing snags show that we are here dealing with a secondary though normal bog sequence.

(1) The Sphagnum-Sedge Association (Figure 4)

This is a low, very flat bog-meadow type of vegetation with a close and almost pure stand of *Carex oligosperma* growing in a continuous sphagnum matrix. There is a sparse occurrence of tussock sedge, cotton sedge, *Vagnera trifolia*, *Viola blanda*, dwarf cranberry, closed gentian and certain others, not all characteristic bog species it will be observed. The failure to note such expected species as sundew, pitcher plant, rose pogonia, and calopogon is noteworthy in this association, and may no doubt be ascribed to the effects of burning and pasturage and the summer surface drying to which this section of the bog is now especially subject. Where the sedge meadow is partially broken up by sphagnum-shrub mounds and where the sedge mat is therefore wetter and unburned, these species occur about as in typical open bogs. The peat here is shallow, being from 8 inches to 2 feet in depth and is bound by the sedge roots into a firm sod. (Figure 6.) In this association the peat is darker and approaches more the quality of muck soil. This is no doubt in part due to the fact that in midsummer drouths the water table sinks quite below the surface of the underlying sand thus favoring more thorough decomposition. It is favored also by the fact that the sedge meadow is lightly pastured by stock while the new sedge shoots are tender. To improve this pasturage it appears to have been the practice to burn over patches of the meadow at a favorable time in the spring. One such burn of the spring of 1919 was closely examined in July of the same season. It was noted that the fire had killed back the old sedge, the few encroaching shrubs and most of the sphagnum to the level of the wet, dead sphagnum cover. All of these elements of the association were sending up new shoots, but it was obvious that the sedge stand recovers most promptly and that by this treatment its period of dominance is prolonged.

With regard to the sphagnum matrix in general, it may be said to control the situation first because its dead and disintegrating shoots form the substratum upon which sedge and other species have to establish themselves and second, because its vigorous growth tends to submerge and smother them. While the bog surface is flatter in the sedge zone than elsewhere, even here sphagnum tends to form mounds by its vigorous climbing among the sedge shoots. What outcome this might have for the future of both sedge and sphagnum if left otherwise undisturbed was not clear, for with this increasing unevenness of surface the shrub invasion of the sedge meadow becomes notable (Figure 7), and the conclusion is drawn that this interaction between sedge and sphagnum whereby the surface becomes built up mound-wise, accelerates the coming of this second stage in vegetation development whose culmination is a close shrub association; i. e., temporarily a complete occupation of the ground by sphagnum-heath shrub vegetation.

(2) The Sphagnum-Heath Shrub Association

Relatively little of the eastern section of the bog, and none of the west section is at present wholly occupied by the meadow like sphagnum-sedge association. Figures 7 to 11 show the

Fig. 6. The bog between Grasse River railroad and Town Line Pond. Well advanced stage of dwarf heath shrub invasion. The surface of Town Line Pond may be seen at the point where it spills over the bog in an ill-defined seepage swale.

Fig. 7. The invading shrub association is closing in over the sedge meadow. Dominantly *Chamaedaphne calyculata* with some *Viburnum cassinoides* at this point.

Fig. 8. Closed sphagnum-shrub association in foreground; advanced stage of black spruce-tamarack bog forest in background. The abrupt line of demarkation may be due to a burn. Looking northeast from about the center of the east section of Grasse River Bog.

Fig. 9. Deer trail across the closed shrub stage. The mound effect is shown. The surface of the bog is a deep spongy cover over which walking is extremely fatiguing. Northern third of east section of bog looking toward Hardwood Island.

progress of shrub invasion from an occasional plant or colony to a closed shrub association. In general, the south one-third of the main marsh may be described as a complex of pure sphagnum-sedge and sphagnum-sedge-shrub associations with sedge predominating; the middle third as an association complex varying from a bare predominance of shrub to a closed sphagnum-heath shrub association, while the northern third is a complex of sphagnum-shrub-conifer with conifers predominating at the northerly boundary. (Figure 15.)

Method of Development. The energy and rapidity with which the shrub elements invade the sedge association would lead one to expect to find abundant examples of shrub seedlings or individual plants recently established. Repeated examinations have however not borne out this expectation. Small young plants of Chamaedaphne and other shrubs may be found, but in the main the original plant has become a clump or colony by its rapid vegetative propagation under the sphagnum. Conditions for the germination of seed and establishment of the invading shrubs would appear to be favored by the creation of sphagnum mounds in the sedge zone. In any event, when a shrub gains foothold the interaction between sphagnum and shrub — the race to avoid suppression as it would seem,— results in building up a higher mound of sphagnum which in turn leads to a more vigorous vegetative expansion of the shrub colony for here as will also be shown for the invading conifer zone, the moist sphagnum stimulates a most vigorous development of shoots and of abundant roots from these which in effect (and in black spruce actually) is rapid reproduction by layering. Thus it comes about that the shrub colonies and the sphagnum-shrub mounds which their interaction creates increase rapidly in height and especially in diameter so that progress is rapid toward a complete dominance of sphagnum-shrub vegetation as well as in building up the surface of the bog. Figure 12 shows a dissection of a mound formed by sphagnum and Chamaedaphne. The spreading shoots of the shrub appear all to be related to a single original plant. The sand substratum is shown. There appears to be no growth of the roots of Chamaedaphne in the sand. Indeed, no case has been found anywhere in the bog where the roots of the present bog vegetation penetrate the underlying sand. The surface becomes much more uneven and more loose and spongy than in the sedge zone and although mounds by expansion become confluent, there still remains an endless succession of mounds and intervening depressions so that walking across this part of the marsh becomes a difficult and exhausting task comparable to floundering through a succession of snow drifts. Figure 11 shows this condition in an interesting way, where deer in crossing the marsh have tramped a trench like trail in the spongy surface. Figure 13 shows the stump of a burned spruce left partly exposed in a zone of rapid growth in thickness of the sphagnum-shrub blanket and the underlying fibrous peat.

The Bog Shrub Species. The shrub species which play a rôle in this invasion of the sphagnum-sedge association are chiefly heaths though *Spiraea latifolia* is of frequent occurrence in the pioneer stages, especially when burning has been a factor in delaying shrub invasion. Of the heath shrubs, *Chamaedaphne calyculata* is the most abundant and aggressive. *Ledum groenlandicum* plays a vigorous rôle especially at a later stage when the conifer invasion begins. *Vaccinium angustifolium*, *Kalmia angustifolia*, and *polifolia* and even *Andromeda polifolia* are frequent and often prominent, though on the whole of rather secondary importance. Of the non-heath shrubs, witherod (*Viburnum cassinoides*) and mountain holly (*Ilicioides mucronata*) are important species notably in the older sphagnum-shrub association. They seem to reach their greatest abundance and highest stature even after conditions have favored the invasion by conifer species.

The expression dwarf heath-shrub association is applicable here for in the pure sphagnum-shrub association all of the shrub growth (both ericaceous and non-ericaceous) is of dwarfed stature. Cassandra and Labrador tea persist in the conifer association and here are of habitually taller stature than in the dwarf heath shrub association.

Fig. 10. Dissection of a sphagnum-shrub (Cassandra) mound. The sphagnum is chiefly *S. recurvum* in such mounds. Its rapid upward growth among the shrub branches induces a sort of layering resulting in an expanding shrub colony. The sand bed is seen below. The shrub roots do not penetrate this.

Fig. 11. The heavy sphagnum-shrub blanket has been torn away revealing the fire scarred stump of a black spruce-remnant of a bog conifer forest which was destroyed by fire.

Growth and Vegetative Propagation. The shrubs named possess in common the quality of vigorous and rapid vegetative multiplication which results as previously mentioned in the formation of spreading colonies and accounts, apparently, for the spotwise occurrence of them. .These phenomena are discussed in a separate paragraph. (Page 40.)

The Black Spruce — Tamarack Association. Bog Forest

At the present time there is only a small portion of the west section of the Grasse River Marsh which may be said to have reached the culmination or bog climax stage of closed high forest. Most of the west section and the north end of the east section are covered by young conifer stands and while most of the northern third of the east section may be characterized as an open stand or even quite scattered occurrence of black spruce and tamarack in the invaded shrub zone, viewed as successive aspects of vegetation development this transition from pure sphagnum-shrub association to the black spruce-tamarack association presents exactly the situation previously described in tracing the succession from pure sedge meadow through various stages of invasion and complete dominance by the heath-shrub and associated species.

(a) **Stages in the Invasion of the Sphagnum-Shrub Association by Bog Conifers.** The northern third of the main marsh area presents for the most part a scattering or fairly open stand of black spruce and tamarack among a heavy growth of bog shrubs in their characteristic mound forming colonies. (Figures 15, 16.) Toward the north boundary the conifers form a closed stand of young forest. The explanation here set forth is that in this part of the marsh we have a concrete example of the continuing, normal course of vegetation development in which species of bog conifers invade the sphagnum-heath shrub association and establish a bog conifer forest in its stead just as in the preceding step the shrub vegetation had overcome and replaced the sphagnum-sedge stage. From this point of view, the vegetation is regarded as inevitably moving forward toward a stage of stable equilibrium — seeking its highest level as one may say — which in ecological terms is a type of plant association that presents the highest degree of mesophytism of which the region as a whole is capable (10), but whose forward movement is locally controlled by soil conditions (edaphic factors) in this case the complex of conditions which a peat bed offers when its surface has been built up to the mean level of the water table. When, in tracing this vegetation succession, one speaks of invasion and of the suppression of one species or type by another, a condition of antagonism is of course implied which is scarcely the status of a normally developing organism to which the phenomena of plant succession have been compared. It is true nevertheless that each association tends to bring about changes in the substratum which, however difficult to detect and measure, throw the balance against the present occupants and in favor of certain other species. We may say that the defense breaks down and the attack succeeds by reason primarily of conditions created by the defense itself. The sharp line of demarkation between pure shrub and an advanced stage of invasion by conifers shown in Figure 10 would suggest that this is the boundary line of a burn. The normal encroachment of conifers upon the shrub stand is clearly shown in Figure 16 where the aggressiveness of black spruce is especially obvious. This species is here, as generally in Adirondack bogs, the foremost conifer in the invasion. Very often, if not generally, the forest stage is a pure stand of black spruce. This condition is clearly related to its aggressive growth habits as well as to its tolerance of bog conditions. This aggressiveness expresses itself in the rapid growth and wide reach of the lower branches in proportion to the main axis which enables it to overcome the shrub species. The rapid upward growth of sphagnum among the wider reaching branches creates a wet blanket about them which induces prolific root development (4) (8) and so as in the case of shrubs previously described, a colony is formed. In the course of time, the growth of the several branches each with its own root system may result in a clump of spruce trees. The compactness of growth in this low spreading habit,

Fig. 12. A wetter area of Grasse River Bog between the center of the raised bog and Hardwood Island. *Carex stricta,* iris and a few other marsh plants occur here. At the center a fire-scarred snag indicates the earlier bog conifer forest which occupied this section of the bog.

Fig. 13. Typical view of the northern third of the east section of the bog. Black spruce and tamarack rapidly succeeding the sphagnum-shrub association. The spreading habit of black spruce is conspicuous and reproduction by layering is common. The peat is seven feet deep here.

the density of foliage and the opaqueness of it result in creating a twilight zone beneath the single young spruce or its newly formed colony or clump such that the shrubs and the climbing mound forming sphagnums are gradually suppressed and finally largely eliminated. Thus one may find situations where the spruce has retarded or eliminated shrub and sphagnum growth so that while the general upbuilding of the spongy bog surface has continued all about, there will be underneath the clump a depression, which if the spruce were removed, would appear as an excavation one to two feet below the general level of the bog. Figure 17. Shrubs, if they still persist, will be found to send up shoots only around the margin of the spruce or more or less etiolated shoots through the gaps in the dense foliage. The bottom of the depression may continue to be occupied by living sphagnum, but this is strongly tolerant of shade and possibly represents the beginning of the sphagnum carpet which comes to occupy the shaded floor beneath the closed spruce stand. (See below under (c), and p. 37 under *the rôle of sphagnum*.)

The rôle played by tamarack in the invasion of the shrub association of Grasse River Bog is rather secondary to that of black spruce, and this appears to be the case pretty generally in Adirondack bogs. However, tamarack is a constant if more scattered associate in the conifer invasion and in places establishes pure stands. In bogs of the less extreme sort this species becomes the dominant conifer, but in a more extreme type, as for example the Bean Pond Bog (Bray [2], p. 125, and Fig. 20) near Wanakena, tamarack is but infrequently represented while black spruce though much dwarfed persists in abundance. Contrasted with the secondary rôle of tamarack in the invading conifer stage and the young forest, is its prominence in the old bog forest as noted below.

The habit of reproduction by layering in the case of tamarack which has been reported by other observers (4) has, if it occurs in the Grasse River Bog, escaped my observation. There is apparently every condition present to favor this for the heavy sphagnum growth imbeds the lower branches in a wet sponge more aggressively than in the case of black spruce, since, of course, tamarack lacks the compactness of form and the opacity of foliage which tend to retard or suppress the sphagnum encroachment noted in the former species. Tamarack, moreover, loses its foliage at the season when sphagnum was observed to make its greatest gains and in this respect appears to be threatened with suppression by the sphagnum blanket as black spruce is not. A compensating feature appears to lie in the more rapid height growth of tamarack, its slender spire contrasting with the spreading habit of black spruce at the period of invasion of the sphagnum-shrub association.

The critical stage for the conifer species is, of course, that in which seed germination and the establishment of the young seedlings take place. The whole question of the time when the vegetation sequence proceeds in the direction of conifer forest rather than remaining static as a closed sphagnum-shrub association turns on this. Unfortunately as had to be admitted before in discussing the pioneer stage of shrub invasion of the sphagnum sedge association, data are lacking notably in finding seedlings of the current year or very young conifer plants.

It is evident however that the chances of germination and establishment of the conifer seedling are increased as the general bog surface becomes diversified by being broken up into mounds with dense shrub and slopes and depressions of exposed sphagnum. In its most vigorous and apparently earlier stage the shrub stand may become very compact and continuous. See figure 10. In such a zone there are obviously fewer chances for conifer seedlings to secure a start and no specimens of conifers have been noted in this zone although it lies adjacent to the area now being invaded.

(b) **The Closed Stand of Young Black Spruce and Tamarack Forest.** This expression refers to the stage at which conifer species have closed in over the bog but have not lost their lower branches by crowding and shading. There is not yet a closed canopy with its under story of more or less clear boles. Figure 18. The northern end of the main bog and the greater part of the western section of it have reached this stage. As

Fig. 14. Showing the habit of black spruce where it invades the deep sphagnum-shrub cover of the bog. The central figure is a black spruce colony. White strips were tied to two branches which by striking root in the sphagnum have become independent though not yet detached young trees.

Fig. 15. Dissection of a black spruce colony to show suppression of heath shrubs and sphagnum by shading and smothering. The depression in the bog surface is conspicuous but the shade was too dense to permit this photograph to show it.

previously stated much of this is approximately pure black spruce stand, the tamarack being scattered and often infrequent. Arbor vitae occurs infrequently only in the western section of the bog. With the arrival of this closed stage of young forest the sphagnum-shrub association has been very largely suppressed or at least dominated. The diversified bog surface with its mounds and depressions and its loose spongy texture becomes leveled and more compact. At this stage few other species of the conifer association have appeared. It is rather the phase of elimination of the species of the sphagnum-shrub association. This in time passes into

(*c*) **The Closed Stand of Older Black Spruce-Tamarack Forest.** This may be regarded as the culminating phase of the purely bog series of associations. Figure 19 shows a remnant of a rather old stand of black spruce and tamarack in which tamarack has made the better growth. Very often this stage will be represented by a pure spruce association. At this stage well recognized forest conditions have been established with respect to the forest canopy, to the semi-twilight zone beneath it (now a more roomy space with boles partially or wholly self pruned to a height of ten feet and upwards) and with respect to the bog surface now to be designated as the forest floor. A fairly uniform pure stand of black spruce over fifty years old presents instructive features in this connection. Bog shrubs have been very largely suppressed though tall spindling shrubs of *Ledum groenlandicum* and *Kalmia angustifolia* are scattered here and there while *Vaccinium canadense* almost or wholly wanting in the open bog is relatively frequent in the forest shade. The floor is covered by a level, deep carpet of living sphagnum — chiefly *Sphagnum magellanicum* which makes a very rapid spindling growth that quickly covers the annual fall of spruce twig and needles, these lying as imbedded layers in the dead sphagnum. The log of a fallen spruce some six inches in diameter was also thus quickly covered. Slight elevations of the forest floor — fallen logs, stumps and the broadened bases of living trees — are becoming occupied by forest floor species commonly found in balsam swamps — bunch berry, creeping snowberry, American twin flower and occasional cinnamon fern — thus showing the pioneers of a later association which carries the sequence of development beyond the strictly bog series toward the balsam swamp forest type.

(d) **Transition Stage from Bog-Conifer to Balsam Swamp Forest.** The oldest phase of vegetation now to be found on the Grasse River bog lies to the south of the railroad beginning near Silver Brook station. Specimens of standing dead tamaracks were found here measuring nearly 18 inches DBH and estimated to be approximately 100 feet tall. Apparently all of the old tamarack in this stand is dead. A gigantic specimen of black spruce in this vicinity, shown in fig. 20, measures over 20 inches DBH. Some arbor vitae is found in this stand. Balsam is rather frequent and red maple occurs sparingly. A single specimen of red spruce was noted. To one who has become accustomed to the monotony of a black spruce tamarack association, these added species are striking signs of a changed status of affairs in the bog. Inquiring into the nature of this changed status, one finds that while the peat bed is here some 3 feet deep, it is obviously more decomposed, being blacker and more mucklike. The surface of the bog — the forest floor — is broken up by the massive roots of trees, elevated about their buttressed bases and upon uprooted specimens (fig. 21) or on rotting stumps. A heavier forest litter covers the ground. Thus, while it is a wet habitat, the upbuilt surface at least is fairly well drained and aerated during much of the growing season. Sphagnum is still abundant, but is often suppressed by incoming species, notably cinnamon fern. Fig. 20. Patches of *Oxalis acetosella* upon the uplifted sphagnum covered forest floor give the appearance often seen in stands of red spruce. Fig. 21. The list of non-bog species is now fairly large. It includes the bunchberry, American twin flower and creeping snowberry mentioned in the preceding phase (c). Beside these and the oxalis and fern just mentioned there are *Dalibarda repens*, *Coptis trifolia*, *Unifolium canadense*, *Gaultheria procumbens*, *Aspidium inter-*

Fig. 16. The oldest living stand of black spruce-tamarack forest on the Grasse River Bog. The specimen of black spruce is over twenty inches in diameter. Gigantic dead tamaracks were found near this. Cinnamon fern and numerous other forest floor species together with occasional red maple and balsam indicate the transition to balsam swamp forest.

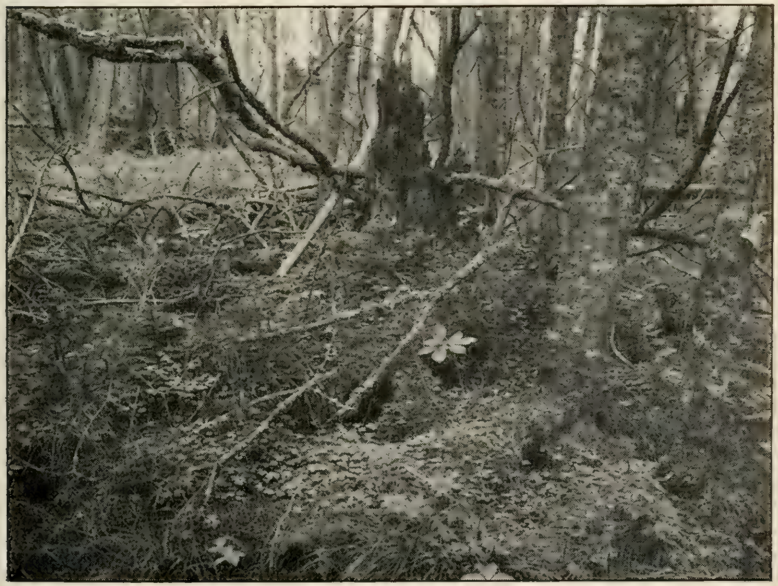

Fig. 17. The most advanced condition of the bog showing how the surface is elevated and better drained. Note the abundance of *Oxalis acetosella*. See text p. 28 for numerous balsam swamp and climax forest species occurring here. The peat is three feet deep and rather mucklike. This is regarded as showing conclusively a transition to balsam swamp forest.

medium (occasional small specimens), *Habenaria obtusata*, *Aralia nudicaulis*, patches of a tall growing *Polytrichum* and mats of the liverwort *Bazzania trilobata*. Abundant seedlings of balsam, red maple and arbor vitae and even yellow birch are becoming established in the moist sphagnum carpet covering buried logs and stumps, so that in this type more than in any of the preceding associations one is able to find evidences of the actual current progress of the new association which is replacing the old. Single erect shoots of the bog shrubs *Ledum groenlandicum*, *Kalmia angustifolia* and *Viburnum cassinoides* serve to emphasize the contrast between conditions in this habitat and the bog shrub associations where these species play an important role. In their occurrence and changed growth form here one is easily led to regard them as survivors of a former vegetation which occupied this same ground which indeed they are, as representatives if not as individual survivors, if we are correct in regarding this old forest as the end of a sequence of bog development.

When it is recalled that this transition stage from black spruce-tamarack bog forest to a semi-balsam swamp type occurs on the same physiographic unit hitherto considered — the peat covered sand plain — the conclusion seems warranted that the foresters' balsam swamp type of forest may in some cases be the temporary climax of a bog sequence of associations. It will require further investigation of other areas to determine how generally this is the case in the Adirondacks.

REVIEW OF VEGETATION DEVELOPMENT ON THE GRASSE RIVER PEAT BEDS

In review it appears that the present vegetation cover on the peat beds falls into a series of well defined types or associations, as follows: 1. The sphagnum-sedge meadow. 2. The sphagnum-heath shrub association. 3. The black spruce-tamarack association. 4. The pioneer stage of balsam swamp forest. There are all stages of intergradation between these types representing the invasion of the sphagnum-sedge meadow by dwarf heath shrubs tending to form colonies and showing sphagnum-shrub mounds: the succession of tall shrubs in the well established sphagnum-dwarf shrub association; the early stages of black spruce-tamarack invasion of the older shrub type; the closed conifer association before pruning; the true forest stand of black spruce and tamarack and finally the more complex association of these species with balsam, red maple and a larger series of forest floor associates. These have been presented with the purpose of showing that peat bed vegetation is of a specialized kind involving the elimination of many species otherwise occurring in wet situations and the selection of a restricted list of bog tolerant species — phenomena, of course, already well known among botanists; second, that the several types and their intergradations represent a sequence of vegetation development — the so-called bog sequence.* The term sequence or succession is meant to imply that all these associations are developmentally related, i. e., that each phase of vegetation or association causes changes in the substratum which literally prepare the ground for species of different soil requirements. It appears that in the oldest and apparently most stable association — the early balsam-swamp type — the substratum is approaching a condition where the percentage of balsam may be expected to increase and it is conceivable that the further upbuilding and differentiation of the still wet substratum with the consequent appearance of greater numbers of less hydrophytic forest floor species, may be creating conditions which will more and more favor the entrance of yellow birch (numerous seedlings of which are found on decayed and half buried logs), of white pine and gradually of hemlock, beech and hard maple — that is the regional climax association with its characteristic well drained and aerated crumbly leaf mold soil and equally characteristic forest floor species. The writer has not, it must be repeated, observed any case in the Adirondacks where such a regional climax forest has developed upon a peat bed, so it appears that the balsam swamp type of forest is the persistent if temporary edaphic climax of a bog sequence. This does not bear the inference, however, that in the Adirondacks balsam swamp forests are generally

* See, for example, Dachnowsky (7), 237.

found to be underlaid by sphagnum peat. Indeed, the Grasse River sand plain itself gives indications that this type may develop on low, rather wet sand beds. See pages 32, 33.

It must not be understood that this presentation of the vegetation sequence of the peat beds of the Grasse River plain assumes the tracing of an uninterrupted original succession. As has been stated, recent fires in the sphagnum-sedge and in the open dwarf shrub zones have materially affected the course of vegetation. In the east section of the bog in the sedge zone to a less extent, but notably in the pure shrub zone, there are still to be found standing, fire charred snags and numerous buried logs and stumps also party burned which indicate a former black spruce-tamarack forest over the whole of this area. Fig. 14 shows a standing burned snag and fig. 13 a burned stump of trees that must have been over 50 years old and represent remnants of a growth that had established forest conditions including clear boles, a canopy and heavily shaded forest floor. No doubt the local history would reveal notable changes in the vegetation of the bog within the memory of the long time residents of the vicinity.

VEGETATION OF THE NON-PEAT COVERED SAND PLAIN

The locally descriptive name Grasse River Marsh refers especially to the low lying peat covered lands — the bog as just described. The sand plain considered as a whole presents also low elevations from flat scarcely discernible rises barely above bog level to well defined undulations or low ridges. The esker like ridge separating the bog from the flood plain has been pointed out already as an important feature. Finally one-half of the west section of the plain — notably between Burnt Rock and the mouth of Silver Brook — lies above the peat forming level, though it is still to be classed as low land. No attempt is made here to analyze the vegetation cover of these sand beds minutely or to establish except in a general way its successional aspects. It is particularly cited in contrast with the situation just described, where the bog sequence of vegetation is determined. Figs. 4, 5, 22 show what appear to be patches or strips of conifer bog forest. They represent in fact "islands" or very flat ridges just high enough to be above the peat forming level. They are occupied by a vigorous young timber growth in which black spruce and tamarack are prominent — occasionally tamarack alone in rather open stand, just as they are on the peat soils, only of taller, more rapid growth. With these are also balsam and an occasional white pine and popple. There is no ground cover of sphagnum as in the surrounding bog and the floor is sand, strewn thinly with forest litter or with a thin layer of quickly dried duff. It is quite conceivable that if the surrounding bog were to develop into the closed shrub stage with its more elevated surface the sphagnum would invade these islands. Possibly they may formerly have been covered with sphagnum and peat which has been burned down to the sand. Of the larger strip of slightly elevated sand beds lying along Grasse River from the railway bridge to Silver Brook, a portion is still covered with forest which, while rather of the character of balsam swamp, presents, beside balsam, black spruce and tamarack, a noteworthy frequence of yellow birch and white pine, and red spruce. This seems to have been the composition of the entire stand of this area which in recent years has been destroyed apparently by the back water of Grasse River flow. The point to be especially noted, however, is that the secondary sequence following destruction of the old forest is not at all dominated by sphagnum; that while dwarf heath shrub occurs — Chamaedaphne notably — on the flattest of it, the prominent vegetation is composed of associations of grasses and sedges with composites and other herbaceous species and with Polytrichum, *Lycopodium clavatum* and *L. complanatum* on the drier, bare sand exposures.

Characteristic Species of the Non-Peat Covered Sand Plain

On Wet Sand	*On Dry Sand*
Osmunda regalis (dwarfed)	Polytrichum sp. (forming mats)
Calamagrostis Canadensis	*Lycopodium clavatum*
Panicularia laxa	*Lycopodium complanatum*
Carex stricta and other sedges	*Spiraea tomentosa*

Fig. 18. One of the "islands" of timber on the very slightly elevated non peat covered sand areas of the Grasse River Bog region. Explanation in text.

Fig. 19. Grasse River flood plain below Hardwood Island, looking toward the flow. The dead snags beyond the flood plain represent the remnant of a destroyed forest (balsam swamp) which occupied the slightly elevated non peat covered sand plain at this point.

On Dry Sand

Juncus effusus
Iris versicolor
Ibidium cernuum
Coptis trifolia
Rubus hispidus
Triadenum virginicum
Spiraea latifolia
Viola blanda
Epilobium lineare
Lysimachia terrestris
Gentiana andrewsii
Solidago uliginosa
Euthamia graminifolia
Occasional leather leaf, Andromeda, cranberry and rarely a tuft of sphagnum.

On Wet Sand

Vaccinium augustifolium
Some introduced species, such as strawberry and pearly everlasting

Willows (several species including *Salix bebbiana* and *discolor*) and alder (*Alnus incana*) have invaded the earlier association and over many acres of the former forest area have established a shrub thicket. The shrubs are more dwarfed than where these species grow in wetter swamp-shrub associations, forming low, compact clumps as shown in fig. 20.

The occurrence of black spruce, tamarack, dwarf heath shrubs and even of occasional patches of sphagnum indicate that this portion of the sand plain is almost at the balancing point as between a bog sequence and a swamp sequence. It seems quite obvious that the deciding factor in such a sequence is simply the difference in the lie of the land; the slightly higher or at any rate better drained tending toward the fresh water marsh and swamp succession, the lower lying or at any rate habitually ill drained terrain tending to favor sphagnum and its consequent peat bed with resulting bog succession. Here again it would seem that adjacent areas of sphagnum dominated associations (sphagnum-sedge, sphagnum-heath shrub or sphagnum-conifer forest) may develop a thickness of spongy sphagnum blanket which would enable the sphagnum to invade the marsh and swamp area and thus reduce it virtually to a bog condition. Possibly the former cover of balsam-swamp like forest was marked by the presence of a sphagnum ground cover and it is not unlikely that the present willow-alder association will be succeeded by a mixed balsam and black spruce-tamarack forest with sphagnum present as the dominant ground cover.

The esker like ridge which it will be remembered is the controlling physiographic feature with respect to creating an undrained condition of the east section of the bog, see fig. 1, rises high enough above the general marsh level to permit its climax vegetation to approximate that of the uplands of this portion of the Adirondacks. A recently logged forest cover consisted of white pine, yellow birch, red maple, red spruce, tamarack and balsam. Smaller examples of these species still remain, but mostly the ridge presents species of a secondary succession characteristic of burns or of logged sand areas in which the previously mesophytic conditions of an edaphic climax forest have been reduced to a semi-xerophytic status, the sand floor lacking the moisture holding blanket of forest humus and litter. These secondary species include Polytrichum, bracken fern, blueberry (especially *Vaccinium Canadense*), trembling poplar and large toothed poplar. Finally by way of the sharpest contrast with the prevailing hydrophytic conditions of the area in general, a sand mound on the west of the river at the railroad crossing (the roadbed was cut through this mound) exhibits the marked xerophytic conditions of quickly drained, loose lying sands. The summit of this mound is very nearly bare sand while the sides are fully covered either by bracken fern or blueberry or by a close stand of young popple — a condition notably frequent throughout the Adirondacks where the forest cover and its protecting soil blanket have been removed by lumbering and burning.

THE VEGETATION OF THE FLOOD PLAIN; BEAVER MEADOW

In the preceding instances emphasis has been placed upon the contrast between the vegetation of a low, undrained or poorly drained sand plain, and the slightly elevated better drained sands. A still more notable contrast with the bog vegetation is furnished by that of the flood plain of Grasse River. This flood plain presents a typical example of the vlaie or beaver meadow of the Adirondacks. Fig. 21. While it is quite level and lies several feet lower than the bog its surface

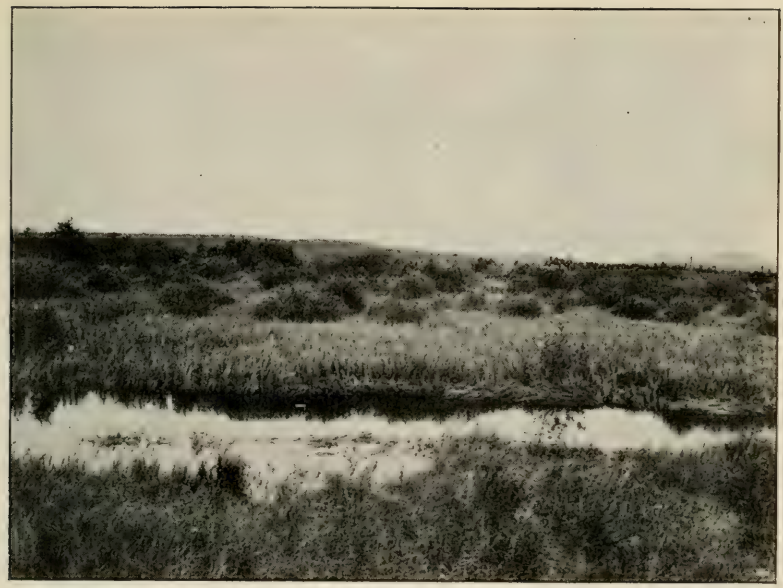

Fig. 20. A marsh meadow with its successor, a willow-alder association following the destroyed forest on better drained non peat covered sands of the Grasse River sand plain.

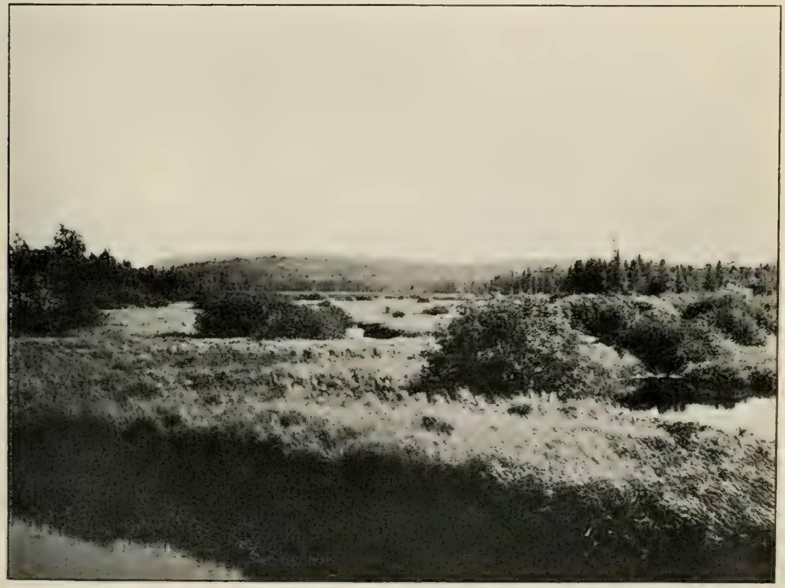

Fig. 21. Typical beaver meadow (*Calamagrostis canadensis* and other grasses) occupying the flood plain of Grasse River adjacent to the bog. The absence of sphagnum and peat is noteworthy. The alder invasion is checked by mowing the meadow, but note greater abundance of it in middle background.

soil is well drained. The water table lies very near the surface — in July, 1920, it was only six inches below the surface — except in very dry seasons when it sinks 18 inches or more. The soil is a very rich black alluvium almost muck like in places, covering the underlying sand to a depth of some two feet. Much of it is the product of the vegetation itself, but in flood periods, as for example in the spring of 1920, the river cuts away its low bank and the black soil is deposited as mud over the flat meadow. It is well mixed with mineral constituents. Angle worms are found under the close meadow sod as in rich cultivated fields. These qualities stand out in sharp contrast with the soils of the sand plain generally and one is impressed at once by the absence of sphagnum, heath shrubs and all the constituents of the bog series. Perhaps no more striking example could be cited of the role of edaphic factors in determining the vegetation cover and its course of development (sequence of associations). There are two prominent associations — (1) the marsh meadow, (2) the alder thicket. See fig. 25.

(1) The Marsh Meadow

Within the area covered by Grasse River sand plain, the marsh meadow occupies the greater part of the flood plain. It forms a series of pastures in the bends of the widely meandering stream. Its extent and persistence (freedom from shrub invasion) are promoted by the practice annually of mowing the hay for stock feed. In general the beaver meadow grass, *Calamagrostis canadensis* is the dominant species in the association, but where the meadow has been pastured and longer mowed, other grasses have become even more prominent. Thus there are almost pure stands of northern manna grass (*Panicularia laxa*), of fowl meadow grass (*Poa triflora*), and silk grass (*Agrostis hyemalis*), while the constantly wet ground is covered by tussock sedge (*Carex stricta*). Other grasslike marsh plants occur in considerable frequence, e. g., *Scirpus cyperinus*, *Carex intumescens*, and there is the usual scattering occurrence of such marsh herbs as *Iris versicolor*, *Thalictrum* *polygamum, Comarum palustre, Rubus triflorus, Viola blanda, Scutellaria galericulata, Veronica scutellata, Campanula aparinoides* and others.

Of mosses, the entire absence of sphagnum has been noted. There are occasional mats of the tall spindling growths of Polytrichum (species) growing in very wet shaded depressions. The meadow floor is a compact, firm sod, and it is interesting to note that at certain drier spots Kentucky blue grass (*Poa pratense*) and orange hawkweed (*Hieracium aurantiacum*) have become established. Of the pioneer species of shrub invaders, *Spiraea latifolia* is fairly well established and maintains itself by vigorous shoot production in spite of the annual mowing. Sweet gale (*Myrica gale*) occurs in small clumps where a wet spot is avoided by the mower.

(2) The Alder Thicket; Alnus incana Association

Within the limits of the sand plain — the Grasse River marsh as here designated — the alder thicket is confined to the stream margin and to the sloping bank of the flood plain. The aggressiveness of the shrub invasion is not fully expressed because, as explained above, the meadow stage is prolonged by the annual hay cutting. *Spiraea latifolia* has gained and maintains a foothold by vigorous sprout reproduction and *Myrica gale* and alder form small clumps in wetter depressions in the meadow. Willows, though frequent along the outer slope of the flood plain, play at the present an inconspicuous role. The vigor and aggressiveness of alder as a successor to the marsh meadow association may be seen farther up the Grasse River where opposite the Grasse River Outing Club the flat flood plain has become fully occupied by an almost impenetrable alder thicket of many acres. The dense alder growth virtually hides the stream itself, rendering the passage of a canoe impossible and forming a most difficult obstruction to passage along its banks. The writer is not informed as to the recent history of the establishment of this "alder flat," nor as to the vegetation which preceded it. It is probable that so dense a growth will rapidly bring about changes in the substratum favorable to the establishment of balsam and comparison with other somewhat similar situations confirms the belief that a balsam swamp forest will be its natural successor.

Such comparison would justify one in concluding that the entire flood plain in this region from the flats above the Grasse River Outing Club to the flow had at an earlier day been occupied by balsam swamp forest. It suffices for the present purpose, however, merely to re-emphasize the contrasting soil conditions of these two adjacent units of the Grasse River sand plain.

THE SIGNIFICANCE OF SPHAGNUM

The foregoing description of the behavior of the vegetation on three physiographically distinct units of the Grasse River sand plain serves not only to emphasize the importance of soil factors in determining vegetation types and sequences. It focuses attention especially upon the important role played by sphagnum mosses. It is obvious that under certain conditions — primarily an undrained terrain — the entrance of sphagnum determines the whole subsequent course of vegetation. This we have seen in the sequence of associations in the sand plain bog from the open sphagnum-sedge meadow to the old conifer forest. Sphagnum is the dominating element in this entire sequence. First by reason of the living plants, second by reason of the blanket of dead, undisintegrated sphagnum and its underlying peat. Sphagnum forms practically a continuous living cover over the entire bog in closed, dark forest as well as in the open sedge meadow. Its upward growth among sedges, shrubs and conifers greatly influences their mode of growth.

The entrance of new plants into the associations by spores or seeds is conditional always upon gaining a foothold in the living sphagnum ground cover excepting that in the conifer forest stage fallen logs, stumps, and other elevations not yet sphagnum covered, furnish a starting place. The roots of the vascular plants are imbedded in the sphagnum blanket. Their absorption of water and mineral nutrients takes place in the superficial zone composed of the living sphagnum and its erect dead stems, the compressed but not disintegrated sphagnum and the upper zone of peat. The environment thus created by the presence of sphagnum and its accumulated products is of a very specialized character. It is permanently wet and this fact increases the chance for seed germination and promotes constant vegetative multiplication. It is not well aerated and this fact entails a train of consequences of disadvantage to the associated vascular plants and affects the condition of the substratum itself. It is deficient in the mineral constituents which one commonly associates with soil. While the nitrogen content is high, most of it is in forms not available for plant nutrition. It is peculiar in its chemical reaction. The peat soil of the Grasse River bog is strongly acid — a condition apparently always present in bogs. The temperature has been shown to run lower than in mineral soils. (6.) Finally, by reason of the peculiarities of sphagnum cells or of the conditions under which sphagnum peat is formed there appear always to be present chemical compounds or a condition of chemical elements actively toxic to plants growing in this substratum. (15.)* The total result of these conditions is seen in the elimination of species from the habitat and in certain peculiarities of structure and growth of those tolerant of it. Xerophytism and dwarfing are well known phenomena in bog plants. It should be noted, however, that these conditions are not equally extreme in all phases of the sphagnum-peat substratum. For example, in the older conifer forest association where the massive roots of trees, the fallen logs, stumps, uprooted trees and forest debris have elevated and loosened up the peat blanket and where there is consequently better drainage and aeration, the peat itself is blacker and more muck-like (decomposition has progressed farther) and many species, including balsam, appear. See list, p. 34. Even in wetter portions of the bog, if there is a fairly marked movement of the water one finds such marsh species as *Calamagrostis canadensis, Iris versicolor and Alnus incana* occupying the sphagnum-peat soils.

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* See also Rigg (13) Summary of Bog Theories.

While edaphically considered sphagnum represents pretty uniformly the conditions just described, there are, in fact, several species of this important genus which play a more or less distinct role in the course of vegetation development of this bog. Thus where open water stands between the mounds or where after fall rains the bog is partially flooded, the finely divided algalike growth of *Sphagnum cuspidatum* is abundant. Its occurrence and abundance consequently fluctuate with the season. It may be supposed that this and other species capable of growing wholly submerged would figure in the early stage of establishing a vegetation cover upon the original constantly or seasonally submerged sand plain. The tall, vigorously growing sphagnum which makes the deep carpet of the open sedge zone is mostly *Sphagnum recurvum* and this species is the active one in forming the rapid upgrowth among heath shrubs. Fig. 12. The soft, deep carpet under shade of high shrubs and in the conifer bog forest is *S. magellanicum* and this species appears to persist often as the main ground cover in the oldest association where balsam, red maple and numerous forest floor species of balsam swamp associations occur. But in the transition from conifer bog forest to balsam swamp type where numerous forest floor species (see previous list, p. 34) have entered the association, *Sphagnum girgensohnii* was found to be the main ground cover. This was found to be the case also in balsam flats outside the bog area.* In the shrub zone where the sphagnum blanket is very thick and spongy and where mounds are built up so that drying out is a periodical phenomenon, the two so-called mound formers, *S. capillaceum* var. *tenellum* and *S. fuscum* make a very close, compact mat. In my observation, however, the mounds themselves are frequently formed by the taller growing species — especially *S. recurvum* and the two previously named species then become established upon these mounds. (11, p. 422.)

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* *Sphagnum girgensohnii* has been observed by the writer to be the first of its genus to invade a marsh meadow (*Calamagrostis canadenssis* and its marsh associates) which has for two years been flooded by back water caused by beaver dams across Sucker Brook (Cranberry Lake). In this case the suggestion arises that this species is a pioneer in the transformation of a marsh into a bog.

COMPETITION BETWEEN SPHAGNUM AND VASCULAR BOG SPECIES

With regard to the interaction between vascular plants and sphagnum, it should be noted that the taller growth and shading effects of the former — notably of shrubs and young black spruce — tend to suppress the sphagnum. In this connection it has been mentioned that *S. recurvum* makes a tall climbing growth about the stems of the vascular plants thus starting the mound formation. A study of the bog in late autumn (November 1) after leaf fall, showed that all the species of sphagnum had made rapid growth during the cooler months of September and October and that thus they had materially increased the thickness of the living sphagnum cover while free from the shading effects of competing shrubs and sedges. Thus by reason of their continued growth, during the dormant stage of their competitors, they were able to make gains which would be compensated for by the rapid development of new shoots and leafage of the vascular plants in the following spring. In the case of black spruce, however, where the opaque foliage is permanent, no such compensating growth of sphagnum occurs and thus it becomes suppressed beneath these dense widely spreading young trees. The rise of the sphagnum blanket about them is very notable so that the spruces seem to stand in depressions in the general bog surface. Fig. 17.

VEGETATIVE PROPAGATION IN THE BOG

The ability to multiply and occupy ground by rapid vegetative propagation is pretty nearly a universal characteristic among plants in the Adirondack bogs. The sphagnums are, of course, notable for the vigor and rapidity of their vegetative propagation. The whole scheme of bog evolution rests upon this fact. The living surface carpet of sphagnum is made up of shoots from old plants gradually dying below where for a season the old stems retain their more or less erect position, becoming flattened and compressed by the weight of the surface growth and especially by the winter load of snow and ice.

Below this zone the dead sphagnum becomes more and more disintegrated, retaining, however, for a time its lighter color and spongy texture. Beneath this is the newer layer of brown fibrous peat which at greater depth becomes more or less decomposed, taking on a blacker mucklike character in situations where periodic lowering of the water table permits better aeration during part of the growing season. Over the greater part of the area here considered, tall growing sphagnums, such as *S. recurvum* and *S. magellanicum*, form the living carpet, so that this living layer may be as much as five or six inches thick. The layer of dead but not disintegrated sphagnum is often of equal thickness. These two layers, together with the upper stratum of newly forming peat, constitute the medium in which the actively absorbing roots of vascular plants develop. In no case, even in parts of the marsh where the peat bed is very shallow, e. g., parts of the sedge meadow, have the roots of bog species been observed to penetrate the underlying sand. As previously mentioned, this substratum of living and dead sphagnum offers a medium in which vigorous development of both root and shoot organs is stimulated. In the sedge meadow, *Carex oligosperma* by vegetative propagation forms an almost exclusive community, binding the substratum into a close, compact sod. Fig. 6. Without exception the bog shrubs spread rapidly by vegetative means. This may occur as for example in *Vaccinum augustifolium* by normally subterranean rhizomes, but also as in Cassandra and black spruce as a result of vigorous root development from normally erect or leafy shoots, where the stem back of the newly formed roots ceases to grow and, becoming atrophied or dead, leaves the newly rooted branch as an independent plant. As a matter of fact, these old stems, though probably functionless, persist for an indefinite period, so that the result of vegetative propagation is to create expanding colonies of each species and thus brings about the spot wise occurrence of these associates in the bog shrub zone.

Thus it will be noted that the conditions created by sphagnum as a growth substratum result in phenomena of vegetative propagation as noteworthy as in the case of submerged vegetation of shallow lakes and ponds.

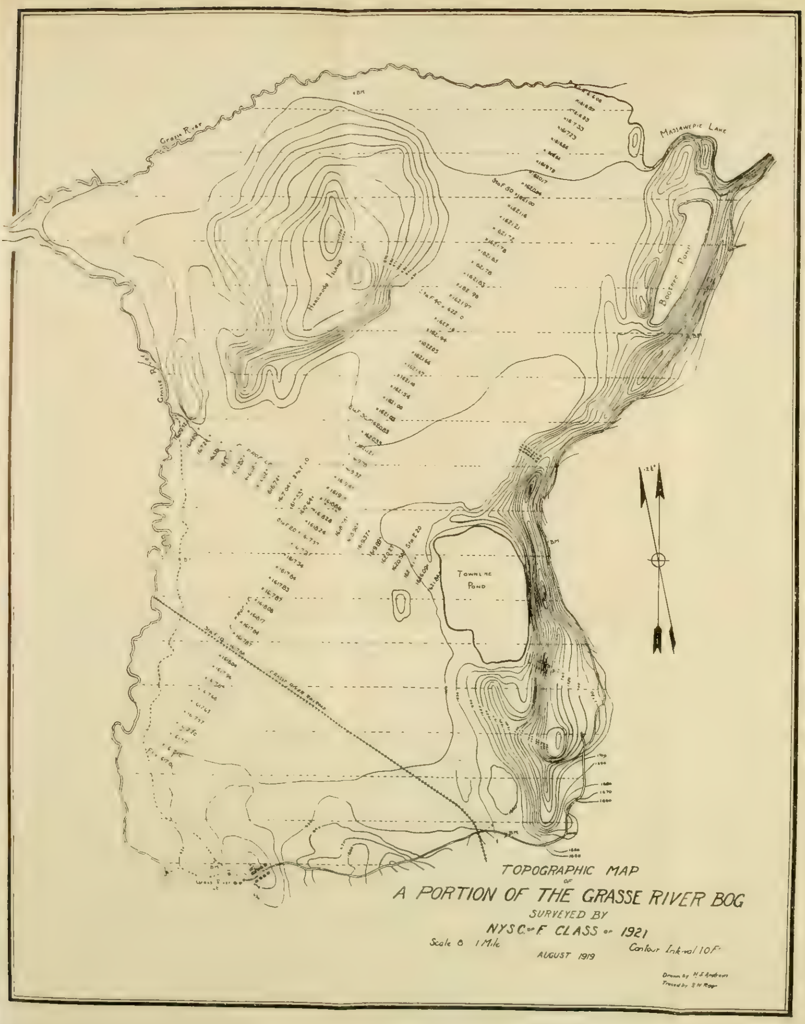
It has not been observed that this prevalence of vegetative propagation is attended by a marked lessening of seed production except perhaps in the case of *Vaccinium augustifolium.* Observations covering three seasons seem to indicate that this species fruits very sparingly in the marsh, while in at least two of these seasons, it has yielded full crops of blue berries where it occurs on drained sandy soils. In general, however, seed production seems abundant in this bog, but insufficient data are at hand as to viability and the extent of reproduction by this means.

COMPARISON OF THE GRASSE RIVER SAND PLAIN WITH OTHER SAND PLAINS OF NEW YORK

It will be recalled that the special interest of the present study of bog vegetation lies in the physiographic character of the region. It is clearly one of the so-called sand plains of which other examples are found in the case of "the plains" of the upper Oswegatchie and on a much larger scale in those of the Hudson and Mohawk drainage near Schenectady and Albany, of the Saranac at Plattsburg and of the Black River below Carthage at Pine Plains. In the case of the Grasse River Marsh, as it is called, the plain lies so low that distinctly hydrophytic vegetation results, becoming a normal bog sequence in the lower undrained portion and showing a secondary sequence of marsh or semi-marsh grasses and sedges and of willows and alders following the destruction of a swamp or semi-swamp (probably a balsam swamp) forest on the slightly elevated and non-peat forming section. On the other hand, the vegetation of the higher lying sand plains mentioned is distinctly xerophytic. In the case of the Hudson-Mohawk, the Saranac and the Black River sand plains, the present vegetation is prevailingly pine heath, a phase of secondary succession following the destruction of an (apparently) edaphic climax formation of white pine. Pitch pine is the dominant species in these cases though heath shrub associations are still strongly represented, notably by *Comptonia peregrina*, *Vaccinium vacillans*, *Gaylussacia resinosa* and *Arctostaphylos uva-ursa*

Fig. 22. By yearly mowing and trampling the beaver meadow (Calamagrostis association) is perpetuated, yielding a heavy and valuable hay crop.

Fig. 23. Pine heath vegetation on the well drained sand plain at Plattsburg, N. Y. Pitch pine is becoming dominant over the heath shrub and sweet fern association. The previous virgin forest on this site was doubtless white pine.


TOPOGRAPHIC MAP
OF
A PORTION OF THE GRASSE RIVER BOG
SURVEYED BY
N.Y.S.C. of F. CLASS of 1921
Scale 0 1 Mile
AUGUST 1919
Grasse River
Townline Pond
Hardwood Island


Grasse River
Townline Pond
Balsam Pond
Pasture
Pasture
BM
No TYPE
1 Pure meadow of Sage and Sphagnum
2 Sedge meadow with scattered Heath shrub Leather-leaf etc, or scattered clumps of shrub
3 Mixed meadow and shrub (Shrub ⅓ to ⅔ of Stand)
4 Pure shrub, practically all Leatherleaf Ledum Blueberry, dead Sphagnum, Mound or Tussock
5 Pure shrub, with taller species like Viburnum cassinoides and scattered conifers
6 Balsam strips: apparently on very low sand ridges
7 Black Spruce, Tamarack, and Balsam, young conifer forest now largely covering north end of east section and in more advanced stage on strictly bog part of western section
8 Beaver meadow of riverbottom
9 Alders of river bottom
10 Alder, Willow stand on cut-over area adjacent to Grass River Flow and Silver Brook.
11 Aspen, Pine, Balsam etc of low sand ridge parallel to river.
12 Hardwood type, mixed stand, mostly mature
13 Mixed conifer type, mature
TYPE MAP of
A PORTION OF THE GRASSE RIVER BOG
SURVEYED BY
N.Y.S.C. of F CLASS of 1921
Scale 8" = 1 Mile
See "Instructions" for Type Numbers
AUGUST 1919

at Plattsburg and these species (excepting bear berry) with two shrub oaks, *Quercus ilicifolia* and *Q. prinoides*, in the Albany pine heaths. The sand plain of the Oswegatchie is rather unique in this that while it presents certain species characteristic of bogs or swamps (*Oryzopsis asperifolia*, *Solidago uliginosa*) it supports in reality a dry-heath like vegetation of more pronounced character than any of the others. This is shown notably by the extent of the ground cover of lichens (*Cladonia rangiferina, alpestris* and *pyxidata*), *Polytrichum* and by *Vaccinium augustifolium, canadense* and *vacillans* (though the first two of these occur in sphagnum bogs). The fact was pointed out in bulletin 3 (2 page —) that tamarack is the dominant invading forest species. All this points to the interesting fact that while this sand plain lies high enough above the water table to become very dry at the surface, it is in fact so low and flat as to shelter wet lands species, and while sphagnum does not occur and there is no peat formation, a very slight rise of the permanent water table would result in bog formation quite as marked as in the Grasse River area. It should be mentioned here that in the Grasse River bog, Polytrichum (apparently the same species as in the Oswegatchie sand plain) is prominent in the drier mounds of sphagnum sedge meadow and that this moss and the lichens *Cladonia rangiferina* and *pyxidata* appear on the very slight elevations of the bog where sphagnums are excluded. While Cassandra does not occur on the Oswegatchie sand plain it often occurs in great abundance on non-peat and sphagnum covered sands (e. g., east end of Oneida Lake), so that really the difference between the dry heath and the wet heath is reduced merely to the occurrence of sphagnums in the latter case and its absence in the former. Floristically the two groups of associations are very similar. The suggestion arises that the edaphic conditions in the low sand plain despite the periodic surface drying are similar to those of sphagnum bogs. This suggestion is strengthened by the frequent occurrence of black spruce on the dry heath and by the aggressive invasion of it by tamarack, which as shown in bulletin 3 (2 fig. 30) is one of the noteworthy features of the plains of the Oswegatchie and has been noted also in other similar dry heaths of the Cranberry Lake region.

SUMMARY

1. The Grasse River Marsh area physiographically considered is one of a series of sand plains occurring in or on the borders of the Adirondacks, formed under certain drainage conditions (presumably glacial) which have ceased to be operative.

2. By reason of its low lying position and of the presence of eskerlike sand ridges which intercept its drainage, the larger part of the area here considered is covered by peat which at present is occupied by a vegetation complex in which sphagnum is the controlling element resulting in typical bog conditions.

3. The bog vegetation presents a series of plant associations which appear clearly to stand in a developmental relation beginning with open sphagnum-sedge meadow and culminating at the present time in the initial stages of a balsam swamp forest.

4. This study supported by evidence from other situations in the Cranberry Lake region appears to warrant the conclusion that while black spruce-tamarack-arborvitae bog forest is a persistent association and may remain in effect an edaphic climax association, it nevertheless tends to create soil conditions which introduce balsam and its swamp forest associates and may in fact go over definitely into balsam swamp forest. The more thorough decomposition of peat into a blacker more muck-like condition indicates better aeration at this stage of transition to balsam swamp. What relation such a bog originating balsam swamp forest may bear to balsam flat and to the Adirondack Climax forest has not been determined.

5. A second feature of the Grasse River Marsh area consists of flat and very slightly elevated or low undulating sands which while they must be classified as wet lands are still well drained enough or lie high enough above the summer water table so that sphagnum is excluded. Hence, true marsh or semi-marsh as contrasted with bog conditions prevail as shown in the present secondary associations of grasses, sedges and

herbaceous species followed by a close willow-alder association which is progressing toward the (presumably) balsam swamp forest which has relatively recently been destroyed by human agency. This situation in its early vegetation stages appears to be intermediate between the wet heath of the low lying undrained sand plain and the dry heath illustrated by the Oswegatchie sand plain.

6. A third feature of the region here dealt with consists of the flood plain of the Grasse River which by reason of its better drainage and its deep alluvial soil exhibits a lively contrast with the bog in its total lack of sphagnum, its early association of *Calamagrostis* and associated species forming a typical beaver meadow (ecologically a typical marsh meadow) and a vigorous invasion (checked in certain places by annual mowing) of alder thicket. It is regarded as not unlikely that this flood plain may in earlier times have been covered by balsam swamp forest and the assumption is made and strengthened by observations elsewhere in the vicinity that the normal course of vegetation here would be toward this type of forest as its edaphic climax.

7. The living sphagnum cover of the bog (ecologically the sphagnetum) is composed of a number of species of sphagnum differing in habits of growth and in light and moisture requirements. Thus certain species are predominant in different stages of the vegetation sequence, e. g., in the open sedge meadow and forming the climbing growth among shrubs, in the shade of old conifer bog forest, and on the drier tops of mounds in the uneven surface of the heath shrub associations.

8. The actively functional roots of vascular bog plants are distributed in the superficial zone of newly formed peat, the dead but not disintegrated sphagnum and the living sphagnum cover. Apparently they do not penetrate the underlying sand in the case of any species.

9. Vegetative propagation is almost universal among bog plants. Vegetative propagation by sphagnum really forms the basis and controls the method of bog evolution. The substratum created by it stimulates active production of roots and

normally rhizomatous stems, and by the upward growth of sphagnum among foliage bearing stems, thus investing them in a constantly wet but porous blanket, stimulates active root development along these stems and thus each branch becomes potentially a new plant. This leads to the development of expanding shrub colonies, especially of heath species, promotes the succession of heath shrub upon sedge meadow and accounts for the spotwise occurrence of these shrub colonies. This layering method of reproduction in black spruce seems at least in part to account for the dominance of this species in many Adirondack bogs.

10. The interactions of growth between sphagnum and the vascular bog plants, although in the nature of communal adjustment, is in reality a competition for advantage of position and exposure. It appears that the vigorous upward growth of sphagnum takes place especially in September and October at low temperature after the shading effect of vascular plants has been reduced by leaf fall. The compensating growth of vascular plants occurring of course during the following growth season. The special aspect of vegetative propagation from stems imbedded by the upward growth of sphagnum (layering) is associated with this phenomenon.

11. A comparison of different sand plains associated with the Adirondack region indicates a very close correlation between the vegetation sequences and the drainage conditions. Certain edaphic conditions due to sand deposits of this nature are common to all as shown by the occurrence of certain identical or ecologically similar species in each, but the height of the water table in connection with a small degree of unevenness of surface due to wind and water erosion determines a series of different association complexes from typical bog in the low lying undrained plain, to semi-marsh meadow and willow-alder associations devoid of sphagnum, to low lying but dry heath with *Polytrichum* and *Cladonia rangiferina* apparently replacing sphagnum in the pioneer stage, finally to pine heath, in the sense defined by Harshberger. (9)

12. This and similar studies have a value in respect to the elaboration of a forest policy in that they show not merely the general tendency of our vegetation development to culminate in forest but especially how closely this development is associated with conditions of soil, drainage, etc., i. e. with edaphic as contrasted with climatic conditions. Any forest policy based on natural regeneration of the forest must have in mind the limitations which edaphic conditions impose upon the rapidity and end result of such natural reforestation.

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Stallard, Harvey and Bergman, H. F. See (1).

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TECHNICAL PUBLICATION NO. 14
OF

The New York State College of Forestry
AT
SYRACUSE UNIVERSITY
FRANKLIN MOON, Dean

IN COOPERATION WITH THE
FOREST SERVICE
U. S. Department of Agriculture
W. B. GREELEY, Forester

WOOD-USING INDUSTRIES OF NEW YORK

BY
R. V. REYNOLDS
Forest Service
AND
RAYMOND J. HOYLE
College of Forestry

Published Quarterly by the University, Syracuse, N. Y.
Entered at the Postoffice at Syracuse as second-class matter

HOW TO FIND A MARKET FOR FOREST PRODUCTS

The information assembled in this bulletin can be put to practical use by those who have forest products for sale and desire to find an advantageous market.

Let us suppose, for instance, that you have a quantity of ash for sale and desire to correspond with manufacturers who use ash and are likely to pay good prices. First, turn to the list in the back of the bulletin, entitled "Kinds of Wood Used by the Industries," in which, under the heading "Ash," a large number of articles made from ash are listed. You note that ash is used largely for motor vehicles, handles, vehicle parts, and toys.

Consulting the index you note that the tables numbered 13, 18, 23 and 26 deal with the manufacture of these article and show that the average prices paid for material were $140.77, $49.67, $114.48 and $51 respectively. The makers of motor vehicles and vehicle parts paid more for the high grade of ash consumed than makers of handles and toys, whose uses are much less exacting, and who can utilize smaller dimensions. If the stock is strictly high grade, you may then determine to address the manufacturers of motor vehicles. Accordingly, you turn to the "Directory of Manufacturers," which is the last section in the volume, and find under the heading "Motor Vehicles" the various manufacturers listed alphabetically by towns and counties. If correspondence with those who are in the vicinity does not find a market for the ash, other firms farther away may be addressed or the wood offered to other industries.

If, for any reason, an owner of forest products is unsuccessful in finding a market with the help of this directory, he is invited to correspond with the New York State College of Forestry at Syracuse. The College maintains an exchange between producers and consumers and will gladly try to assist in finding a market for forest products.

Producers should recollect that the prices in this bulletin are for 1919, and while they are of some help for making comparisons in that year, the present prices are much less. It should also be recollected that high prices are only obtained for well manufactured and properly graded stock. Usually, also, purchasers prefer to buy larger rather than smaller lots of stock, other things being equal.

Wood-using plants which have large amounts of waste may find a profitable market for this material in factories which use small pieces for toys, small handles, backs of brushes and mirrors, novelties, furniture parts, souvenirs, small box material, chair stock, and vehicle parts. Conversely, plants which can use small-sized stock may be able to make advantageous purchases of waste from plants which work upon larger stock of the same kinds of wood.

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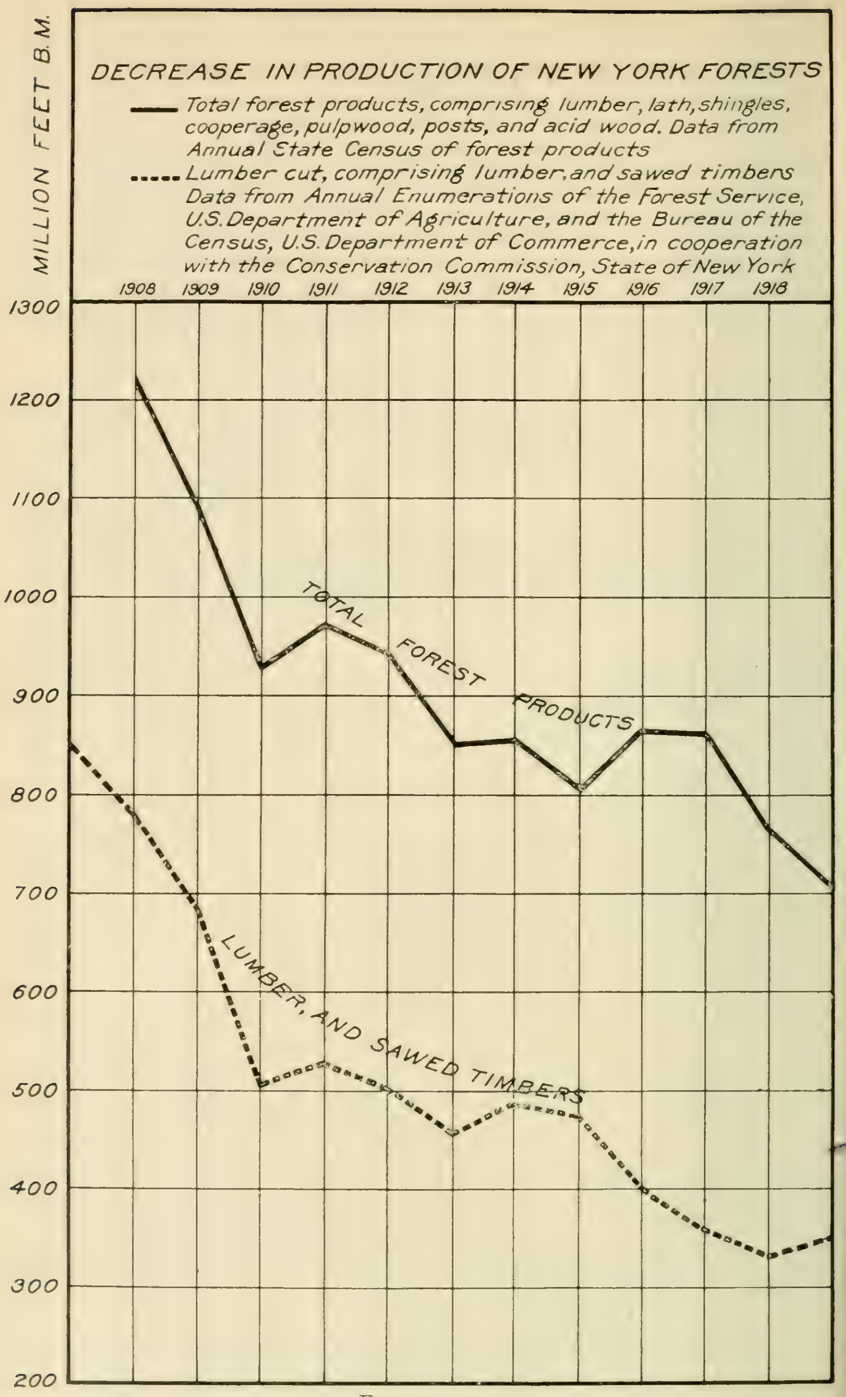
LIST OF ILLUSTRATIONS



FRONTISPIECE

The ominously steep downward slant of these curves threatens New York with the loss of her commanding position in the secondary wood-using industries. Only vigorous and prompt action can provide the billion odd feet of lumber per year which the industries need and which the State is capable of producing. See page 26.

EXPLANATION AND ACKNOWLEDGMENT

The study upon which this report is based was undertaken by The New York State College of Forestry at Syracuse University in cooperation with the Forest Service, U. S. Department of Agriculture. It covers the period of one year ending December 31, 1919, and is in part a revision of the bulletin bearing the same title, published in 1913, covering the calendar year 1912.

As a preliminary step it was necessary to secure the names and addresses of all wood-using operators in the State. The firms listed in the report for 1912 contained the bulk of these addresses. Field agents visited the larger cities in the effort to locate firms established subsequently to the report of 1912, and eliminate those which had gone out of business. In a large number of cities and villages the postmasters corrected the mailing lists. To these wood-using manufacturers a questionnaire was sent asking the information necessary for the purpose of the report. Firms which did not reply were addressed a second time, and after a suitable interval field agents visited these industries which had made no report of their operations. Although a great deal of effort was directed to the preparation of a list which would include all woodworkers, it is known that there are some firms which are not upon the lists, either because of their period of existence, failure to cooperate, changes of name or address, removals, sales, or other reasons which could not be overcome within the time available.

The work was done under the superintendence of Edward F. McCarthy, New York State College of Forestry, and Harold S. Betts, of the Forest Service. Professor McCarthy, as a collaborator, carried the work to a point where all the data had been collected; he also assisted personally on the field work. John T. Harris, of the Forest Service, and Professor Alfred Akerman, of the College of Forestry, also took part in the preliminary planning and correction of the mailing lists.

Information on forest conditions, lumbering, manufacturing, and utilization was secured in all parts of the State by Raymond J. Hoyle, of the New York State College of Forestry, and R. V. Reynolds, of the Forest Service, and these men jointly prepared the text. Credit is due to Albert H. Pierson and Wilbur Mattoon of the Forest Service, who contributed assistance respectively in the completion of the tabulations and the discussion of farm woodlands.

In view of the fact that this is a revision and not a new project, the text of the previous edition has been adopted liberally, wherever it was found applicable.

Similar reports were at one time prepared for all of the important lumber-consuming States, in cooperation with the Forest Service. New York is, however, the first cooperating State to revise her report of the wood-using industries.

PART I

CONDITIONS AFFECTING LUMBER SUPPLY OF NEW YORK

Abnormal Business Conditions in 1919

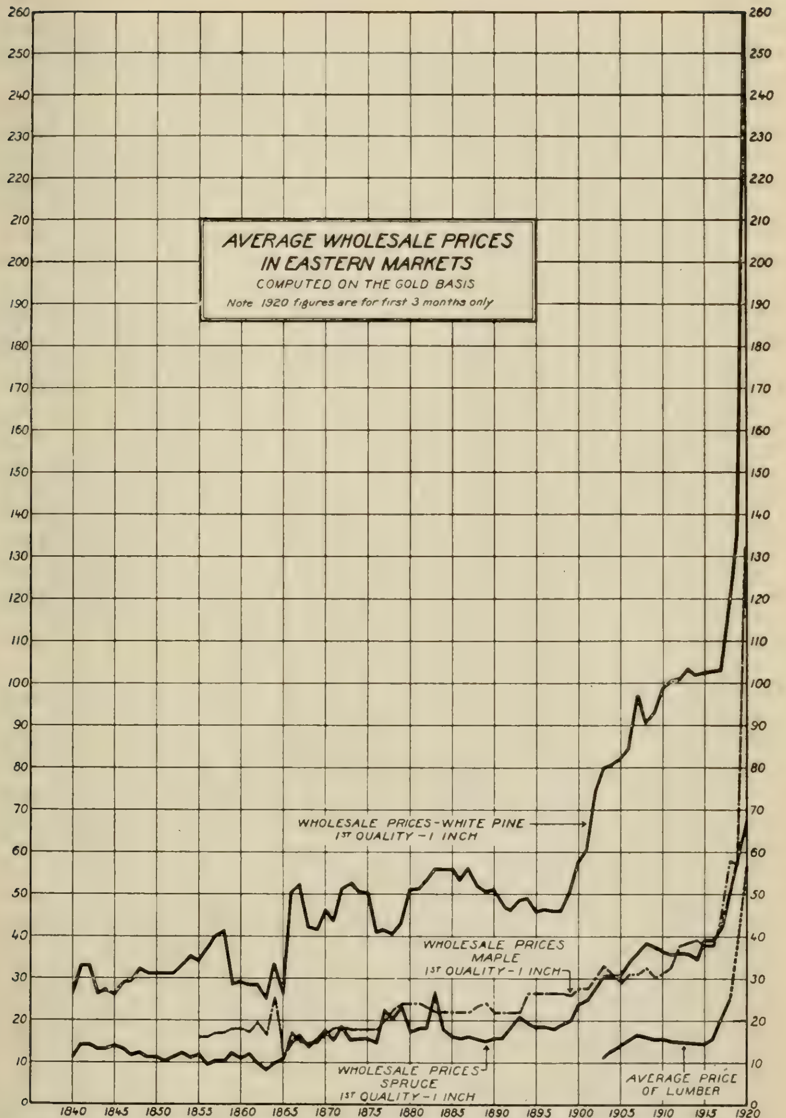
This revision was undertaken during the latter part of 1919, at a time when business in general was endeavoring to adjust itself to changed conditions following the world war. The absence of four million men in the army caused a serious disruption of their connection with the industries. The transfer of countless others to war industries further disturbed the balance of the economic machinery of the country. Once broken loose from quiet pursuits the roving habit began. Large numbers of workmen, after discharge from military service, never returned permanently to the country districts and villages where they were enlisted, and others drifted to the cities. Labor troubles were acute and strikes were of frequent occurrence, sometimes accompanied by violence, sabotage, and other forms of direct action. The shortage of labor affected not only the wood-working factories but also the sawmills, the logging camps, and the railway systems. Embargoes intended to regulate the transportation of commodities became increasingly frequent and throttled the normal transmission between the mills and the lumber yards. At the same time wages in all branches of labor had been approximately doubled to meet the increasing cost of the necessities of life. Behind and beneath these surface disturbances lay the fact, often flouted but inexorable, that the depletion of the timber supply in the United States has arrived at the acute stage.

The result of these conditions was an unprecedented rise in the cost of lumber of all kinds, which became notable during the summer of 1919, and continued steadily until it reached its peak in March, 1920. This rise was so pronounced that the average mill price of lumber was tripled within nine months. The cost of building material became prohibitive and this, in conjunction with the advancing rates demanded for loans and the labor and transportation difficulties, practically resulted in the shutting down of the building trades in the face of a demand for housing facilities for approximately four million people. This abnormal demand was attributed in part to the drift of workers from the country to the cities, attracted by high wages and a generally higher standard of living. As a matter of fact the country regions were also experiencing a lack of houses. The suspension of building had resulted in a general shortage of homes for the normally increasing population. Rents of both homes and factory space were exceedingly high.

The cities thus contained not only the surplus laborers and craftsmen, but also the larger lumber markets which had the best chances of obtaining supplies of material from the mills. Also there were better facilities within the cities to obtain power derived either from hydroelectric sources or the use of coal as fuel, while remote country towns were less favored, owing to the partial failure of railroad transportation.

As might be expected under these conditions the returns resulting from this study show the total number of firms engaged in the wood-using industries of New York decreased by 35 per cent, the number of firms in the cities of the first class decreased 25 per cent, while those in the small towns and villages decreased 40 per cent. Although there are only a few cases actually noted in which country firms actually moved to the city, yet it appears that the city firms had a stronger business foothold against adverse conditions. The reduction of the number of firms was no doubt caused in part by the tendency noted for many years toward the consolidation of business in fewer hands with larger capitalization.

During the depression in the year following the war many firms suspended operation, although rather less than the normal number went into bankruptcy.



The rocketing price of white pine and other essential woods in 1920 is a landmark in the forest economics of America. On account of the shortage of houses it resulted in misery for millions of Americans. An ample and well distributed supply of lumber was needed as never before. Should we restore the forests or idly await another catastrophe?

In the consideration of the reports, and in the conclusions drawn from them, it has been the endeavor of the authors to give due weight to these abnormal conditions.

The rapidly advancing depletion of the forests of New York is obvious in most of the industries. A serious situation is in view even after making allowances for the abnormal conditions in the business world.

The Depleted Forest Wealth of New York

For variety of valuable tree species and the quality of its forest products, combined with long-sustained yield in large quantities, few other States have rivaled New York. Eighty years ago New York led all States in the production of lumber, and the supply was then supposed to be inexhaustible. In 1850, New York ranked first in lumber cut and furnished 20 per cent of the national supply. Today New York has dropped to the twenty-fifth place among the lumber-producing States, and the annual cut is only one per cent of the entire production in the United States. The remaining stand is estimated roughly at 26 billion board feet, of a quality decidedly inferior to that of earlier days.

The State Forester reports that in 1908 the total forest products of the State were 1,226,754,000 feet B. M. In 1918 this yield had shrunk to 762,290,000 feet B. M., a reduction of 37 per cent. Between 1907 and 1919 the lumber cut decreased from 848,894,000 feet to 363,000,000 feet. Thus, in 12 years, the New York lumber cut decreased by 59 per cent of its former volume. (See Frontispiece.)

Comparing the figures resulting from this study with those obtained from the same project in 1912, it is noted that in the short space of seven years the amount of lumber supplied by the State to its wood-working industries has diminished from 548,000,000 feet to 189,000,000 feet, a reduction of 65 per cent.

The fact that in 1919 the amount of lumber imported from other States and foreign countries was 115 million feet less than in 1912 is, in part at least, evidence of the increasing difficulty of obtaining supplies in times of stress from sources over which New York has no control. It is one phase of the threatening conditions which confront the wood-working industries. The fact that a State, once foremost in timber production, should be brought to such a plight, at a time when public desire for the products was never more urgent, reveals the extent to which the depletion of important native species, such as white pine and oak, has proceeded. It is in times of stress that fundamental weaknesses become evident, and the weakest spot in the organism is the one which will probably show the most acute symptoms of distress.

Possibilities for Closer Utilization

In the period of ample wood supply the chief aim of the superintendent of a wood-working plant was to increase his production, without much calculation of the percentage of waste involved. Where not lavishly wasteful his methods may properly be termed economical, for the overhead, the additional attention, and the labor involved in preventing wastage would often have cost more than the material. Shop customs have a tendency to become habits, passed on from one generation of workers to another, and the American shop worker has not always adjusted his methods to the rising cost of material. The frontiersmen who built bonfires of black walnut, oak, and cherry logs were acclaimed as homebuilders at one period in our history, but at this date such destruction of valuable material would be unthinkable.

For ten or fifteen years the doctrine of waste utilization has been given increasingly careful scrutiny in most shops. Yet the present proportion of waste lumber is ordinarily reported as 10 per cent, and in some cases up to 33 per cent. The turning of curved forms may result in 50 or 60 per cent of loss in shavings. It is obvious that there is a very profitable field for the introduction of closer calculations, better methods, and improved machinery.

It must be recognized that in the production of any given article there is probably an irreducible minimum of waste, and that attempts to save by methods involving a considerable increase in labor will be those most liable to defeat themselves. All forms of wood waste, even sawdust, are capable of being turned into some form of useful product, yet the use of such material for fuel when it is already convenient to the power plant may be real economy compared with the purchase of coal or electric power at high prices. In other words, an attempt at too close utilization might easily result in still greater loss. This is one side of the case.

On the other hand, it is doubtful whether woodworkers in general scrutinize their methods and machinery with the same care that is given to the prevention of waste in up-to-date establishments in other lines, such as metal-working shops.

Wood is so bulky compared with metal that it gives an impression of relative cheapness not always accurately gauged. Also, wood is easily and rapidly worked and the retention of old-style or worn machinery may appear justified where labor costs are not running so high as to attract attention, although the waste due to inefficient machinery may be in reality excessive. Metals, of course, can be cast and forged in a practically wasteless manner, while wood cannot; yet, in spite of this advantage, the metal-working industries utilize improved machinery and methods and especially the services of production engineers to a much greater extent than woodworkers. Every resource of mechanics and chemistry is given practical trial, and the engineers through their associations diffuse the improved ideas throughout the entire industry. As another example, the meat-packers have for years boasted that they utilize everything but the squeal of the hog. It is probably more than a coincidence that the business success of the great packers and the perfection of their utilization go hand in hand.

The plans and methods of working expensive wood should in reason seek improvement over those which were justified when wood was plentiful and cheap. This applies strongly to the sawmill first of all, for what is done badly there must result in excessive waste thereafter. Careless slabbing, edging, and trimming may be very wasteful. In purchasing, the species of wood and the grades best suited for the purpose are matters which, if poorly decided, may make all the difference between success and failure. As depletion of the forests advances, changes in specifications must be made to conform with market conditions and still retain needful qualities in the lumber. With poor handling and piling much injury or deterioration may take place.

The purchases should be of thickness which best suit the process, or permit resawing the exact sizes, perhaps without replaning. Better sawing, better planing, the restriction of planing and turning operations to the minimum, the use of built-up stock, all offer avenues for saving which in large establishments may amount to many thousands of dollars a year. Finally comes careful discrimination as to the most advantageous and useful disposal of the waste itself. These highly technical matters warrant the enlistment of the best grade of technical overhead. Other things being equal, the margins of profit to be made through improved utilization will in years to come be a deciding factor in the success or failure of many shops. Following the peak in 1920 the price of lumber has already fallen to a reassuring extent, but the logic of past events indicates that never again will the old low levels be known in America. In other words, the time has come when the practice of scientific economy is not only possible but is an essential to continued business prosperity. Better utilization has become necessary not only in the shops but throughout the range of industries which use wood in any form.

In the building trade, in 1919, where poor supervision existed, conscienceless carpenters were known purposely to cut boards and dimension stuff to create shorts, which they were allowed to take home for fuel. Such practices and the attitude toward the job which they engender are sufficient to account for a high percentage of waste.

The Assistant Director of the Forest Products Laboratory recently asserted that it would be possible to save ten billion feet of timber annually, if the American people would put in general practice what is already known relative to the closer utilization and preservation of wood. Of this quantity five billion feet could be saved in the mills and shops and the other five billion by extending standard preservative treatment to many of those forms of timber exposed to the weather, such as ties, poles, posts, piles, mine props, shingles, and exposed construction. Ten billion feet is more than one-fourth of the annual lumber cut. As a conservative estimate it would be worth a quarter of a billion dollars. This would not be net gain because of the planning, labor, and preservatives necessary to accomplish the saving. Yet it would be the most practical means of prolonging the service of our rapidly vanishing virgin timber, and bridging the interval of shortage which is now inevitable before American forests can begin, under management, to yield an annual supply approaching satisfaction of the national needs.

Forest Management Required.

The wastage of New York's forest resources, deplorable as it may now appear, was probably no worse than many other Commonwealths have suffered. It was unavoidable because, in the presence of an apparently endless supply, public opinion was not moved to call a halt and could not be educated rapidly enough to check destruction until most of the damage had been done.

Many other communities, not excluding parts of France and Germany which are now well forested, went through similar slow stages of change in their economic viewpoint, and only determined to save and grow timber when they had been forced to do so by the sharp pinch of necessity. But there is an important difference between their situation and ours. They had the abundant natural forests of North America to draw upon, while we no longer have that advantage.

The original forests of New York have been mainly cut over twice or more. The store of forest products our fathers called inexhaustible has shrunk to a rapidly dwindling supply, as shown by the diagram used as a frontispiece.

The unprecedented rise in lumber prices, which reached its peak in March, 1920, has drawn the attention of thinking men to the widespread forest depletion as no amount of assertions and discussions could do. The acute shortage of supply and the widespread discomfort and suffering arising from it will eventually have most beneficial effects, if they result in a wiser management of natural resources hereafter.

It seems obvious that the rising prices of forest products will permit and even compel much closer utilization of wood and more general protection of wooden structures. But economy alone is far from sufficient to supply the needs of the present and the future. There must be vastly greater production. Nature must be aided in every possible way to increase the production of existing forest areas, and there must also be the development of new producing forests on a scale never before attempted by a State.

New York needs a lumber cut two or three times as great as at present, and has forest lands capable of producing it. Without prompt and vigorous action looking to that end the pre-eminence of New York wood-working industries is as uncertain as that of her wood-pulp industry. So long as wood was cheap there was no possibility that business men would turn from the old ways, but the experience which the American people are now going through may be just the stimulus needed to bring about the active practice of forestry on both public and private holdings.

Fortunately, New York State has its future largely within its own hands. The heavy precipitation of her mountainous regions insures dense forests in the future, the composition of which will be determined in part by her foresters, though past lumbering has already resulted in a strong set toward the reproduction of hardwoods rather than white pine and spruce.

Although the productive capacity of the forest soils has in many instances been reduced by fire and erosion, yet the soils themselves are not extensively removed, as in some deforested lands, and this is an incalculable asset. It has been the custom to speak of standing forests as principal, and the yearly growth as interest. This is a true comparison if the soil is reckoned as a part of the forest. The loss of the timber has not bankrupted New York, for the soil is still there to produce endless dividends of forest wealth. Thus, only the less valuable part of the principal is gone. A tree may grow in a century, but the restoration of soil may require many centuries.

The State is rich in lands suitable for timber production. Out of the total of 29,600,000 acres of available* land surface, 21,700,000 acres constitute the farms. The remaining 7,900,000 acres are forest regions. But within the farms are 4,100,000 acres of woodlots and 2,800,000 additional acres of unimproved lands which probably will find their highest use in growing timber. Hence upwards of 14,000,000 acres, or nearly half the land of the State, is suitable for forest and should eventually be devoted to that purpose. *At present 62 per cent of it contains material which is suitable neither for lumber nor pulp, and furnishes only fuel or acidwood.*

Fourteen million acres of forest, each acre growing 150 board feet per year, would supply about 2 billion feet annually, an amount considerably in excess of the total consumption of the secondary industries as reported in 1912. Such a general and sustained average yield is, of course, a result which the most optimistic would not expect for many decades, as it would represent what might be called at this time ideal conditions of management. Moreover, the areas suitable for forest are not available in their entirety as sources of timber supply, and parts of them should never be made so.

Parts of the Adirondacks, the Catskills, and other forest regions possess such natural attractions that their value for recreational purposes outweighs even the present need for timber. They should be permanent recreation grounds for the people. In addition, such lands as the steep mountain slopes

*About 900,000 acres are reported to be occupied by cities, villages, and roads.

at the headwaters of the Hudson and other rivers should remain covered with permanent protection forests, which may be cut lightly or perhaps not at all.

Years ago the State set aside the Adirondack Preserve and the Catskill Mountain Preserve with these purposes in view. Article 7, section 7 of the State Constitution provides that they shall be forever kept wild forest lands, much like the National Parks of the West. These preserves now contain 1,936,492 acres, or about 15 per cent of the lands suitable for forest. Additional purchases are being made as fast as conditions permit. In the preserves the State has a magnificent forest property. At present no timber may be cut from them either for commercial purposes or improvement, but they are under patrol to protect them from fire and theft, and valuable species are being planted. In 1919 about 5,000 acres were thus reforested. New York may well be thankful that so much has been and is being accomplished. Just what areas in the future will be reserved wholly for recreation or protection, without use of the timber, cannot be determined at the present time. Undoubtedly the State forests will in the long run be largely extended, and will play an important part in the future timber supply, especially of high grade materials.

Large tracts are also owned by lumber companies, which for the most part have not seen fit to handle their lands with a view to another forest crop. There are also a few large privately owned tracts held mainly for recreational purposes, which have received protection by patrol.

Forest management means cutting, as well as planting and protection from fire. The old crop must be harvested to make way for the growth of new timber. It is probable that not more than a small fraction of the forest soil of the State is producing the quantity, species, and quality of wood which would be possible if human intelligence were everywhere directing the latent productive forces of the soil. The best timber, like the best corn, can not be produced without planning, watchfulness, and labor. Moreover, the depletion of the remaining timber is now so far advanced and the productive capacity of the soil

DENSE WOODLAND

The annual growth of wood on a given timbered acre is about the same, whether the stand is crowded or moderately open. A fairly dense stand is good at first, to compel the growth of tall straight trunks, but if allowed to continue will result in a crop of cordwood. This woodland is producing chiefly cordwood and perhaps 40 to 80 feet per annum of saw timber. Properly thinned the growth might be 100 to 200 feet of saw timber plus half a cord of firewood, a year.

is so much reduced that there will unquestionably be a long period of scarcity before even the best methods, applied generally and immediately, could secure a sufficient supply from all the available lands.

Next to the establishment and protection of the State Preserves, the most hopeful thing about the situation in New York is that a very large amount of information relative to the necessity of conservation of the forest wealth has been disseminated by the forest agencies of New York State, as well as by the Federal Government. As a result, the public mind is fairly well prepared for the adoption of proper silvicultural methods both on public and private holdings, as well as for legislation of whatever description may be found necessary to make it possible. More and more education of public opinion is imperative, for, until the public knows the need and the remedy and is stirred to the point where there is not only passive acquiescence but an active demand for the new order of affairs, the present inertia will continue to bar progress.

One of the first things needed is a comprehensive study of forest conditions in the State. New York contains a great diversity of lands under widely varied conditions of culture and use. Some farming soils are forested, some forest soils are farmed, and some soils raise no crop of value because no care has been taken to draw dividing lines between agricultural soils and lands which should be permanently forested.

The highest form of use to which each tract of land ought ultimately to be put, whether farming, woodlot, protection forest, scenic area, or lumber production, can only be determined by Statewide examination of the facts on the ground, comprising soils, slopes, timber conditions, and all other facts pertinent to forestry. Both soils and timber should eventually be mapped and described and the permanent classification of each tract approved by suitable authority. With such a record it will be possible to appraise the stock and direct future forest management to the best advantage, besides furnishing advice of fundamental value to farm owners. In this matter

THIN WOODLAND

Moderately wide spacing is desirable to secure the rapid growth of saw timber; but too open spacing results in loss of growth because there are too few trees. The number of trees and hence the productive power of woodlands are reduced by the grazing and trampling of livestock, and by fires which destroy the spongy leaf-litter and humus and disturb soil and moisture conditions. Fire is the deadliest foe of the forest, even though it merely burns along the ground in leaves and grass. This stand is too thin to produce either timber or firewood to advantage. Livestock and fires should be excluded and the young growth given a chance to spring up in the openings.

farmers and foresters have a common interest, because the business of each depends upon using the soil to the best advantage.

Possibilities of Farm Woodlots

The increasing scarcity and value of wood, as has been said, now makes conditions more favorable than they have ever been for the taking of active measures to grow timber.

In their woodlots the farmers have in their possession one of the State's most valuable and least developed natural resources. The demand for wood by the industries is from three to five times as much as is now being grown in the State. New York soils are fertile and second-growth forests under proper care develop rapidly. A great variety of native woods of high grade could be supplied from this source with relative ease, and farmers by devoting a part of their winter time to this work could produce a crop of useful, worth-while trees at the maximum rate of growth. Forests are by nature self-perpetuating and yield an unlimited number of crops under suitable care. The College and the State can furnish information and demonstration of the proper methods. In 1920 the "Free Tree Bill" was passed, which provides for the raising of trees by the Conservation Commission and their free distribution to persons desiring to reforest. This is a commendable step and should stimulate planting. There is already sufficient man-power to handle the lands to advantage. In addition to the better utilization of time, the rising price of lumber would be all in favor of the farmer, and it is recognized that stumpage values are moving steadily upward but seldom downward. With this crop there is never the need of sacrificing the profits of a season's toil, because the timber can ordinarily be held without deterioration until the market prices are sufficiently attractive to warrant cutting. That is one thing which most people do not consider in regard to timber lands. Improved timber lands are increased in value as much as the improvement adds to them, regardless of whether the present owner ever cuts the crop.

IMPROVEMENT CUTTINGS

These mature beeches are not increasing in value, but actually deteriorating by reason of fungous diseases. The longer they stand, the poorer their lumber will be: hence they should be cut and marketed at the first favor- [illegible] young fast-growing timber, such as red oak, ash, hickory, New York farm-forests should be permanently supporting wood-manufacturing industries established throughout the State. The small local factories could be completely supplied by the successive cuttings from numbers of woodlots in the vicinity. The woodlot owner would have his dependable market and the factory owner a dependable supply. In competition with outside sources of timber, the farmer has the telling advantage of a short haul and the saving of long-distance freight charges on a heavy and bulky commodity. This saving again appears in giving the factory owner who has dependable local forests an advantage over others of his kind who would be compelled to purchase lumber in distant markets.

If a growth of 150 board feet per acre yearly is assumed as an average for all the State timber lands, the farm woodlot should easily surpass that average because of the more intensive care which can be bestowed upon it and the chances to utilize the local market for all inferior material removed in making improvement cuttings. For lumber, pulpwood, distillation, or fuel, practically every scrap of material cut could be utilized.

Ash, oak, basswood, hickory, and yellow poplar should be grown in the place of less valuable species. Tall, straight, promising trees of the useful kinds should be given ample growing space by the removal of defective or inferior trees which crowd them.

Planting in certain instances is necessary and can profitably be done, but as a rule the more satisfactory and less expensive methods of improvement are thinnings and improvement cuttings on second-growth stands. The old-growth pine and hemlock, largely removed in New York, has been followed by fast-growing hardwood, tall, clean, and of excellent quality. Nature responds quickly to a little guidance, and judicious cuttings will often double the rate of production of high-grade marketable timber.

In 1919 the State paid out over $60,000,000 for timber brought in from other States. There is every reason to believe with the woodlots of the State under an efficient system of management, one-half of the money now paid out to the South and West for raw material could be kept within the State to enrich local communities. It is certain that the proper handling of the farm woodlots is one obvious step to be taken to bridge the gap between the present deficiency of the timber supply and a production from the State more adequate to its total annual needs. Later, from the force of example and aroused public sentiment, the larger forest areas could be placed under intensive management.

In some counties in days gone by the farmers depended to a considerable extent upon hemlock bark, cut in the winter, for their annual profits. Now much of that industry has gone, but there is a better substitute to take its place. Properly handled, the woodlot will provide the farmer with profitable winter work on his own property, will provide a steadily increasing income for his immediate family needs, and will permanently build up the general prosperity of many a community now disintegrating for the lack of a proper balance of industrial pursuits.

The Need for Action

New York, once the leader in the production of timber, and still the leader in those manufactures using wood as a raw material, is drawing rapidly to the end of her accumulated forest wealth. In support of this statement one need but glance at the production curves shown in the frontispiece, with their ominously steep downward trend. Three or four hundred billion feet — nobody knows how much — of the best virgin timber formed the original forest. We must add to this at least a hundred billion feet of growth during the century in which the mills had their way. Perhaps a half of it all was utilized. The remainder went up mainly in smoke, though age, windfalls, disease, and insects also took their toll. Twenty-six billion feet of sawtimber are still in sight.

The per capita production, which in 1869 was 300 feet per person, in 1918 had shrunk to 30 feet per person.

The lumber cut decreased 59 per cent in the 12 years ending with 1919.

The lumber supplied by the State to its secondary industries decreased 65 per cent in the seven years subsequent to 1912.

Approximately two-thirds of the lumber used in the State is imported.

Because of devastation the forest lands no longer can play their part in supplying the rapidly growing need. Sixty-two per cent of the lands which normally should be producing timber are either denuded or contain only fuel or acid wood. The annual cut, relatively small though it is, is three to five times as great as the amount which the failing powers of the forest areas can produce under present conditions.

The quality and sizes of the material produced are greatly depreciated from the former high standards.

In 1919 New York manufacturers paid approximately $11,000,000 for lumber grown in New York, while the lumber imported cost about $66,000,000.

Sixty-six millions of dollars were sent outside the State for material of which fully two-thirds could be grown to equal or better advantage in New York.

Some of the imported lumber came 3,000 miles by rail. Every mile of hauling added to the cost of finished products.

Every foot of lumber, every cord of pulpwood imported costs more because of this wasteful expenditure of coal and labor in hauling.

Men could no longer afford to build or buy wooden houses, the cheapest form of dwelling.

Newspapers had to restrict operation because of the scarcity of newsprint in a State once famous for its spruce.

Directly or indirectly every commodity of life cost more because of the depleted supply of forest products.

Every citizen paid, and is still paying — and for a long time will continue to pay — an unnecessarily large part of his income for shelter and food and clothing, furniture, fuel, amusements, and transportation — necessaries and luxuries alike — because the depletion of New York's forests has placed her in an economically dependent situation. She can no longer command one of the fundamental necessities of human existence and happiness.

In 1919, 25 out of 48 industries depending upon wood showed a notable decrease in the amount consumed as compared with 1912.

The number of firms decreased by 35 per cent.

The State-grown wood used was 17 per cent of the total consumption, whereas in 1912 it was 45 per cent.

" From him that hath not shall be taken away even that which he hath." Unless vigorous steps are taken in the near future to increase the supplies from her forests, those manufactures depending upon local supplies of wood must either curtail their activities or migrate to regions having a more dependable supply. Others will no doubt continue operations by increasing their imports, paying constantly increasing prices for their raw material as the supply becomes scarcer, more remote, and more expensive to haul. The finished products will cost more in proportion. The importation of supplies from other States is at best an uncertain reliance, for those sources of supply are themselves rapidly diminishing, not excepting much of the softwoods in the Far West, three thousand miles away. We must have hardwoods, too, and there is no hardwood supply on the Pacific Coast, or in Alaska.

Obviously this is a problem which demands immediate action on a large scale, such as only the full resources of the State can provide and manage. The enlargement of the Erie Canal is a comparable project, as regards the effort needed, the complexity of the problems presented, the probable total cost, and the ultimate benefits to be gained.

The barge canal was in a sense a matter of choice, but reforestation is a matter of sheer necessity. The alternative is to forego the commanding position now occupied in manufactures depending upon wood and the forcing into other work or into unemployment of large numbers of skilled workmen.

Finally, as has been said, there is and there will be, until this problem is solved, an appreciable and increasing addition to the mounting cost of every commodity of life, for directly or indirectly each one is affected by the scarcity of forest products.

Therefore every citizen of the State is directly and vitally concerned to inform himself and to see that suitable action is taken by the State authorities. A comprehensive plan for reforestation should be formulated, agreed upon, and put into execution. Forest laws must be revised and new laws enacted. Better treatment of private woodlands, better methods in logging, milling, and preservative treatment of timber must be required, or there is no hope of prolonging the use of the present-day timber to bridge the gap while the seedlings of today are growing into the merchantable timber of the future. Above all there is need of the driving power of a united public opinion, determined that New York shall not suffer for the lack of forests for all her future needs.

The people who have the most at stake are the manufacturers of wooden products in all lines. Their industries are in a position of increasing difficulty. They have organizations which enable them to present their wishes effectively. They are, or they should be, the best informed as to the reality of the need for action. New York has talked of forest replenishment for fifty years. With every additional year of delay the difficulties and the ultimate losses are multiplying.

Business demanded the barge canal, and saw that it was completed. If business now demands the perpetuation of the State timber supply, it can bring about the conditions which are needed to draw from the forest soils of New York the potential wealth now going to waste.

The war is over. The economic affairs of the States and the Nation must be put upon foundations built broad enough and strong enough for the needs of the greater America yet to come. New York should be the leader in this essential form of economic reconstruction.

PART II

DISCUSSION OF SECONDARY WOODWORKING INDUSTRIES

Summary of Kinds of Wood Used in New York

The following table (Table 1) shows the relative importance of the various species used for making wooden articles in New York. The total for all species amounts to 1,279,795,000 feet annually, for which the manufacturers paid during 1919 a total of $77,786,000, or an average of $60.78 per M. feet. The amount of raw material cut in New York was 189,109,000 feet or approximately 15 per cent of all material used by local wood-using industries. Sixty-five species are listed.

In compiling this report, owing to incompleteness of information furnished, it was considered impracticable to distinguish between the various species of certain genera and the data for such were combined.

Among the native woods white pine contributes the largest amount. Its total of over 329 million feet amounts to 25 per cent of the wood used and more than twice the amount contributed by spruce, the next largest quantity reported for any one species. Note that nearly 306 million feet of the supply was imported from other States. White pine is now and always has been the leading commercial species in New York. When the State occupied first place in the production of lumber, white pine stood foremost among American woods, growing in great abundance throughout New England, the Lake States, and along the Appalachian Mountains. The wood is light, soft, easily worked, comparatively free from resin, and warps and shrinks but little in seasoning. It has all the essential qualities demanded by a large number of wood-using industries, particularly those of sash, doors, blinds, general millwork, pattern work, and general planing mill products. Its average price of \$53.54 is comparatively low for such desirable stock. New York woodlots now contribute only 23 million feet of white pine annually to the wood-using industries of the State.

Spruce ranks second in the order of consumption. Both the red and the white species are common throughout the State, red being the principal one. Its wood is light, soft, stiff, and moderately strong. In the manufacture of pianos and other musical instruments, its resonance or capacity to amplify sound waves makes it one of the most valuable of woods. It is also the most valuable of all woods for paper making on account of its long, strong, light-colored fiber. While red spruce is slightly harder and of slower and more uniform growth than white spruce, the two have the same general mechanical and physical properties and are generally used interchangeably by the various industries without reference to species. Black spruce is a decidedly inferior species sold mixed with the others.

Southern yellow pines include longleaf pine (*P. palustris*), shortleaf pine (*P. echinata*), loblolly pine (*P. taeda*), and slash pine (*P. caribaea*). Pine which came from North Carolina, at comparatively low prices and found use in the industries using cheaper qualities of pine is listed as loblolly pine. All other pine coming from the Southern States, unless it was specifically called loblolly pine, is listed as southern yellow pine and includes longleaf, slash, and shortleaf pines. On account of the lack of information furnished, it was impossible in most cases to distinguish between the longleaf and shortleaf, and these consequently are listed together as southern yellow pine. The total consumption of the southern pines is found to be in practically the same ratio to the total lumber consumption of the State as seven years ago. Seventeen per cent of the lumber consumed in New York is southern yellow pine.

Soft maple comprises red maple (*Acer rubrum*) and silver or soft maple (*Acer saccharinum*). The qualities of these two woods are quite similar and both are mixed and sold with hard maple. Silver maple is stronger and not so brittle as red maple. Red maple, or scarlet maple as it is sometimes called, is more abundant and found on the market in greater quantities. It reaches its best growth along streams and in low, wet swamps.

The staple demand of the market, however, is for hard or sugar maple (*Acer saccharum*), because this wood has qualities of hardness, strength and stiffness, combined with unusual beauty of grain and capacity to receive finish, which fit it for a very wide variety of uses. No other wood used in New York is reported to be used in so many different industries.

White oak follows maple closely in the amount of wood used. In several industries, such as agricultural implements, vehicles and vehicle stock, white oak is one of the most important species. Its high average price of $93.81 per M. feet f. o. b. factory is evidence of its desirability for most uses. Local woodlots contribute only about 6 million feet, or one-tenth of the total white oak consumed in the State, whereas in 1912 the home-grown supply was over 30 million feet. West Virginia, Kentucky, Ohio, Indiana, and Arkansas supply most of the oak shipped into New York from outside.

Birch includes several different genera: yellow birch (*Betula lutea*), paper birch (*Betula papyrifera*), sweet birch (*Betula lenta*), and gray birch (*Betula populifolia*), which are listed in order of quantity consumed. Yellow birch is by far the most important of these birches commercially, and finds a ready market in a great variety of industries. New York produces over one-half of the birch consumed by her factories, most of which is yellow birch. White or paper birch has qualities of strength, hardness, and closeness of grain similar to yellow birch, but is much lighter in weight and is also whiter. White birch is used mostly for pulleys and brush backs, as reported by New York industries. Gray birch and sweet birch are relatively unimportant but find entrance into the industries in mixture with other genera.

Ash growing in New York consists of several different kinds, but the only two of importance are: white ash (*Fraxinus americana*) and black ash (*Fraxinus nigra*). White ash is much more valuable and is used to a greater degree than black ash, because of its greater abundance and its wonderful qualities of strength and elasticity. The automobile industry has made exceedingly heavy demands upon the supply of white ash, since its qualities make it an excellent wood for frame and wheel construction. The single industry which draws heavily upon black ash is that of basket making, to which it is adapted because of its ease in separating into thin layers. Other ashes growing in New York, but of little importance, are red ash (*Fraxinus pennsylvanica*) and green ash (*Fraxinus lanceolata*). Over half of the ash used by the industries in 1919 was homegrown and a very large proportion of this was white ash. The ranges of black and white ash overlap throughout the State. In general, the white ash occupies the better-drained lands, and occurs sparsely in the colder swamps, whereas black ash grows generally in the cold swamp land and along water fronts.

Three kinds of elm grow in commercial quantities within New York: slippery or red elm (*Ulmus pubescens*), white elm (*Ulmus americana*), and cork or rock elm (*Ulmus racemosa*). The second and third are by far the most important. Rock elm is harder and more durable than either of the other and is in great demand for certain parts of vehicles, especially for hubs. White elm, however, is in more general use, particularly in the form of rough lumber and for the production of cooperage stock, vehicles, furniture, agricultural implements, and shipbuilding. Red elm is weaker and not generally sought by wood users.

Several species of hickory are indigenous to the State, and their qualities are in many respects so similar that no notice is taken of such differences in the markets. The four species contributing to the New York manufacturing industries are shagbark hickory (*Hicoria ovata*), mockernut (*Hicoria alba*), pignut (*Hicoria glabra*), and bitternut (*Hicoria minima*). The shagbark hickory, locally known as shellbark hickory, is the most important species and is very important in many New York industries, especially for automobiles, vehicles, and agricultural implements on account of its tough, hard grain and elasticity. The manufacturers import more than two million feet of hickory annually from the central western States, most of which is the shellbark species. The supply of this valuable species is rapidly disappearing.

New York manufacturers use many woods which are not grown within the State. The principal shipments from without, in addition to the southern pines, consist of red gum and cypress. Gum, once considered a weed tree, is now in high demand for furniture and other ornamental uses. Bald cypress (*Taxodium distichum*) is conspicuous in many industries, including boat-building, caskets, and interior finish. It comes generally from Louisiana, but is found in commercial quantities throughout the southeastern United States.

Many woods are imported from foreign nations. Mahogany contributes nearly 12 million feet, most of which comes from Mexico, Central America, the West Indies, and Africa, but a small amount comes from the northern states of South America. Balsa, a relatively new wood in our markets, takes second place in quantity among imported woods. South America supplies this extremely light and rapid-growing wood. It is now used principally in manufacturing life rafts and floats. Experiments are also being tried in its utilization as a heat insulator. Because of the porosity and weakness of this wood, and some difficulties of working and handling it, its field is as yet somewhat limited. Spanish cedar comes from Mexico and Central America for use almost exclusively in the manufacture of cigar boxes.

Circassian walnut comes from southeastern Russia and the adjacent regions of Asiatic Turkey and the Black Sea. Teak comes from India and Siam, and is valued for bearings and ship decking. Ebony is imported from many countries, but the best grades are supplied by Ceylon, India, and Madagascar. Lignumvitae comes from the American tropics, and is very important in the manufacture of mallets, rollers, bushings, casters, and bowling balls. A small amount of satinwood finds its way into New York factories and is shipped chiefly from India and Ceylon. The chief source of granadilla is Africa, but a few varieties are found in the tropical area of South America. Costa Rica and other points in Central America contribute the small amount of cocobola reported. The last two woods are largely used for knife handles.

Many minor species, such as bamboo, congo, corra, furze, Scotch thistle, weitzel, and whangee are purchased in small amounts by the ton, and the shipments are frequently mixed orders so that the price data and quantities can not be separated. English oak is received in veneer form and the price of $980 per M. feet b. m. makes it the most costly of all woods used in New York except satinwood, which was quoted at the same price. It is a very beautiful wood used in high-grade furniture and interior finish.

TABLE 1

SUMMARY OF WOODS USED IN NEW YORK, BY KINDS, 1919

Kinds of Wood		Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Quantity grown in New York. (Feet b. m.)	Quantity grown out of New York. (Feet b. m.)
Common name	Botanical name	Feet b. m.	Per cent				
Total		1,279,795,750	100.00	$60 78	$77,786,690	189,109,000	1,090,686,750
White pine	*Pinus strobus*	329,485,000	25.75	$53 54	$17,640,756	23,569,000	305,916,000
Spruce	*Picea* species	149,373,000	11.67	51 63	7,711,661	20,155,000	129,218,000
Loblolly pine	*Pinus taeda*	112,007,000	8.75	48 86	5,472,961	....	112,007,000
Southern yellow pine	*Pinus* species	106,688,000	8.34	59 35	6,331,862	....	106,688,000
Hard maple	*Acer saccharum*	74,481,000	5.82	54 01	4,023,052	47,693,000	26,788,000
White oak	*Quercus alba*	68,879,000	5.38	93 81	6,461,253	5,786,000	63,093,000
Hemlock	*Tsuga canadensis*	53,330,000	4.17	39 96	2,130,984	11,578,000	41,752,000
Birch	*Betula* species	49,249,000	3.85	54 46	2,682,221	27,405,000	21,844,000
Chestnut	*Castanea dentata*	49,079,000	3.83	58 40	2,866,113	1,955,000	47,124,000
Yellow poplar	*Liriodendron tulipifera*	41,375,000	3.23	81 17	3,358,238	293,000	41,082,000
Red gum	*Liquidambar styraciflua*	37,254,000	2.91	76 64	2,855,203	....	37,254,000
Bald cypress	*Taxodium distichum*	32,416,000	2.53	71 08	2,304,149	....	32,416,000
Basswood	*Tilia americana*	29,897,000	2.34	54 85	1,639,955	11,347,000	18,550,000
Beech	*Fagus grandifolia*	28,955,000	2.26	36 07	1,044,352	22,947,000	6,008,000
Ash	*Fraxinus* species	21,017,000	1.64	98 47	2,069,508	7,870,000	13,147,000
Western white pine	*Pinus monticola*	14,362,000	1.12	65 69	943,459	....	14,362,000
Douglas fir	*Pseudotsuga mucronata*	13,340,000	1.04	53 76	717,097	....	13,340,000
Mahogany	*Swietenia mahagoni*	11,901,000	.93	208 94	2,486,608	....	11,901,000
Tupelo	*Nyssa* species	7,318,000	.57	68 37	500,326	....	7,318,000
Elm	*Ulmus* species	7,103,000	.56	42 58	302,420	4,340,000	2,763,000
Red oak	*Quercus borealis maxima*	6,291,000	.49	87 80	552,381	1,050,000	5,241,000
Black walnut	*Juglans nigra*	3,451,000	.27	199 45	688,288	6,000	3,445,000
Soft maple	*Acer* species	3,328,000	.26	59 33	197,448	1,368,000	1,960,000
Red cedar	*Juniperus virginiana*	3,210,000	.25	139 72	448,500	....	3,210,000
Cottonwood	*Populus* species	3,090,000	.24	48 34	149,366	171,000	2,919,000
Sugar pine	*Pinus lambertiana*	2,774,000	.22	61 10	169,480	....	2,774,000
Red pine	*Pinus resinosa*	2,650,000	.21	42 92	113,750	20,000	2,630,000
Balsa	*Ochroma lagopus*	2,500,000	.20	110 00	275,000	....	2,500,000
Hickory	*Hicoria* species	2,370,000	.19	97 85	231,914	314,000	2,056,000
Western red cedar	*Thuja plicata*	2,120,000	.17	53 48	113,370	....	2,120,000

Spanish cedar	*Cedrela odorata*	1,849,000	.14	179 19	331,331	....	1,849,000
Black cherry	*Prunus serotina*	1,830,000	.14	71 55	130,935	1,068,000	762,000
Sitka spruce	*Picea sitchensis*	1,766,000	.14	187 57	331,250	....	1,766,000
Redwood	*Sequoia sempervirens*	1,174,000	.09	80 07	94,005	....	1,174,000
Sycamore	*Platanus occidentalis*	768,000	.06	67 50	51,840	....	768,000
Arborvitae	*Thuja occidentalis*	582,000	.05	90 42	52,625	25,000	557,000
Buckeye	*Aesculus* species	374,000	.03	44 03	16,468	....	374,000
Willow	*Salix* species	354,000	.03	37 03	13,107	4,000	350,000
Witch hazel	*Hâmamelis virginiana*	341,000	.03	136 16	46,430	....	341,000
Western yellow pine	*Pinus ponderosa*	250,000	.02	38 00	9,500	....	250,000
Southern white cedar	*Chamaecyparis thyoides*	204,000	.02	84 90	17,320	....	204,000
Port Orford cedar	*Chamaecyparis lawsoniana*	153,000	.01	150 08	22,962	....	153,000
Lignum-vitae	*Guajacum officinale*	129,000	.01	293 02	37,800	....	129,000
Persimmon	*Diospyros virginiana*	105,000	.01	123 71	12,990	....	105,000
Butternut	*Juglans cinerea*	72,000	.01	155 00	11,160	3,000	69,000
Tamarack	*Larix laricina*	68,000	.01	46 84	3,185	....	68,000
Balm of Gilead	*Populus balsamifera*	65,000	.01	37 00	2,405	....	65,000
Balsam fir	*Abies balsamea*	59,000	*	39 78	2,347	59,000	....
Teak	*Tectona grandis*	55,000	*	715 55	39,355	....	55,000
Black locust	*Robinia pseudacacia*	53,000	*	72 53	3,844	....	53,000
Dogwood	*Cornus florida*	50,000	*	140 00	7,000	25,000	25,000
Holly (American)	*Ilex opaca*	45,000	*	150 00	6,750	....	45,000
Applewood	*Malus* species	33,000	*	36 36	1,200	33,000	....
Rosewood	*Dalbergia* species	30,250	*	396 86	12,005	....	30,250
Cocobola	*Platymiscium* species	26,000	*	606 73	15,775	....	26,000
Pitch pine	*Pinus rigida*	25,000	*	35 00	875	25,000	....
Circassian walnut	*Juglans regia*	17,000	*	508 53	8,645	....	17,000
Ebony	*Diospyros* species	16,000	*	906 25	14,500	....	16,000
Satinwood	*Chloroxylum swietenia*	5,000	*	980 00	4,900	....	5,000
English oak	*Quercus* species	2,000	*	980 00	1,960	....	2,000
Granadilla	*Brya ebenus*	1,000	*	400 00	400	....	1,000
Sassafras	*Sassafras sassafras*	1,000	*	21 00	21	....	1,000
Boxwood	*Buxus sempervirens*	500	*	250 00	125	....	500
Cork	*Quercus suber*	....	....	....	....	....	....
Rattan	*Calamus* species	....	....	....	....	....	....

* Less than one hundredth of one per cent.

TABLE 1-A

Comparative Statement of Woods Used by Species in New York, 1919–1912

Kind of Wood (Common name)	Quantity Used				Grown in New York	
	1919		1912		Quantity in board feet	
	Board feet	Average value per M ft.	Board feet	Average value per M ft.	1919	1912
Total	1,279,795,750	$60 78	1,754,519,217	$30 76	189,109,000	548,236,159
White pine	329,485,000	$53 54	422,686,634	$27 70	23,569,000	158,109,000
Spruce	149,373,000	51 63	169,107,607	21 31	20,155,000	76,162,900
Loblolly pine	112,007,000	48 86	70,596,671	20 77	....	....
Southern yellow pine	106,688,000	59 35	194,503,215	28 98	....	....
Hard maple	74,481,000	54 01	90,194,650	27 07	47,693,000	56,905,700
White oak	68,879,000	93 81	130,421,577	46 25	5,786,000	30,335,677
Hemlock	53,330,000	39 96	83,028,900	19 82	11,578,000	49,080,400
Birch	49,249,000	54 46	44,136,326	30 07	27,405,000	30,508,032
Chestnut	49,079,000	58 40	71,054,190	28 56	1,955,000	13,627,550
Yellow poplar	41,375,000	81 17	57,016,889	40 47	293,000	5,250,900
Red gum	37,254,000	76 64	41,940,175	29 16	....	75,000
Cypress	32,416,000	71 08	60,314,370	39 97	....	....
Basswood	29,897,000	54 85	56,977,220	27 36	11,347,000	32,621,350
Beech	28,955,000	36 07	42,546,814	20 54	22,947,000	31,492,600
Ash	21,017,000	98 47	17,556,225	38 49	7,870,000	8,369,225
Western white pine	14,362,000	65 69	3,935,000	40 65	....	....
Douglas fir	13,340,000	53 76	1,508,600	50 95	....	....
Mahogany	11,901,000	208 94	11,208,720	138 84	....	....
Tupelo	7,318,000	68 37	1,598,616	39 24	....	....
Elm	7,103,000	42 58	17,310,500	28 37	4,340,000	8,300,600
Red oak	6,291,000	87 80	59,868,300	38 49	1,050,000	17,282,050
Black walnut	3,451,000	199 45	2,629,128	117 15	6,000	570,675
Soft maple	3,328,000	59 33	8,960,650	25 71	1,368,000	4,587,400
Red cedar (southern)	3,210,000	139 72	16,766,575	37 98	....	2,500
Cottonwood	3,090,000	48 34	22,778,000	21 00	171,000	14,508,000
Sugar pine	2,774,000	61 10	1,647,100	46 83	....	....
Red pine	2,650,000	42 91	12,420,300	22 99	20,000	140,000
Balsa	2,500,000	110 00	20,000	40 00	....	....
Hickory	2,370,000	97 85	8,755,100	43 03	314,000	2,551,150
Western red cedar	2,120,000	53 48	1,245,200	30 85	....	....
Spanish cedar	1,849,000	179 19	8,582,500	113 11	....	....
Cherry	1,830,000	71 55	3,242,750	46 22	1,068,000	748,050
Sitka spruce	1,766,000	187 57	27,000	49 07	....	....
Redwood	1,174,000	80 07	767,700	41 74	....	....
Sycamore	768,000	67 50	182,712	37 06	....	2,700
Arborvitae	582,000	90 42	1,623,600	24 61	25,000	929,700
All other kinds	2,533,750	....	17,359,712	....	149,000	6,075,000

Summary of Woods Used in New York by Industries

Table 2 shows the relative demands made upon the species by 44 wood-using industries of the State, the average price paid for the raw material delivered at the manufacturing establishments, and a comparison of the consumption of home-grown and imported woods.

The term industry as here used includes the production of articles that are similar or closely related. Each industry is discussed individually in the pages following Table 2, and the particular articles combined in that industry are enumerated.

Under modern commercial conditions the woodworking plants have been specialized, the various branches of the general art demanding a particular class of machinery, labor, and a certain form of raw material. A study by industries is the only way to point out to woodlot owners where they may most profitably dispose of their surplus timber, in what form they are expected to prepare the raw material for the market, and what kinds of wood may be most profitably grown to meet the requirements of the wood-using establishments in a given locality. A study by industries is helpful to the manufacturers of finished products, in that it enables them to compare their individual operations with the average for all the manufacturers engaged in a particular branch of the trade. The chair manufacturer, for example, can compare the woods used in his own establishment with the reports from other chair manufacturers; he can study the particular use to which each species is put, the form of raw material used, the general physical and mechanical properties of the species used in various factories, and what is being done with the waste. Thus each manufacturer who aided in this investigation may benefit by the cooperation of all and be in a better position to effect economy. A comparison of one industry with another should also result in a benefit to all. The disposal of waste in a large establishment is a matter of growing importance, and the smaller plants are frequently able to utilize much of the waste about the larger plants. New industries spring up and sometimes they utilize or depend upon the waste of the older industries for their raw material. Small, clear blocks of maple, walnut, birch, mahogany, and other waste woods that are sometimes used for fuel in a city planing mill might be profitably turned into brush and hand-mirror backs at an adjoining establishment. The discussions of the various industries aim to point out the form and source of the raw material needed by the various industries, the uses of the various species, the qualities that recommend them for such uses, the cost of the different woods delivered at the factory, the relative demand made upon our woodlots by the various industries, the form of the waste, and to make some suggestions relative to the practical utilization of the waste.

Table 2 shows the wide range of manufacturing going on throughout the State and the enormous amount of raw material needed annually. No other State has so much capital employed or so many men engaged in the wood-using industries. In nearly all of these industries New York is conspicuous nationally, while in many of them she occupies first position in the matter of raw material consumed and the value of the finished products. While her planing-mill output is exceeded by the output of the more heavily timbered States of the South and West, no other State compares with New York in total consumption of wood for certain classes of finished articles. At the time when the previous edition of this bulletin was published, numerous other States had recently been similarly canvassed. It was therefore possible to draw comparisons between the States which can not be made at the present time. Of the individual industries, however, it is believed that New York still retains leadership in the following: packing boxes, sash, door, and blinds, ship and boat building, musical instruments, boot and shoe findings, matches, and probably numerous others.

The average price of $60.78 paid for the raw material is almost exactly twice what it was in 1912. The reports of the manufacturers were rendered, however, near the peak of the phenomenal high prices following the war, which have since subsided to a marked degree. Except as a record of an ephemeral period these prices are of little value. They show too great fluctuations to be an index of the permanent advance in cost of material which is slowly progressing.

TABLE 2

SUMMARY OF WOODS USED IN NEW YORK BY INDUSTRIES, 1919

Industry	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Quantity grown in New York. (Feet b. m.)	Quantity grown out of New York (Feet b. m.)
	Feet b. m.	Per cent				
Total	1,279,795,750	100.00	$60.78	$77,786,690	189,109,000	1,090,686,750
Boxes and crates	324,219,000	25.33	$47.48	$15,394.009	16,492,000	307,727,000
Planing-mill products	230,259,000	17.99	54.33	12,509,017	31,241,000	199,018,000
Sash, doors, blinds, and general millwork	200,504,000	15.67	67.49	13,532,772	13,273,000	187,231,000
Furniture	76,963,000	6.01	80.52	6,197,300	15,828,000	61,135,000
Ship and boat building	62,815,000	4.91	65.52	4,115,727	979,000	61,836,000
Musical instruments	53,569,000	4.18	89.03	4,769,358	16,533,000	37,036,000
Car construction	34,476,000	2.69	59.32	2,045,035	1,335,000	33,141,000
Shade and map rollers	29,946,000	2.34	44.23	1,324,434	2,523,000	27,423,000
Caskets and coffins	29,230,000	2.28	65.41	1,911,838	360,000	28,870,000
Chairs	22,318,000	1.74	58.35	1,302,410	13,073,000	9,245,000
Motor vehicles	20,813,000	1.63	101.08	2,103,699	5,592,000	15,221,000
Agricultural implements	19,064,000	1.49	62.83	1,197,890	6,551,000	12,513.000
Boot and shoe findings	14,705,000	1.15	65.44	962,280	12,465,000	2,240,000
Matches	14,250,000	1.11	52.32	745,500	300,000	13,950,000
Woodenware and novelties	13,745,000	1.07	39.94	548,981	9,270,000	4,475,000
Handles	11,986,250	.94	37.95	454,814	11,293,000	693,250
Refrigerators and kitchen cabinets	11,562,000	.90	71.59	827,767	145,000	11,417,000
Fixtures	10,739,000	.84	85.44	917,587	1,929,000	8,810,000
Professional and scientific instruments	9,754,000	.76	82.47	807,358	534,000	9,220,000
Baskets and fruit packages	8,527,000	.67	35.85	305,746	7,499,000	1,028,000
Vehicles and vehicle parts	7,660,000	.60	89.20	683,270	3,690,000	3,970,000
Dairymen's, poulterers' and apiarists' supplies	7,556,000	.59	37.79	285,578	4,683,000	2,873,000
Tanks and silos	7,471,000	.58	66.65	497,950	632,000	6,839,000
Toys	6,864,000	.54	45.79	314,313	3,195,000	3,669,000
Picture frames and mouldings	6,647,000	.52	83.57	555,474	186,000	6,461,000

Plumbers' woodwork	5,424,000	.43	85.13	461,792	1,170,000	4,254,000
Pumps and piping	4,833,000	.38	46.84	226,388	866,000	3,967,000
Laundry appliances	4,241,000	.33	59.23	251,189	....	4,241,000
Trunks and suitcases	3,984,000	.31	82.16	327,430	185,000	3,799,000
Cigar boxes	3,295,000	.26	164.66	541,859	....	3,295,000
Patterns and flasks	3,039,000	.24	75.95	230,809	219,000	2,820,000
Brushes and brooms	2,713,500	.21	43.19	117,208	2,124,000	589,500
Shuttles, spools, and bobbins	2,310,000	.18	42.55	98,280	1,125,000	1,185,000
Electrical machinery and apparatus	2,216,000	.18	70.94	157,209	162,000	2,054,000
Machine construction	1,779,000	.14	53.76	95,644	812,000	967,000
Pulleys and conveyors	1,614,000	.13	53.42	86,221	33,000	1,581,000
Airplanes	1,427,000	.11	230.34	328,693	105,000	1,322,000
Elevators	1,288,000	.10	79.93	102,078	160,000	1,128,000
Clocks	896,000	.07	82.17	73,625	8,000	888,000
Sporting and athletic goods	429,000	.03	74.62	32,010	212,000	217,000
Dowels and skewers	377,000	.03	55.94	21,080	377,000	....
Firearms	258,000	.02	147.78	38,130	....	258,000
Whips and umbrella sticks	250,000	.02	50.00	12,500	250,000	....
Printing material	72,000	.01	87.29	6,285	48,000	24,000
Miscellaneous	3,708,000	.29	72.32	268,153	1,652,000	2,056,000

TABLE [illegible]a

COMPARATIVE STATEMENT OF WOOD USED IN NEW YORK BY INDUSTRIES, 1919-1912

Industry	Number of Establishments Classified in Each Industry in — 1919	1912	Quantity of Material Used in Board Feet by Each Industry in — 1919	1912	Percentage of New York State Grown Material Used in — 1919	1912
All industries	2,142	3,507	1,279,795,750	1,754,519,217	14.78	31.25
Boxes and crates	316	429	324,219,000	370,550,400	5.08	18.03
Planing-mill products	240	667	230,259,000	388,191,660	13.57	47.10
Sash, doors, blinds, and general millwork	411	607	200,504,000	341,277,662	6.62	27.62
Furniture	166	242	76,963,000	104,452,092	20.57	31.32
Ship and boat building	99	141	62,815,000	37,700,500	1.56	13.78
Musical instruments	58	81	53,569,000	58,816,550	30.86	35.84
Car construction	11	20	34,476,000	76,201,900	3.87	4.07
Shade and map rollers	4	6	29,946,000	1,622,500	8.43	15.25
Caskets and coffins	21	21	29,230,000	18,161,000	1.23	3.42
Chairs	33	80	22,318,000	21,612,200	58.58	55.51
Motor vehicles	[1] 74	....	[1] 20,813,000	....	[1] 26.87	....
Agricultural implements	43	67	19,064,000	28,055,600	34.36	33.66
Boot and shoe findings	25	24	14,705,000	22,882,000	84.77	85.40
Matches	3	2	14,250,000	....	2.11	....
Woodenware and novelties	59	82	13,745,000	8,364,900	67.44	67.92
Handles	23	44	11,986,250	6,474,979	94.22	91.24
Refrigerators and kitchen cabinets	15	25	11,562,000	12,268,700	1.25	29.36
Fixtures	51	70	10,739,000	20,175,615	17.96	28.49
Professional and scientific instruments	13	22	9,754,000	19,811,800	5.47	8.71
Baskets and fruit packages	47	85	8,527,000	18,007,250	87.94	78.55
Vehicles and vehicle parts	[2] 110	269	[2] 7,660,000	30,633,100	[2] 48.17	36.31
Dairymen's, poulterers', and apiarists' supplies	48	104	7,556,000	39,045,000	61.98	24.76
Tanks and silos	26	49	7,471,000	11,332,950	8.46	12.97
Toys	10	13	6,864,000	2,994,500	46.55	65.50
Picture frames and mouldings	25	33	6,647,000	7,514,450	2.80	26.20

Plumbers' woodwork	4	7	5,424,000	1,787,000	21.57	48.68
Pumps and piping	6	10	4,833,000	9,804,800	17.92	15.37
Laundry appliances	4	20	4,241,000	5,201,340	....	31.83
Trunks and suitcases	9	12	3,984,000	3,536,000	4.64	34.25
Cigar boxes	13	22	3,295,000	10,115,550	....	....
Patterns and flasks	59	55	3,039,000	3,388,300	7.21	29.68
Brushes and brooms	18	19	2,713,500	1,562,500	78.28	75.02
Shuttles, spools and bobbins	3	5	2,310,000	962,000	48.70	77.13
Electrical machinery and apparatus	4	18	2,216,000	4,602,860	7.31	50.08
Machine construction	28	33	1,779,000	4,555,900	45.64	63.30
Pulleys and conveyors	4	4	1,614,000	823,000	2.04	40.70
Airplanes	5	3	1,427,000	31,400	7.36	54.78
Elevators	7	9	1,288,000	2,663,200	12.42	26.21
Clocks	3	3	896,000	2,948,159	.89	5.81
Sporting and athletic	8	19	429,000	4,230,100	49.42	33.18
Dowels	4	8	377,000	753,000	100.00	93.36
Firearms	4	3	258,000	370,000	....	....
Whips and umbrella sticks	4	3	250,000	2,237,000	100.00	89.41
Printing material	6	5	72,000	1,737,500	66.67	35.25
Gates and fencing	....	6	....	725,500	....	22.12
Miscellaneous	18	24	3,708,000	31,639,800	44.55	13.16
Excelsior	....	[3] 36	....	14,697,000	....	91.71

[1] Included in vehicles and vehicle parts.
[2] Includes motor vehicles.
[3] Includes thirty-six concerns cutting excelsior, included in Appendix in 1919.

Boxes and Crates, Packing

Table No. 3 includes box shooks, packing boxes, piano and organ shipping boxes, packing crates, and all kinds of material used in the industrial establishments for the storage and shipment of factory products. New York is truly the Empire State in manufacturing, and naturally the demand for boxes and crating is enormous. The total annual output of the box factories in New York amounts to 324,219,000 feet. Among the secondary wood-using industries this one is now first in the State in point of quantity of wood consumed, having surpassed the planing-mill industry by 94,000,000 feet in 1919. Adding the wood material put into "Baskets and Fruit Packages," including baskets proper, berry crates, and packages, the total output of wooden containers comes up to 332,-746,000 feet. These combined industries form a true index to the relative importance of New York in manufacturing, leaving out of consideration the cigar and tobacco box industry and the manufacture of cooperage.

Table 3 shows the consumption of 29 different species of wood, the average cost of which delivered at the factory is \$47.48 per thousand feet. Boxes and crates can be produced generally from low-grade stock. From the standpoint of wood utilization, this is one of the desirable features about modern manufacturing business. The enormous development of manufactures has naturally resulted in the increased consumption of lower grades of lumber for boxes and crates. Frequently as much lumber is needed to crate a wooden article, such as a piece of furniture, as is used in making the article. The kinds and sizes of boxes and crates are so numerous that discussion of their form is impracticable. Box material is generally consumed in the vicinity of its manufacture, because freight rates discourage long hauls. Some of the Southern States, however, such as Virginia, produce large amounts of box material in the form of shooks that can be shipped in a knockdown form by carloads to great distances.

The differences in the physical and mechanical properties of the various species are not so important in boxes and crates.

Almost any kind of wood can be used in some form or other for crates, the principal recommendation being that it is cheap, light, and capable of holding nails without splitting. Strength, while desirable, is not the first requisite of a box material. In New York, white pine naturally combines all the qualities of good box wood and contributes over 40 per cent of the raw material consumed by this industry. Only 10,000,000 feet of the white pine is grown within the State, while over 120,-000,000 feet is now imported. With a few exceptions, the dominant species in any locality contributes most of the material going into boxes. While white pine leads in New York, Wisconsin, Massachusetts, and Michigan, it is noticeable that in other States, like Virginia and North Carolina, southern yellow pine contributes the larger amount to the industry. In Louisiana, where longleaf pine is the principal species, it contributes most to the box industry. In Kentucky and Arkansas red gum leads all others. This utilization of the most abundant species in a community clearly indicates that the industry does not demand special qualities in woods, but utilizes the nearest suitable wood that is cheap and abundant. In New York other important local woods contributing to the industry are spruce, hemlock, basswood, cottonwood, hard maple, beech, birch, chestnut, and elm. Yellow pine is the principal wood shipped into the State for boxes, the contribution amounting to 101,000,000 feet annually. As will be noted, the first five species are softwoods. Softwoods are generally of sufficient strength for shipping cases and have the additional advantages of being light, easily worked, and comparatively free from shrinking and warping. In some respects white pine excels loblolly and shortleaf as a box material. Although not particularly strong, it tends to dent rather than to break or split upon impact. For this reason it was formerly used by the Army for ammunition cases and is now used for shipping cases for Government transits. It is not so resinous and hence is better for shipping foodstuffs; its color, being nearly white, is admirable for the display of brands and firm names on packages; and it is more workable than the other species. New

York woodlots and forests, if properly cared for, will always be important producers of white pine, spruce, hemlock, cottonwood, and the other important species so much in demand by the manufacturing industries of the community. Here is one of the finest opportunities for the sale of small-sized and low-grade timber cut from young plantations in making improvement thinnings. Some of the less important species, such as beech and elm, are very desirable for certain kinds of crating because of greater strength and toughness. Elm crating, when properly secured by metal cleating, is especially satisfactory where strength and toughness are required.

The box industry offers exceptional opportunities for the close utilization of low grades and waste. New England box-board custom is to saw the log through and through. This, of course, is always second-growth material, and consequently they cut it this way. The board is cut into lengths and edged just sufficiently to take off the bark on each side, with the result that many boards are narrow at one end and wider at the other. This practice of making box boards permits the closest utilization possible. Some mills are manufacturing box boards from slabs that would otherwise go to the hog, slasher pile, or refuse burner. Some industries work up veneer cores as box boards. Many industries instead of buying box material or boxes use their otherwise waste pieces or poor ends of the grades for this purpose. All of these expedients save money and permit the use of better lumber for more exacting purposes.

TABLE 3

BOXES AND CRATES, PACKING

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	324,219,000	100.00	$47 48	$15,394,009	16,492,000	307,727,000
White pine	132,286,000	40.80	$49 94	$6,606,363	9,996,000	122,290,000
Loblolly pine	93,814,000	28.94	46 84	4,393,768	....	93,814,000
Spruce	59,388,000	18.32	46 27	2,747,883	1,200,000	58,188,000
Hemlock	8,098,000	2.50	36 21	293,229	1,065,000	7,033,000
Southern yellow pine	7,348,000	2.27	45 04	330,954	....	7,348,000
Basswood	4,769,000	1.47	45 81	218,468	964,000	3,805,000
Cottonwood	2,651,000	.82	47 67	126,373	62,000	2,589,000
Red gum	2,371,000	.73	40 62	96,310	....	2,371,000
Yellow poplar	2,340,000	.72	44 28	103,605	2,000	2,338,000
Hard maple	1,836,000	.57	29 45	54,070	892,000	944,000
Beech	1,429,000	.44	34 22	48,900	1,072,000	357,000
Western white pine	1,418,000	.44	50 54	71,666	....	1,418,000
Cypress	1,356,000	.42	39 76	53,915	....	1,356,000
Chestnut	1,169,000	.36	36 57	42,751	342,000	827,000
Birch	914,000	.28	35 42	32,374	635,000	279,000
Red pine	625,000	.19	38 00	23,750	20,000	605,000
Elm	454,000	.14	31 18	14,156	176,000	278,000
Willow	351,000	.11	37 00	12,987	1,000	350,000
White oak	338,000	.10	130 00	43,940	62,000	276,000
Redwood	300,000	.09	60 00	18,000	....	300,000
Douglas fir	290,000	.09	46 40	13,456	....	290,000
Tupelo	250,000	.08	43 00	10,750	....	250,000
Ash	130,000	.04	200 00	26,000	2,000	128,000
Sugar pine	90,000	.02	36 50	3,285	....	90,000
Balm of Gilead	65,000	.02	37 00	2,405	....	65,000
Buckeye	60,000	.02	37 00	2,220	....	60,000
Tamarack	40,000	.01	41 00	1,640	....	40,000
Soft maple	38,000	.01	19 73	750	....	38,000
Cherry (black)	1,000	*	41 00	41	1,000	....

* Less than 1/100 of one percent.

Planing Mill Products

Planing-mill products are those considered as finished upon leaving the planer, such as flooring, ceiling, siding, molding, base boards, and dressed and matched material. Undoubtedly some plain surfaced lumber and dimension stock has unintentionally been included in these returns. A certain amount of such duplication in the returns is unavoidable.

Of the 230,259,000 feet consumed in the planing-mill industry, only 31 million, or 13 per cent, was found to be home-grown. This is in striking contrast to the returns of 1912 which showed 47 per cent of the planing-mill products grown in New York. In the short space of eight years a great change has taken place. No longer are the New York forests supplying even a considerable percentage of the home demand for building material. The total white pine, spruce, and hemlock from New York in 1919 is only one-sixth of the amount supplied from sources within the State in 1912. The amount of these three woods brought in from other States was over 40 per cent greater than in 1912, although the total production of planing mills in 1919 was 40 per cent less.

The planing mills report the use of 31 different species, the average cost of which at the planer was $54.33, an increase of 100 per cent in cost. Of these only 2 are not imported, elm and balsam fir, and these are insignificant in quantity. Out of 13 species indigenous to New York, 7 were imported in quantities greater than the State supplied, while 2 were imported in total. The remaining 4 include hard maple, birch, and beech, and even of these staple hardwoods more was purchased elsewhere than was cut in New York. In 1912 every one of the 13 came in larger quantity from home sources than from outside, and 3 of them came entirely from the State.

White pine is the most popular wood for general house building purposes in this country. It has all the desirable qualities, being sufficiently strong and having a fine, straight grain and even texture. It is also easily worked, comparatively free from shrinking and warping, very light in color, only slightly resinous and capable of taking paints and oils, and stains well. It should be remembered, however, that white pine is falling off in quality, and that only a small proportion of it now comes from New York.

Spruce is light, soft, straight-grained, of uniform growth, easily worked, and takes paint well.

Hemlock was neglected in lumber operations for many years until the scarcity of other woods caused manufacturers to utilize this abundant species. It is used chiefly for construction work, but it is also valuable for floor lining, siding, and panel work. The wood is strong, straight-grained, and fairly hard. It finishes smoothly and works fairly well. Its tendency to splinter is one feature which has made it unpopular in comparison with pine.

With the steady shrinkage of the supply of northern species has come the increasing reliance upon southern and western species. The southern yellow pines — longleaf, shortleaf, and loblolly — constitute valuable materials for house construction. Longleaf wood is heavy, hard, very strong, straight-grained, compact, very resinous, and is highly desirable for flooring. For interior finish, ceiling, partition, and flooring, longleaf is extensively used where formerly high-grade hardwoods were largely employed.

Shortleaf pine comes from the South Atlantic and Gulf States. It is particularly suited to interior finish and door construction on account of its fine grain and easy working qualities. The so-called North Carolina pine consists mainly of loblolly with an occasional small percentage of the other species of southern pine.

Bald cypress is of great commercial importance in Louisiana and throughout the southeastern United States. It is put to almost every use as an interior trim for houses and is finished in natural color or stained. Containing little resin, it affords a good surface for paint. It is much used for ceiling, wainscoting, panels, and to some extent for flooring. It shrinks and warps but little and is therefore used for drain boards, sinks,

Planing Mill Products

A room finished in Douglas fir. Pan-American Building, Washington, D. C. Although the forests of the Pacific Coast are vast in extent, it is doubtful whether they can bridge the gap until the eastern forests have been restored. No forest is inexhaustible to modern sawmills.

kitchen cupboards, and in places where it is subjected to dampness and heat. For parts of houses exposed to weather it is most serviceable, and as siding it practically wears out before it decays.

From the West, New York receives considerable quantities of the so-called western white pine, which is the yellow pine of the Inland Empire (*Pinus ponderosa*) with a slight admixture of Idaho white pine (*Pinus monticola*). Idaho white pine also appears in New York markets, both separately and as a substitute in the wood sold as eastern white pine.

Douglas fir (*Pseudotsuga taxifolia*) is also coming in increasing quantities from the far West as the supply of southern longleaf becomes more restricted. It is a rather heavy, strong wood, obtainable in almost any reasonable length, and will in future be one of the main market species, if not the most important. It is used for many purposes, from bridge timbers to interior finish.

Redwood, shipped from California, is used largely for interior finish and shingles. It takes stains well and is very resistant to decay. Of the foreign woods, mahogany, teak, and Circassian walnut are used mainly as thin veneers for partitions and panels. Teak at $707 per thousand is the most expensive wood in the list. Black walnut at $203 is the costliest native wood.

The larger planing mills situated in the commercial centers are now saving much material that hitherto was thrown away. Today nearly all establishments sell their shavings and sawdust for one purpose or another, especially for bedding horses, packing ice, and distillation, while the slabs are generally made into moldings; hardwood strips and blocks are converted into novelties, brush backs, mirror backs, etc.; while the softwood ends and strips are frequently turned into articles such as balusters, posts, railings, dowels, hamper covers, slats, and cratings. Basswood ends are resawed into ironing boards, while other hardwoods go into such articles as swinging chairs and dimension stock for all other industries using small pieces. The high price of lumber in manufacturing centers encourages close utilization and New York establishments should set an example, both in shop economies and in the advantageous disposal of waste.

TABLE 4

PLANING MILL PRODUCTS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	230,259,000	100.00	$54 33	$12,509,017	31,241,000	199,018,000
White pine	84,310,000	36.62	$54 44	$4,589,836	2,775,000	81,535,000
Spruce	49,868,000	21.66	52 95	2,640,511	11,583,000	38,285,000
Hemlock	28,866,000	12.54	40 68	1,174,269	7,739,000	21,127,000
Southern yellow pine	20,679,000	8.98	61 88	1,279,708	....	20,679,000
Loblolly pine	10,983,000	4.77	58 92	647,118	....	10,983,000
Hard maple	6,852,000	2.98	49 57	339,654	3,493,000	3,359,000
White oak	5,314,000	2.31	95 25	506,159	555,000	4,759,000
Birch	4,755,000	2.07	38 25	181,879	2,632,000	2,123,000
Western white pine	4,605,000	2.00	69 78	322,237	....	4,605,000
Cypress	3,303,000	1.44	60 06	198,378	....	3,303,000
Beech	2,571,000	1.12	35 35	90,885	1,493,000	1,078,000
Yellow poplar	1,964,000	.85	73 46	144,275	40,000	1,924,000
Chestnut	1,770,000	.77	59 68	105,634	228,000	1,542,000
Basswood	1,151,000	.50	48 91	56,295	457,000	694,000
Red pine	1,000,000	.43	45 00	45,000	....	1,000,000
Douglas fir	910,000	.40	70 55	64,200	....	910,000
Redwood	390,000	.17	108 00	42,120	....	390,000
Ash	319,000	.14	36 84	11,752	146,000	173,000
Red gum	250,000	.11	103 33	25,833	....	250,000
Arborvitae	69,000	.03	50 00	3,450	....	69,000
Red oak	50,000	.02	87 25	4,363	....	50,000
Hickory	50,000	.02	52 00	2,600	....	50,000
Balsam fir	44,000	.01	26 08	1,147	44,000	....
Elm	41,000	.01	35 00	1,435	41,000	....
Cherry (black)	36,000	.01	63 33	2,380	15,000	21,000
Mahogany	28,000	.01	196 52	5,503	....	28,000
Locust	25,000	.01	68 74	1,719	....	25,000
Western red cedar	25,000	.01	120 00	3,000	....	25,000
Teak	21,000	.01	707 14	14,850	....	21,000
Black walnut	8,000	*	203 33	1,627	....	8,000
Circassian walnut	2,000	*	600 00	1,200	....	2,000

* Less than one-hundredth of one per cent.

Sash, Doors, Blinds, and General Millwork

New York wood users report the consumption of 34 different species in the manufacture of sash, doors, blinds, and general millwork, with a total annual consumption of 200,000,000 feet, the average cost of which is $67.49 per M. feet f. o. b. factory. This industry overlaps the planing-mill industry to some extent. These factories consume raw material that is one step further removed from the forest, as compared with planing-mill products, and the cost of the raw material is over $13 per M. in excess of the latter industry. Generally the establishments manufacturing sash, doors, and general millwork are located in cities and villages where the raw material comes to them in the form of rough and surfaced lumber, whereas the planing-mill products use a great amount from the logs. General millwork establishments manufacture a great variety of articles, but the most important items turned out are balusters, baseboards, blinds, cabinets, columns, cornice work, doors, grills, mantels, newel posts, porch work, posts, railing, sash, screens, scroll work, shutters, stairwork and window frames.

Workableness and ability to hold its shape, combined with the capacity to take oils and paints well, are the principal requirements of woods that go into general millwork. White pine is unexcelled for this industry and occupies first place. For articles such as balusters, columns, posts, scrolls, and stairwork white pine is used almost exclusively. Its clear grain and the ease with which it may be cut makes it a favorite for scroll and cornice work, and it is preferred above all others by cabinet makers. It occupies a leading position in all of the States where the wood grows and not infrequently it is a leader in contribution to many of the industries in States where no white pine is grown, where it is given preference over all other woods for the manufacture of sash, doors, blinds, and patterns. Its desirability as compared with most native woods of other communities for general millwork is patent when more of it is consumed in many States than of native woods. Next to the white pine comes bald cypress of which nearly 20 million feet were used. It is particularly suitable for construction where resistance to decay is of importance.

Third comes southern yellow pine, embracing longleaf and shortleaf. Longleaf pine is used extensively in doors, especially for the panels on account of its ornamental grain, though a solid longleaf door would be too heavy for convenience. It would take two men to hang it. Therefore, shortleaf and white pine are used more extensively than longleaf in door construction. Frequently longleaf is combined with white pine in the same door, the white pine forming the rails and stiles. Immense quantities of southern pine are made into sash and doors, while smaller quantities are used for railing, balusters, stairs, newel posts, and columns. Because of their hardness, sugar maple and longleaf pine are favorite woods for doorsills.

Hemlock, a native species, is fourth in importance, and here again the ominous condition is seen that the State produced only about one-seventh of the amount consumed in 1919. Hemlock, like spruce, is in heavy demand for pulpwood.

Yellow poplar has come up from tenth place to fifth, and this may be taken as a tribute to its pleasing appearance and workable qualities. It is frequently preferred for columns, newels, and screen frames.

White oak is used largely for high-grade finish, such as mantels, on account of its beautiful grain. It is capable of taking a high polish and when quarter-sawed it has a conspicuous "silver grain," which makes it most attractive for exterior parts of interior finish. Unless seasoned with care it checks and honey-combs badly, but next to mahogany it is considered by many to be the most beautiful wood for interior finish.

Red gum, imported from the Central Southern States, is extremely popular because it can be made to take a beautiful finish, especially in imitation of Circassian walnut. The raw material comes into the State at prices that compete with local woods, and it is used in nearly all of the larger hotels and apartment-houses in one form or another as decorative material. Red gum was formerly considered a weed tree or practically so, until lumbermen learned how to dry it by special methods which overcame its tendency to warp and twist. It is now so valued that in order to use it to the best advantage large quantities are made into veneers for ornamental work.

Many woods give evidence of their suitability for certain uses in this industry by coming extreme distances, among them being Douglas fir from the northwest, sugar pine from southern Oregon and California, western white pine from the Inland Empire, and Western red cedar from Washington. Mahogany, Circassian walnut, and other high-priced foreign woods are brought from the ends of the earth for the ornamentation of interior trim, carvings, cabinets, etc.

Mahogany is a favorite wood for revolving doors in large hotels and office buildings. The hard foreign woods such as ebony, rosewood, and teak take a high polish and are made largely into carvings for interior decoration. Mahogany, Circassian walnut, English oak, and white oak are used largely in the form of veneer, with chestnut and yellow poplar for backing or cores. Chestnut is used principally, however, for interior finish and for doors. Western white pine (P. *ponderosa*), sugar pine, and Idaho white pine (P. *monticola*) go largely into sash and doors. Cherry is in great demand for casings and cabinets. The large amount of birch consumed is indicative of a very wide range of uses, but it is generally used in connection with mahogany as an interior finish.

Several woods, including elm, pitch pine, arborvitae, and hickory appear to be rather out of place in this industry because their special qualifications are not those of workability, beautiful grain, and capability to take a high finish; but their presence in small amounts is accounted for by the wide range of the industry, including everything from the repairing of porches in humble cottages to the finishing touches on the most expensive grills in New York City.

This industry more closely utilizes waste than general planing mills located in rural districts. In the large commercial centers the general millwork establishments have very little waste, selling their sawdust, kindling wood, and shavings, and manufacturing very small articles. The best waste lumber is made into cores or fillers for veneered doors, while small strips are made into mouldings, dowels, lattice, etc. Small blocks are turned into brackets, corners, base blocks, carvings, novelties, and brush and mirror backs.

The contribution of New York's forests and woodlots to this industry, which in 1912 was 27 per cent, has fallen in 1919 to less than 7 per cent. Although the total quantity of material used was only about 60 per cent of the amount used in 1912, the cost to the manufacturers was increased by two million dollars, owing to the fact that the average cost per thousand had increased a little over 100 per cent in the period closely following the world war.

TABLE 5

SASH, DOORS, BLINDS, AND GENERAL MILLWORK

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	200,504,000	100.00	$67 49	$13,532,772	13,273,000	187,231,000
White pine	44,689,000	22.28	$60 60	$2,708,153	4,411,000	40,278,000
Cypress	19,707,000	9.83	75 38	1,485,514	....	19,707,000
Southern yellow pine	16,759,000	8.36	58 06	973,028	....	16,759,000
Hemlock	15,332,000	7.65	40 45	620,179	2,163,000	13,169,000
Yellow poplar	14,849,000	7.41	87 74	1,302,851	5,000	14,844,000
White oak	14,607,000	7.29	106 34	1,553,308	883,000	13,724,000
Spruce	13,932,000	6.95	51 56	718,334	361,000	13,571,000
Red gum	11,044,000	5.51	68 37	755,078	....	11,044,000
Chestnut	9,040,000	4.46	73 56	664,982	420,000	8,620,000
Birch	8,504,000	4.25	74 67	634,994	2,018,000	6,486,000
Tupelo	6,025,000	3.00	63 20	380,780	....	6,025,000
Loblolly pine	5,279,000	2.63	62 07	327,668	....	5,279,000
Hard maple	3,966,000	1.98	41 00	162,606	648,000	3,318,000
Douglas fir	3,391,000	1.69	62 89	213,460	....	3,391,000
Basswood	3,031,000	1.52	50 86	154,156	929,000	2,102,000
Sugar pine	2,622,000	1.31	60 70	159,155	....	2,622,000
Western white pine	2,507,000	1.25	81 54	204,421	....	2,507,000
Soft maple	2,085,000	1.04	66 25	138,131	1,083,000	1,002,000
Ash	667,000	.33	53 68	35,805	82,000	585,000
Beech	633,000	.32	40 70	25,763	233,000	400,000
Mahogany	589,000	.29	254 74	150,042	....	589,000
Red oak	510,000	.26	132 63	67,641	....	510,000
Cherry (black)	243,000	.12	167 41	40,681	10,000	233,000
Southern red cedar	150,000	.08	110 00	16,500	....	150,000
Black walnut	125,000	.06	178 23	22,279	....	125,000
Redwood	103,000	.05	75 00	7,725	....	103,000
Western red cedar	35,000	.03	120 00	4,200	....	35,000
Pitch pine	25,000	.02	35 00	875	25,000	....
Butternut	25,000	.02	74 00	1,850	....	25,000
Witch hazel	16,000	.01	75 00	1,200	....	16,000
Elm	10,000	*	46 20	462	2,000	8,000
Arborvitae	2,000	*	200 00	400	....	2,000
Hickory	1,000	*	51 00	51	....	1,000
Circassian walnut	1,000	*	500 00	500	....	1,000

* Less than one-hundredth of one per cent.

FURNITURE

The furniture industry in the State is extremely important, ranking all but the three general industries of boxes, planing mills, and sash, doors, and general mill-work. The kinds of furniture referred to in Table 6 include cabinets, bookcases, chests, bed frames, dressers, chiffoniers, couches, folding beds, davenports, desks, china cabinets, toilet cabinets, buffets, file boards, tool chests, general bedroom furniture, sideboards, tables, table pedestals, wardrobes, divans, cradles, stretchers, filing cabinets, desks, office, bank and store furniture, library, school, and college furniture.

Furniture calls for a great variety of woods of good quality. No industry better illustrates the natural location of wood-working establishments within a State capable of producing the raw materials needed. Most of the 29 species reported can be grown locally. The idle lands of the State could be producing this raw material. This report, however, shows but one quarter of the material as home-grown.

White oak still holds the leading place, as in 1912, in quantity consumed. The wood is strong, hard, with very large pith rays, giving a conspicuous "silver grain" when quarter-sawed. A good deal of white oak enters the furniture trade as quartered stock. Although white oak is preferable in many respects to red oak, since it is less porous and therefore lends itself better to finishing processes, that feature is seldom considered by the ultimate purchaser. Considering the same grades, there is very little difference in price between these two species.

The importance of red gum in the furniture trade is shown by its rise from ninth to second place. Red gum both as plain and quarter-sawed stock is frequently used for imitation mahogany and walnut which are now much in demand. Gum is also used as a core wood for mahogany veneer facing. The average cost of $81.65 per thousand, which is high in comparison with other native hardwoods of similar grade, shows the demand for this wood, once considered a poor material, and also the marvelous way in which it has succeeded in competition with other vanishing species.

Birch, while now taking third place in quantity used, contributes a slightly larger amount than in 1912. New York, however, is supplying a much smaller quantity than seven years ago. This seems strange because birch is one of the principal New York hardwoods. Birch is a splendid wood for furniture and is comparatively cheap, as shown in these tables, because some plants own their stumpage. Its popularity over some other high-grade woods is largely due to the fact that it is used in veneers for imitating mahogany. Birch might well be called a companion of mahogany in the furniture and fixture trade.

Beech has risen to a point of greater importance than formerly in the furniture industry, contributing a large amount at the remarkable price of $29.86. This low figure is due to the fact that such a large amount of the material is home-grown and owned in part by the manufacturers.

Hard maple has lost considerable ground in the furniture trade. Nearly twice as much is imported as is produced in New York. Wisconsin and Michigan supply much maple and birch to this trade. The grain of maple is fine and compact, sometimes containing curly or speckled pith-flecks giving the effect known as birdseye maple. The wood has a satin-like luster, and when cut into veneers is one of the most beautiful of our native species. It is especially attractive as bedroom furniture.

The demand for mahogany-finished furniture in the larger centers, such as the metropolitan district, is exceedingly great. Birch, maple, and gum are frequently stained to represent mahogany.

Yellow poplar is used principally for backing and cores. Drawer bottoms and sides are made chiefly from basswood, red gum, and yellow poplar, while drawer fronts use sugar maple, walnut, oak, birch, and cherry. Mahogany, Circassian walnut, teak, and English oak are the foreign woods entering this industry. These are all very beautiful woods and capable of taking a high polish.

The average price of $80.52 per thousand is rather high in comparison with the other industries. This fact is accounted for by the high grade of stock required and the fact that some furniture stock enters the factory in dimension form.

In addition to the 76,963,000 feet cut up by the furniture trade, a considerable number of million surface feet of hard veneers are used in furniture. This quantity has not been added to the tabulation, which shows only lumber. Birch, gum, oak, mahogany, and black walnut are the important veneers, which form the surfaces of our most expensive furniture.

Inferior species and grades enter the trade as core stock and backing. Some of the quantities reported in the table are used for frames, braces, drawer bottoms and sides, and other invisible parts, using poor stock. "Built-up" (laminated or veneer) material not only gives a rare beauty of grain and figure but makes a stronger article, which is lighter, less liable to warp or split than a solid piece, and at the same time uses inferior pieces to advantage. The use of built-up stock is increasing to a large extent not only because of the call for stronger material, but also on account of the necessity of closer utilization.

Wormy chestnut is no doubt the species used to the greatest extent as core wood, because the small holes in the chestnut which make it unsightly for exterior use, give extra holding strength to the glue, and for that reason are actually a desirable feature.

A few concerns in New York devote most of their time to the manufacture of built-up panels which are utilized by the furniture and fixture trades to a large extent.

The number of firms reporting in 1919 is 31 per cent less than in 1912. The total consumption of lumber by this industry has decreased 26 per cent. These figures seem to indicate that the industries though smaller in number are individually of about the same size as to lumber consumption. New species entering into the industry are witch hazel, hickory, arborvitae, and teak.

One correspondent wrote that on account of the increased cost of labor, power, and rent it had been necessary to discontinue practically all of his manufacturing from raw material and to work upon completed or semi-completed furniture imported from other States. This was an instance illustrating the effect of the war combined with the excessive price of hardwoods, which cost almost 100 per cent more in 1919 than in 1912. A few months later, in February, 1920, gum was sold at $195 per M. and quartered oak at $400 per M. wholesale. Yet there was no great decrease in the demand for luxury products. The main problem of the dealers was to obtain the goods.

TABLE 6

FURNITURE

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	76,963,000	100.00	$80 52	$6,197,300	15,828,000	61,135,000
White oak	14,484,000	18.82	$104 92	$1,519,661	$435,000	14,049,000
Red gum	12,530,000	16.28	81 65	1,023,070	....	12,530,000
Birch	10,393,000	13.50	52 48	545,525	4,944,000	5,449,000
Chestnut	9,297,000	12.08	49 06	456,111	94,000	9,203,000
Beech	6,175,000	8.02	29 86	184,385	4,689,000	1,486,000
Hard maple	4,987,000	6.48	52 23	260,471	3,242,000	1,745,000
Mahogany	4,398,000	5.71	204 96	901,414	....	4,398,000
Yellow poplar	4,250,000	5.52	52 94	224,995	22,000	4,228,000
Black walnut	2,512,000	3.26	215 71	541,864	2,000	2,510,000
Basswood	1,534,000	1.99	57 62	88,389	890,000	644,000
Southern red cedar	1,000,000	1.30	125 00	125,000	....	1,000,000
Spruce	931,000	1.21	43 47	40,471	331,000	600,000
Soft maple	820,000	1.07	43 91	36,006	183,000	637,000
Elm	812,000	1.06	46 46	37,726	271,000	541,000
White pine	730,000	.95	45 02	32,865	378,000	352,000
Ash	574,000	.75	67 50	38,745	186,000	388,000
Southern yellow pine	560,000	.73	65 00	36,400	....	560,000
Red oak	543,000	.71	68 39	37,136	100,000	443,000
Cherry (black)	223,000	.29	92 12	20,543	46,000	177,000
Witch hazel	60,000	.08	475 00	28,500	....	60,000
Cypress	53,000	.07	71 13	3,770	....	53,000
Buckeye	37,000	.05	45 00	1,665	....	37,000
Hemlock	15,000	.02	27 50	413	15,000	....
Arborvitae	12,000	.02	91 66	1,100	....	12,000
Circassian walnut	11,000	.01	475 00	5,225	....	11,000
Loblolly pine	10,000	.01	65 00	650	....	10,000
Butternut	8,000	.01	180 00	1,440	....	8,000
Teak	2,000	*	900 00	1,800	....	2,000
English oak	2,000	*	980 00	1,960	....	2,000

* Less than one-hundredth of one per cent.

Ship and Boat Building

Ship and boat building is another important wood-using industry in the State, the consumption of nearly 63 million feet for this purpose placing this branch of trade seventh from the top when considered from the standpoint of quantity of wood consumed annually. New York is normally the leader among the shipbuilding States. Possessing the finest harbor in the world and with the Hudson and other large rivers, the Barge Canal, and the Great Lakes supplying water transportation for passengers and freight from border to border, it is not strange that such craft, ranging in size from enormous battle cruisers and palatial passenger steamers to the innumerable and expensive private yachts, are the product of her shipyards. In fact there is every reason why ship and boat building in this State should stand at the forefront.

In the table southern yellow pine (mainly longleaf) leads, contributing over 50 per cent of the raw material used in the industry. This wood goes largely into ships, its availability in large structural sizes, its strength and hardness recommending it above homegrown woods. White oak is used in large quantities (especially at this period) in construction of wooden shipping for the U. S. Shipping Board. Douglas fir comes entirely across the continent to supply ships with spars, while mahogany, teak, Circassian walnut, lignum-vitae, and balsa (cork) wood are imported from foreign countries, the balsa being important in the equipment of boats with life preservers. The foreign woods are generally used for decorative parts of ships and yachts, but not always so. Lignumvitae, for example, is used for steering wheels, tackleblock wheels, and pulleys. Teak is a fine material for wooden decks, as is also white oak, but neither of these woods has been easily obtainable in recent years in lengths desirable for the purpose. Douglas fir is being used as a substitute, as well as southern yellow pine. For this purpose, as well as for planking, the hard pine is preferred to the softer fir because it resists denting better.

For small craft, such as rowboats, the southern white cedar is considered the finest of woods, because it is light, can be struck without serious indentation, resists decay in contact with water, and finishes well. Its capacity to resist splintering when bumped is important.

Ship and boat building is an industry in which substitution has been going on steadily. In larger vessels steel and iron have taken the place of wood to a great extent. For pleasure boats of less than 80 feet in length, however, wood is preferred.

TABLE 7

SHIP AND BOAT BUILDING

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m)
	Feet b. m.	Per cent				
Total	62,815,000	100.00	$65 52	$4,115,727	979,000	61,836,000
Southern yellow pine	32,342,000	51.49	54 86	$1,774,282	....	32,342,000
White oak	9,838,000	15.66	76 09	748,573	676,000	9,162,000
Douglas fir	6,200,000	9.88	43 28	268,336	....	6,200,000
White pine	4,399,000	7.00	85 72	377,082	209,000	4,190,000
Spruce	3,207,000	5.11	59 09	189,502	8,000	3,199,000
Balsa	2,500,000	3.99	110 00	275,000	....	2,500,000
Western white pine	752,000	1.20	82 91	62,348	....	752,000
Sitka spruce	500,000	.80	92 50	46,250	....	500,000
Cypress	493,000	.79	88 61	43,665	....	493,000
Ash	325,000	.52	168 68	54,821	....	325,000
Yellow poplar	320,000	.51	157 23	50,314	....	320,000
Mahogany	292,000	.47	214 14	62,529	....	292,000
Loblolly pine	285,000	.46	67 74	19,306	....	285,000
Arborvitae	258,000	.42	88 85	21,923	25,000	233,000
Southern white cedar	204,000	.33	84 90	17,320	....	204,000
Port Orford cedar	150,000	.24	150 00	22,500	....	150,000
Chestnut	146,000	.23	41 81	6,104	4,000	142,000
Birch	115,000	.18	100 00	11,500	40,000	75,000
Hard maple	102,000	.16	58 27	5,944	5,000	97,000
Hickory	83,000	.13	116 66	9,683	1,000	82,000
Hemlock	53,000	.08	45 00	2,385	....	53,000
Elm	40,000	.06	48 00	1,920	....	40,000
Sugar pine	34,000	.05	101 18	3,440	....	34,000
Butternut	33,000	.05	225 00	7,425	3,000	30,000
Teak	32,000	.05	709 52	22,705	....	32,000
Western red cedar	30,000	.04	95 65	2,870	....	30,000
Locust	23,000	.03	75 00	1,725	....	23,000
Southern red cedar	20,000	.03	90 00	1,800	....	20,000
Tamarack	18,000	.02	52 50	945	....	18,000
Basswood	10,000	.01	170 00	1,700	5,000	5,000
Lignum-vitae	6,000	.01	300 00	900	....	6,000
Red oak	2,000	*	200 00	400	....	2,000
Cherry (black)	2,000	*	175 00	350	2,000	....
Black walnut	1,000	*	180 00	180	1,000	....

* Less than one-hundreth of one per cent.

Small steel vessels are stiff and vibrate so badly that they are much less comfortable for passenger service.

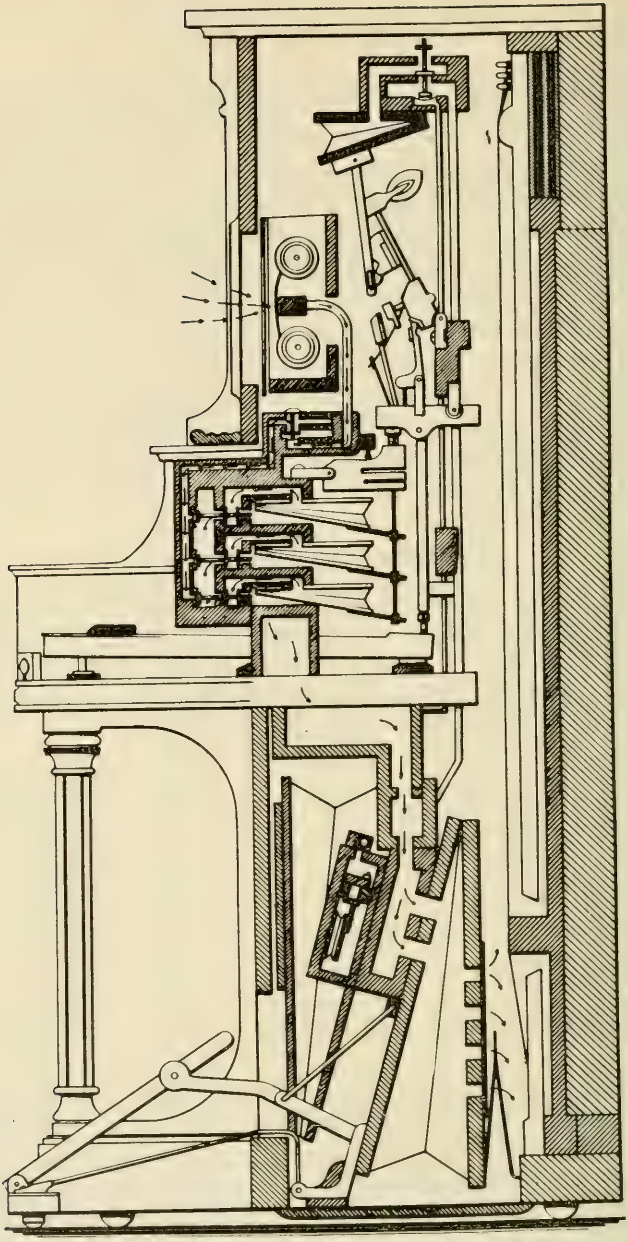
The fact that 34 species are shown in Table 7 is evidence of the varied kinds of water craft produced in New York. Only one-ninth of the raw material is home grown, but this is partly accounted for by the location of the leading plants along New York harbor where shipments by water are very economical from South Atlantic ports, and the exacting nature of some of the requirements. It should be noted that this report was subsequent to the rush period of the World War, during which a much larger quantity of timber and lumber was consumed in construction of the wooden fleet of the U. S. Shipping Board and extension of docking.

Musical Instruments

It is not generally realized that New York is the leading State in the production of musical instruments, her consumption of wood for this purpose being about double that of her closest competitor, Massachusetts. In 1912 the relative standing of the leading States was as follows:

	Feet
New York	58,816,550
Massachusetts	27,463,412
New Jersey	15,582,316
Michigan	12,274,010
Connecticut	11,811,927
Kentucky	8,643,000
Ohio	8,583,000
Pennsylvania	2,945,000

All other States are insignificant in output compared with those named. While the factories of New York produce many kinds of instruments, such as accordions, banjos, drums, flutes, guitars, harps, mandolins, music boxes, phonographs, and violins, the great bulk of wood consumed goes into piano and organ cases and action parts. New York City, Buffalo, North



Arrangement of Parts in a Player Piano

This complicated musical instrument would not be possible if there were no wood. Can you imagine a concrete violin or a cathedral organ built of steel? This world would be a much less enjoyable place without music. Wood is essential to human happiness.

Tonawanda, Rochester, Syracuse, and Utica, are among the important centers of piano and organ manufacture.

The number of active plants in the State is very small compared with the number of firms engaged indirectly in the production of instruments. This is because one active plant, such as a large producer of action parts, will sometimes supply scores of firms with its output. Likewise, one large plant manufacturing piano cases will supply a large number of wholesale assemblers. The piano industry is specialized and the firms engaged in the business are mainly manufacturers of one part of the instrument, such as action, case, or sounding board, while the great majority of wholesale firms are only assembling establishments. New York is also the headquarters for a large number of corporations that have active factories in other States and whose consumption of wood is not included in this study.

Sugar maple is the leading species and contributes over one-fifth of the raw material, one-half of which species is reported as homegrown. It is one of the high-grade woods required by the industry, and no doubt its local abundance is one of the reasons for the concentration of the industry in the State.

The industry consumes a great variety of woods, but most of them are used to meet the various styles in cases. Such woods as maple, chestnut, white oak, mahogany, birch, walnut, cherry, rosewood, satinwood, Circassian walnut, and others are largely used in the form of veneer for outside finish and give a great variety of styles. Some woods, however, are used because of their special qualifications for certain parts. Spruce, for example, is perhaps the most resonant of woods, and its capability of amplifying sound makes it the most valuable wood for piano sounding boards, organ pipes, and ribbing on smaller instruments, such as guitars and mandolins, as well as for essential parts of violins. One violin maker stated that in order to get old, well-seasoned spruce he was in the habit of buying spruce timbers from old buildings which were being torn down. Rosewood and other foreign woods in the form of veneer are important, supplying much of the material used in guitars and mandolins. Sugar maple and yellow poplar strips are in great demand for banjo necks. White pine is not conspicuous here as in other industries, but a small amount is used for pipes of church organs and bottoms of piano keys. Red gum and sugar maple are especially suitable for action parts and a very large amount is used in this way. White ash, white oak, and red oak, in addition to service for framework of larger instruments, are used for keyboards. White pine also appears in keyboards, maple in bridges and bottoms, gum for cores and trim, yellow poplar for cores and edgings, and spruce for bar stock. Basswood is a favorite for keys, birch is used for key-rails and hammers, beech, elm, and Douglas fir for backs of pianos and organs and small instruments, and beech for bottoms. Mahogany is prominent in the industry, contributing 4,000,000 feet board measure. Its use is very general for veneering in all industries and this amount of lumber represents probably 80,000,000 feet, superficial measurement. One large importing establishment in New York reports a local consumption of several million feet of mahogany logs. This enormous quantity of mahogany is converted largely into standard veneer 1/24 to 1/28 of an inch thick, and much of it goes into the piano and furniture industries in the States of New York, New Jersey, Connecticut, and Massachusetts.

In the recent development of the phonograph business great numbers of these instruments are built by the musical instrument factories, often on the same floors with pianos. Built-up panels and veneer are consumed in vast quantities in this branch of the industry. Practically all of the sounding boards for this industry are furnished by two factories in the Adirondacks. Eastern spruce is as good if not even better than western spruce for sounding boards, as its ring grain is more even. Although western spruce can be obtained in greater widths, narrow strips are preferred, consequently eastern spruce meets this need with the utmost satisfaction. One of the best developed machines in the wood-working industry is found in the plants manufacturing piano parts. Strips of wood are fed in the form of molding and after a series of operations the material comes out at the other end of the machine worked into delicate piano parts. Other industries could profitably introduce specialized machinery such as this on account of the great saving in labor effected and the interchangeability of the finished parts which constitute the product.

Among the more striking features of Table 8 are the enormous amounts of raw material consumed, the variety of woods used, and the relatively large proportion of home-grown woods used. Next to planing-mill products musical instruments consume more material from our own woodlots and forests than any other industry in the list. The annual use in 1919 was

TABLE 8

MUSICAL INSTRUMENTS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	53,569,000	100.00	$89 03	$4,769,358	16,533,000	37,036,000
Hard maple	11,228,000	20.96	$66 31	$744,529	5,736,000	5,492,000
Spruce	8,767,000	16.37	88 23	773,512	5,980,000	2,787,000
Yellow poplar	8,213,000	15.34	89 19	732,517	37,000	8,176,000
Chestnut	7,053,000	13.13	56 79	400,540	238,000	6,815,000
Red gum	5,256,000	9.82	97 11	510,410	....	5,256,000
Mahogany	4,172,000	7.78	208 73	870,822	....	4,172,000
Birch	3,891,000	7.26	62 34	242,565	2,958,000	933,000
White pine	1,443,000	2.69	84 69	122,178	786,000	657,000
White oak	1,181,000	2.22	154 40	182,346	....	1,181,000
Beech	662,000	1.24	64 68	42,818	545,000	117,000
Elm	484,000	.90	69 41	33,594	100,000	384,000
Basswood	353,000	.66	85 74	30,266	103,000	250,000
Sitka spruce	200,000	.38	92 50	18,500	....	200,000
Ash	183,000	.35	83 18	15,222	12,000	171,000
Redwood	89,000	.17	49 12	4,372	....	89,000
Black walnut	78,000	.15	134 09	10,459	1,000	77,000
Soft maple	70,000	.13	50 71	3,549	37,000	33,000
Loblolly pine	65,000	.12	46 46	3,020	....	65,000
Cherry (black)	56,000	.11	140 00	7,840	....	56,000
Douglas fir	43,000	.08	81 84	3,519	....	43,000
Western red cedar	30,000	.06	110 00	3,300	....	30,000
Witch hazel	23,000	.04	66 52	1,530	....	23,000
Rosewood	10,000	.02	900 00	9,000	....	10,000
Sugar pine	8,000	.01	200 00	1,600	....	8,000
Holly (American)	7,000	.01	150 00	1,050	....	7,000
Cypress	3,000	*	65 00	195	....	3,000
Red oak	1,000	*	105 00	105	....	1,000

* Less than one-hundredth of one per cent.

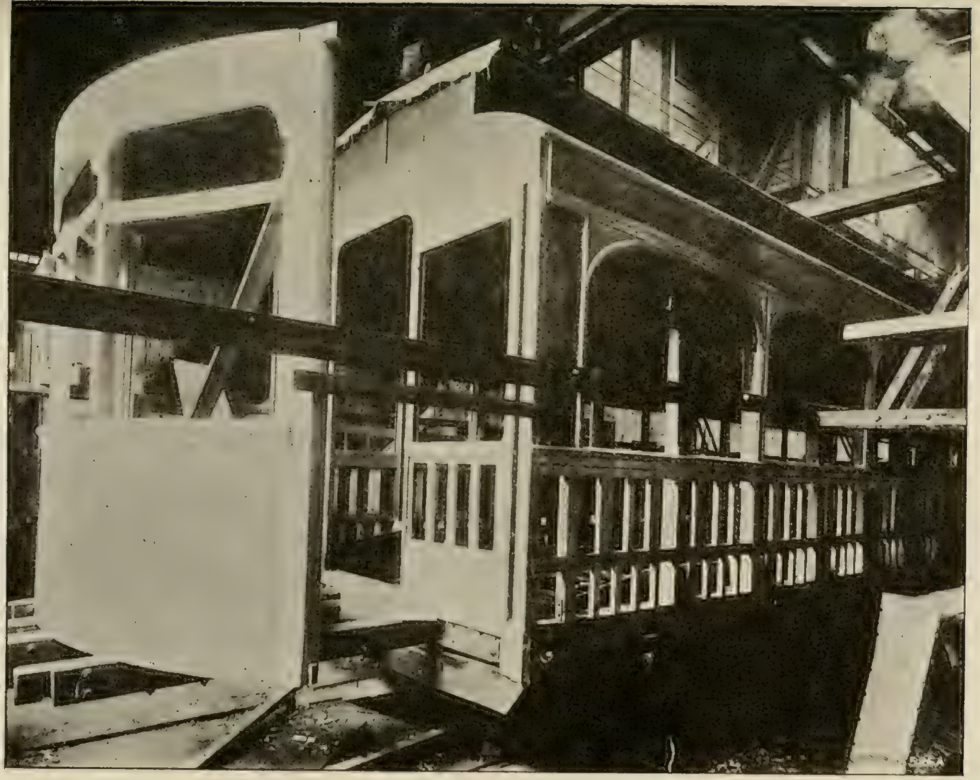
over 16,000,000 feet of local raw material. The average price for the whole industry, $89.03 per thousand, is only exceeded by eight other industries in the State and is indicative of the high class of material demanded for musical instruments.

There is no great waste in the factories. While only the clear stock free from all defects can be used, most of the small ends and blocks can be utilized. Yellow poplar, maple, and gum waste generally can be turned into small parts for interior of pianos, while the waste from the dimension stock of the high-grade woods is used for ornaments, carvings, corners, moldings, etc. The cost of assorting is the great obstacle to economically handling such waste for the production of some valuable by-product.

Car Construction

Car construction is one of the most important wood-using industries in the State. It ranks seventh in the list of industries reporting and consumed 34,476,000 feet of lumber and dimension stock. The wood is used in the manufacture and repair of freight, passenger, Pullman, and baggage cars, and in the cabs of locomotives. Several large railroads have important establishments and repair shops within this State. Some material entering the repair trade comes direct from the mill all worked and is consequently not reported in this industry but has been included with planing mills and general mill work. A large amount of material, especially in dimension form, is used in the maintenance of way; none of this material is reported in this table.

Southern yellow pine contributed about two-thirds of all wood entering this important industry at an average cost of $63.86 per thousand or about $4.50 per thousand less than the average cost for all species. These southern yellow pines find a great variety of uses in the car trade. Especially they are used for heavy framing and construction, siding, flooring, roofing, decking, and grain doors. The oaks are used largely for car frames, posts, and locomotive woodwork. White oak is very



Car Construction

Frame of a street car in course of construction. Wood is still largely used for frames and flooring, notwithstanding the inroads made by steel construction.

important in high-grade repair work where great strength is required. Some specifications demand oak only for the framework of pilots and for passenger-car draft-timbers and sills, while either oak or ash must be used for car trucks. Oak is demanded generally for end sills of tenders and bumper beams of locomotives, car bearers, bolsters, posts, and braces. Spruce is mainly used for running boards. White pine, in addition to general construction uses such as siding and framing, is used for tool boxes, core boxes, and trim. Yellow poplar, one of the higher-priced woods, is used along with mahogany, maple, and the oaks for passenger car finish. The higher-grade quarter-sawed oaks, showing such beautiful grain in interior finish, come from the central western States. Hard maple is used in considerable quantities for car platforms. Douglas fir, like yellow pine, is used for sills and beams where strength is required. Mahogany, supplemented by imitations from birch and other woods, is the principal finish of passenger cars.

The average cost of all woods, $59.32, is lower than in most industries. Among the reasons why the cost of car stock is comparatively low, notwithstanding the fact that a good grade of material is demanded, are that the stock for car repairing need not be dressed and that the railroads can haul stock from distant States without paying heavy charges for transportation.

The form of the raw material is generally rough planks, but much of it is dimension stock for posts, sills, etc. The lengths, widths, and thicknesses of the rough planks are generally cut to order. The standard lengths for car and dimension oak are 8, 9, 10, 12, 14, and 16 feet. Dimension-sawed common oak plank and timbers used for car building purposes must be free from wind shakes, dry rot, rotten knots, or defects which impair the strength of the piece.

While New York contributes but 1,335,000 feet of the raw material, there is a great possibility of developing a splendid market at home. Railroad companies prefer to buy local stock whenever it is available and New York woodlot owners should endeavor to ascertain the form, grade, and species desired by purchasing agents in their vicinity. Only a few of the 18 species needed by the railroads are necessarily purchased abroad and in very small amounts for interior finish. The total expenditure of over $2,000,000 annually by the railroad companies for woods should attract the attention of our local lumbermen and bring about a greater consumption of home-grown mature timber especially along the railroads. The species in order of importance contributed by New York are white oak, birch, hard maple, and red oak; other species contributing but small quantities are yellow poplar, beech, chestnut, basswood, and hemlock.

TABLE 9

CAR CONSTRUCTION

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	34,476,000	100.00	$59 32	$2,045,035	1,335,000	33,141,000
Southern yellow pine	22,652,000	65.71	$63 86	$1,440,557	....	22,652,000
White oak..........	6,564,000	19.03	52 86	346,983	380,000	6,184,000
White pine.........	1,166,000	3.38	55 83	65,098	....	1,166,000
Hard maple........	545,000	1.58	30 41	16,573	270,000	275,000
Yellow poplar.......	531,000	1.54	101 59	53,944	10,000	521,000
Birch..............	530,000	1.53	34 17	18,100	288,000	242,000
Red oak...........	500,000	1.46	40 00	20,000	250,000	250,000
Beech..............	470,000	1.36	30 08	14,138	50,000	420,000
Chestnut...........	452,000	1.31	31 09	14,053	50,000	402,000
Basswood..........	352,000	1.03	30 75	10,824	25,000	327,000
Ash................	220,000	.64	59 38	13,064	....	220,000
Spruce.............	213,000	.62	41 01	8,735	....	213.000
Douglas fir.........	128,000	.37	32 00	4,096	....	128,000
Western white pine..	50,000	.15	135 00	6,750	....	50,000
Mahogany..........	28,000	.08	215 00	6,020	....	28,000
Red pine...........	25,000	.07	120 00	3,000	....	25,000
Hemlock...........	25,000	.07	34 00	850	12,000	13,000
Cypress............	25,000	.07	90 00	2,250	....	25,000

The total quantity of lumber reported by the car trade is but one-half the amount in 1912. This decrease is due to a smaller number of establishments in the State, to the excessive cost of labor and materials, and to the displacement of wood by metal. It is a fact that steel has forged ahead tremendously as a car-building material within the past ten years. "The Railroad Tie Producer" for March, 1920, quotes an authority as saying that, because of a lack of 500,000 freight cars, it will take the car manufacturing plants at full time three years to catch up with the demand for new cars. This statement indicates that in the near future the car industries will be calling for a greater quantity of wood than was used in 1919.

Shade and Map Rollers

Table 10 refers to curtain poles, rug poles, map rollers, and shade rollers, the consumption of such articles being 29,946,000 feet annually. The manufacture of shade rollers is a special line, and several firms are engaged exclusively in the production of this article. A large part of the white pine reported is used by such establishments. Some plants are equipped only to manufacture shade roller blanks bored and fitted to receive the spring. The dimensions of shade rollers used in large quantities are 15/16 of an inch in diameter and 36¼ to 42 inches in length, bored in one end to a depth of 9 inches to receive the spring and chamfered on the same end to receive the ferrule. The raw material is largely shipped in from Canada and is well-seasoned and kiln-dried white pine. Some of the rollers are made of two pieces and joined together with a plug splice which is, of course, glued. Local manufacturers have for years reported a scarcity of suitable clear stock. There is no reason why the clear, soft, light, white, nonresinous, workable white pine of New York's forests should not supply all their needs, if it were always available in sufficient quantities.

TABLE 10

Shade and Map Rollers

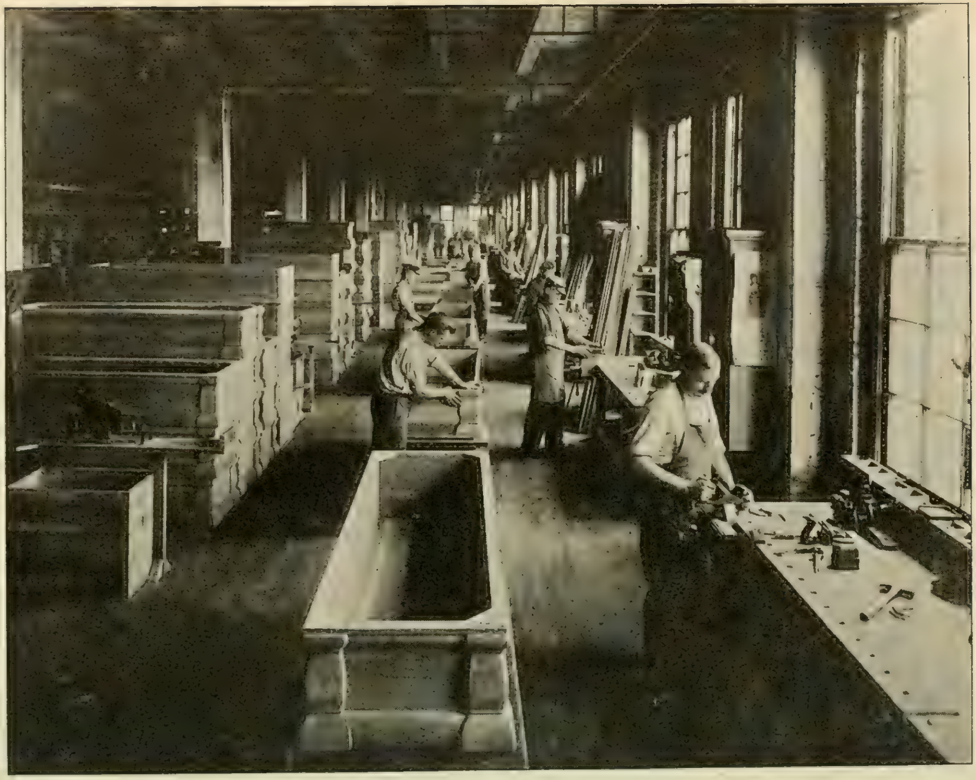
Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Tota	29,946,000	100.00	$44 23	$1,324,434	2,523,000	27,423,000
White pine	26,226,000	87.57	$44 40	$1,164,434	1,923,000	24,303,000
Basswood	1,100,000	3.67	42 00	46,200	100,000	1,000,000
Red pine	1,000,000	3.34	42 00	42,000	....	1,000,000
Spruce	1,000,000	3.34	42 00	42,000	....	1,000,000
Hard maple	250,000	.84	45 00	11,250	250,000	....
Beech	250,000	.84	45 00	11,250	250,000	....
Red gum	100,000	.34	55 00	5,500	....	100,000
Ash	20,000	.06	90 00	1,800	....	20,000

The hardwoods contribute the raw material for the curtain poles and trimming. Red gum is used exclusively for curtain poles, while basswood is used only for rug poles. Beech, ash, and sugar maple contribute to the production of both curtain and rug poles, but the principal raw material used for rug poles is beech. In 8 years this industry has undergone a tremendous expansion, as twenty times as much is now consumed in a single year as was reported in 1912.

Caskets and Coffins

Twenty-two woods are consumed locally for the production of caskets and coffins, and 29,230,000 feet of raw material brought an average price of $65 per thousand during the high-market period of 1919. The industry includes not only caskets but also the rough outer boxes, which explains the use of a large quantity of very ordinary wood. The more expensive veneers, such as mahogany, are imported from the tropics for the outside finish of the highest-grade caskets.

Two styles of caskets are made, usually the finest class being finished in natural wood, while the others are covered with dark woolen cloth. Since the cloth-covered caskets are in more general use, the woods which are suitable for this purpose include chestnut and white pine, the principal species contributing to the industry. Chestnut has the capacity to resist decay and contributes more than 50 per cent of the raw material for the whole industry. Some of the larger factories depend almost entirely upon chestnut and white pine. Because chestnut resists decay and because minor defects, such as worm holes, do not interfere with usefulness in this industry, its utilization in the form of very low-grade stock is possible. The standard grade known as "sound wormy" is consumed in very large quantities and at prices well below the average for the industry Well selected high-grade chestnut stock is sometimes used as outside material, but generally it is used as a backing with a veneer of the more expensive woods or as the body of the cloth-covered coffins. Mahogany and yellow poplar, white and red oak, and birch are all popular woods for the outside finish.



Caskets and Coffins

The assembling room of a casket factory. An eminent authority remarks that human beings are surrounded, from the cradle to the grave, by essential articles made of wood.

TABLE 11

CASKETS AND COFFINS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	29,230,000	100.00	$65 41	$1,911,838	360,000	28,870,000
Chestnut	15,689,000	53.67	$56 40	$874,860	150,000	15,539,000
White pine	5,983,000	20.47	62 72	376,254	....	5,983,000
Red oak	1,704,000	5.83	106 74	183,485	....	1,704,000
Western white pine	1,677,000	5.74	52 10	87,372	....	1,677,000
White oak	1,340,000	4.58	90 73	121,578	....	1,340,000
Cypress	978,000	3.35	71 68	70,103	....	978,000
Mahogany	656,000	2.24	174 68	114,590	....	656,000
Yellow poplar	298,000	1.02	69 54	20,723	....	298,000
Redwood	247,000	.85	64 93	16,038	....	247,000
Spruce	125,000	.43	48 00	6,000	....	125,000
Birch	115,000	.39	70 00	8,050	95,000	20,000
Basswood	100,000	.34	73 00	7,300	100,000	....
Black walnut	53,000	.19	119 62	6,340	....	53,000
Douglas fir	50,000	.17	70 00	3,500	....	50,000
Southern yellow pine	50,000	.17	59 00	2,950	....	50,000
Buckeye	44,000	.15	67 50	2,970	....	44,000
Tupelo	30,000	.10	60 00	1,800	....	30,000
Southern red cedar	26,000	.09	135 00	3,510	....	26,000
Ash	25,000	.08	65 00	1,625	....	25,000
Hard maple	20,000	.07	72 00	1,440	....	20,000
Beech	15,000	.05	60 00	900	15,000	....
Red gum	5,000	.02	90 00	450	....	5,000

For the outer boxes and shipping cases white pine, yellow pine, and yellow poplar are generally used. Cypress is also used on account of its resistance to decay in contact with the soil, and throughout the United States it is one of the principal casket woods. Red cedar, like cypress, is one of the most enduring woods. It has the further recommendations of holding its form well, taking a pleasing finish, and having an agreeable odor. The comparatively small amount used at this time is evidence of the scarcity of the wood, as it formerly was extensively employed everywhere for the burial of the dead. Two million feet of California redwood finds its way across the continent for use in this industry on account of its ability to resist decay in contact with the soil, and it is supplied at a price below the average. Black walnut is, on account of its workable qualities, a desirable material but too scarce and expensive to be utilized to a large extent. With the exception of southern red cedar, it is the most expensive native wood used in the industry. There is much chestnut in the woodlots of New York that might be utilized in the casket and coffin industry were it not for the fact that the large corporations in the business generally prefer to obtain their stock from wholesalers located in the larger timber areas of West Virginia, Kentucky, and North Carolina. Chestnut which has suffered chestnut blight makes very satisfactory material.

Large factories are located in New York, Brooklyn, Buffalo, Rochester, Elmira, Oneida, Syracuse, Webster, and other points throughout the State.

Chairs

Table 12 accounts for 22,300,000 feet of raw material consumed. This industry is really a part of the furniture manufacture; but certain manufactories make a specialty of chairs, and it is possible to fairly well distinguish these plants from the general furniture establishments. Hardwoods contribute almost all of the woods going into chairs. The seats and backs are generally of veneer and manufactured as a separate commodity by some factories. Usually three sheets of thin veneer are glued together, and the articles are generally perforated. Such built-up stock for three-ply seats and backs, having the grain of the middle sheet at right angles to those on the outside is much stronger than a solid wood construction of the same thickness.

New York turns out all kinds of chairs, from the cheapest camp chairs to the finest office and lodge furniture. Mahogany and black walnut are the most expensive woods employed, and beech is the cheapest. The rather low price, as reported in this table, is due to the fact that one of the largest firms using several million feet of Adirondack hardwoods, owns its stumpage. This is an example for the trade. There is no insurance against a wave of high prices that can compare with the ownership of forest land. To some extent the employment of standard dimension stock also helps to keep moderate the price of this class of lumber. Other classes of furniture change so rapidly in styles and forms, as fashion may dictate, that it is difficult to conduct a furniture factory on an economical basis of production. The chair industry is not wasteful, the plants being able to utilize very small pieces. This is an industry in which home-grown material predominates on account of the relatively large amounts of birch, maple, and beech employed. Nearly 60 per cent of the chair stock reported was grown in New York State.

The chair industry has within the past 10 years become highly specialized. There are three distinct divisions: First, the manufacture of chairs of the cheapest variety, such as kitchen chairs, dining-room chairs, nursery chairs, and living-room chairs made to meet the demand for the lowest priced article that can be produced; second, the manufacture of a medium grade of chairs for living room, library, and parlor use which are known to the trade as "fancy chairs"; third, the manufacture of chairs which are partly or entirely covered with upholstery, which are known to the trade as "upholstered chairs." The latter division, however, can not be clearly defined because all three classes use more or less upholstering in their product. The first class employs beech, gum, and maple to a large extent. The second class uses principally birch, gum, and mahogany. The third class employs birch and mahogany for the exposed parts of the frame, while those parts which are upholstered are made largely of sound wormy chestnut and of elm, beech, and maple. The use of built-up veneered seats and backs is largely confined to the first or cheapest class and to the manufacture of store and railroad station furniture, such as settees. Chairs designed for the furnishing of school rooms are of special models suitable for the purpose and are made largely of oak, but to some extent employ the veneered seat.

TABLE 12

CHAIRS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	22,318,000	100.00	$58 35	$1,302,410	13,073,000	9,245,000
Birch	4,938,000	22.13	$48 05	$237,271	2,349,000	2,589,000
Hard maple	4,270,000	19.13	45 49	194,192	4,055,000	215,000
Beech	3,270,000	14.65	34 71	113,502	3,270,000	....
White oak	3,212,000	14.38	93 10	299,037	250,000	2,962,000
Elm	1,686,000	7.55	39 25	66,175	930,000	756,000
Basswood	1,128,000	5.06	39 82	44,917	1,086,000	42,000
Red gum	1,070,000	4.80	79 23	84,776	....	1,070,000
Mahogany	795,000	3.56	191 32	152,099	....	795,000
Cherry (black)	783,000	3.51	39 79	31,156	760,000	23,000
Ash	610,000	2.73	48 68	29,695	348,000	262,000
Red oak	276,000	1.24	77 63	21,426	....	276,000
Black walnut	185,000	.83	129 65	23,985	....	185,000
Buckeye	38,000	.17	45 00	1,710	....	38,000
Spruce	30,000	.14	40 00	1,200	....	30,000
Chestnut	27,000	.12	47 00	1,269	25,000	2,000

MOTOR VEHICLES

The phenomenal increase in the use of motor-driven vehicles has so outstripped the manufacture of horse-drawn vehicles that the wood consumption of each line of industry is tabulated separately for the first time in this study. Trade statistics show that in New York the ratio of motor vehicles to population is now 1 to 19.12, while in the United States the ratio is 1 to 14.14. Canada comes next in order with a ratio of 1 to 21.

In 1919 the manufacturers of automobiles, trucks, auto bodies, truck bodies and wheels, together with the repairers of motor-driven vehicles report the consumption of 20,813,000 feet of wood. The high grades necessary for this exacting service are indicated by the very high average price of $101.08 per thousand paid for the raw material.

White ash with a consumption of over 7,000,000 feet or 35 per cent of the total is the wood in greatest demand. Northern grown ash has qualities of toughness and resiliency which render it matchless for the purpose. It is the king of woods for the motor industry, being used for more purposes as well as in greater quantity than any other. Several manufacturers note their appreciation of this wood and regret that a larger supply is not available having the qualities of that grown in New York. It appears in the bentwood bows for tops, seats, bodies, wheels, and even in the chassis of certain well known cars. Maple and oak go into bodies of both pleasure cars and trucks, with paneling of ash, oak, maple, elm, and poplar. Seats are of yellow poplar, oak, and ash. Bodies of heavy trucks have frames of oak, maple, and yellow pine, with flooring and steering-wheel rims of maple. Hickory, ash, and oak are the main components of motor wheels, and here again the makers call for a larger supply of New York-grown hickory, as well as basswood for panels. In the bodies of light trucks and in repairs, the other species mentioned are all utilized, except mahogany which is reserved for trimmings of the finest touring cars. Rosewood, though not tabulated, is also used for this purpose.

Recently the Forest Service canvassed all the automobile manufacturers of the United States, asking what woods were best adapted to the different parts of the wooden construction. The following table is a condensation of the major part of the replies received. The figures opposite each species indicate the number of makers who choose that wood for the purpose at the top of the column.

Woods Chosen by Manufacturers of Automobiles and the Purposes to which They Are Adapted

	Spokes	Rims	Body Parts		Door frames	Floor boards	Seat boxes	Running boards	Top bows
			Straight	Bent					
Ash	3	7	41	28	36	26	11	16	33
Oak	....	7	23	10	10	27	14	13	26
Elm	....	4	15	23	15	......	9	1	6
Maple	....	....	22	....	18	15	5	4	.....
Gum	....	....	6	2	2	5	6	2	1
Yellow poplar	....	....	9	1	2	7	19	......	.....
Hickory	55	43	......	1	......	......	......	......	5

The heavy majority in favor of hickory for spokes should be noted. The failing supply of this wood has resulted in the application of much inventive genius to the evolution of wheels which could dispense with hickory. Wheels made of steel disks are seen not infrequently, and other plans are being tried, notably along the line of laminated wooden construction.

The repair of motor cars and trucks and the building of delivery bodies adapted to transform old automobiles into light trucks constitute an enormous business, which occupies many of the shops and the men who were formerly in the wagon-building and repair trade. The 566,511 motor vehicles reported in New York State will continue to require great amounts yearly of ash, oak, hickory, maple, elm, and basswood. The racking strains of motor service demand the finest quality of wood to be had, both for repairs and in new cars and trucks.

Out of the 19 species tabulated 14 can nowhere else be grown to better advantage for quality than in New York. Yet the

TABLE 13

MOTOR VEHICLES

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b m.	Per cent				
Total	20,813,000	100.00	$101 08	$2,103,699	5,592,000	15,221,000
Ash	7,322,000	35.18	$140 77	$1,030,718	2,329,000	4,993,000
Hard maple	3,126,000	15.02	87 99	275,057	789,000	2,337,000
White oak	2,905,000	13.96	105 63	225,855	681,000	2,224,000
Yellow poplar	1,319,000	6.34	116 48	153,637	12,000	1,307,000
Southern yellow pine	1,204,000	5.78	71 44	86,014	....	1,204,000
Birch	1,151,000	5.53	60 95	70,153	1,000,000	151,000
Basswood	860,000	4.13	66 72	57,379	313,000	547,000
Hickory	831,000	3.99	100.14	83,216	165,000	666,000
Spruce	536,000	2.58	83 04	44,509	4,000	532,000
Red gum	424,000	2.04	38 81	16,455	....	424,000
Beech	400,000	1.92	40 00	16,000	160,000	240,000
Loblolly pine	314,000	1.51	38 61	12,124	....	314,000
Elm	143,000	.69	65 11	9,311	37,000	106,000
White pine	105,000	.50	90 00	9,450	....	105,000
Red oak	100,000	.48	60 00	6,000	100,000	....
Cypress	38,000	.18	99 82	3,793	....	38,000
Cottonwood	25,000	.12	60 00	1,500	....	25,000
Mahogany	8,000	.04	300 00	2,400	....	8,000
Chestnut	2,000	.01	64 00	128	2,000	....

State produced only one-fourth of the total amount consumed This would seem the finest opportunity possible for the owners of New York woodlots to keep within the State nearly $1,500,-000 which was paid out to other States for wood used in motor vehicles.

Agricultural Implements

New York is prominent in the manufacture of agricultural implements. The factories cover a broad field of activity, producing general agricultural implements, such as threshers, binders, corn cutters, cultivators, drills, ensilage cutters, grain cradles, harrows, harvesters, hay loaders, hay racks, hay tedders, hay presses, hoppers, lawn mowers, planters, plows, spreaders, windmills, etc. This industry is closely related with handles and vehicles in that most of the material going into the agricultural-implement stock consists of vehicle poles, singletrees, whiffletrees, or handles for articles such as plows, cultivators, and drills, while only the conveying or vehicle parts consist of wood. The manufacture of agricultural implements in the State is extremely important, the amount of wood consumed being only a small proportion of the raw material used in the production of the finished article. The total consumption amounts to 19,000,000 feet annually and the average price paid by the manufacturers $62.83 per thousand feet in 1919. About one-third of the raw material is home-grown and the various establishments are so generally distributed over the State that woodlot owners are in a position to supply the needs of factories at their doors without heavy transportation charges.

The southern pines have superseded maple in first place since 1912, relative to quantity consumed. Longleaf pine is imported in large quantities for use as implement poles, where its strength makes it a desirable material.

Sugar maple is consumed in larger quantities than any other wood except yellow pine, and is used largely for singletrees, neck yokes, eveners, drill frames, lawn mower handles, drill boxes, and seed boxes of general agricultural implements. Its hardness recommends it also for ensilage cutter frames and cutter blocks. Two-thirds of the sugar maple used in the industry is home-grown.

White oak is needed for the framework of articles such as hay presses and hay racks, and as beams for handles. Ash takes its place in the handle parts of cultivators and along with oak in plow beams, plow handles, and tanks of the heavier farm machinery. Many of the woods, such as spruce, basswood, beech, white pine, hemlock, and yellow poplar, have no special qualifications for a particular use in the industry but are used indiscriminately for all kinds of framework.

Red gum is imported in large quantities and finds use mainly as box material in threshing machines and other smaller articles.

Hickory is used for maul and hay fork handles and for repair work of vehicles, especially the replacing of spokes. A small amount is used for rods connected with threshing

TABLE 14

AGRICULTURAL IMPLEMENTS

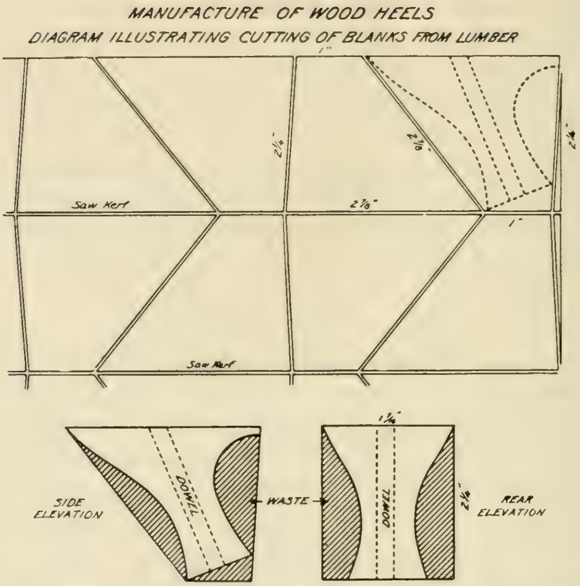
KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	19,064,000	100.00	$62 88	$1,197,890	6,551,000	12,513,000
Southern yellow pine	4,117,000	21.60	$80 97	$333,353	....	4,117,000
Hard maple	3,495,000	18.33	63 06	220,395	2,390,000	1,105,000
Spruce	2,620,000	13.74	38 00	99,560	20,000	2,600,000
Birch	1,427,000	7.49	55 17	78,728	1,290,000	137,000
White oak	1,308,000	6.86	71 71	93,797	866,000	442,000
Basswood	1,271,000	6.67	71 52	90,900	178,000	1,093,000
White pine	1,265,000	6.64	43 82	55,432	352,000	913,000
Beech	1,238,000	6.49	45 06	55,784	1,127,000	111,000
Ash	348,000	1.83	74 42	25,898	188,000	160,000
Elm	340,000	1.78	66 04	22,454	75,000	265,000
Yellow poplar	319,000	1.67	76 51	24,407	....	319,000
Western white pine	300,000	1.57	70 00	21,000	....	300,000
Cottonwood	270,000	1.42	70 55	19,049	....	270,000
Hemlock	165,000	.87	40 00	6,600	65,000	100,000
Red gum	165,000	.87	79 70	13,151	....	165,000
Hickory	125,000	.66	87 00	10,875	....	125,000
Cypress	116,000	.60	71 40	8,282	....	116,000
Loblolly pine	100,000	.52	130 00	13,000	....	100,000
Douglas fir	50,000	.26	82 00	4,100	....	50,000
Chestnut	25,000	.13	45 00	1,125	....	25,000

machines, where extreme toughness and capacity to resist shock are essential properties. A small amount of bald cypress is imported into the State and is used principally for tanks in the threshing line. Elm is used chiefly for hay racks and ensilage cutter frames. Hickory is the highest-priced wood consumed in the industry, the entirely disproportionate price tabulated for loblolly pine being caused by a freak of the market at a time when astonishing prices were paid occasionally for material to keep factories up to the demand.

Boot and Shoe Findings

Boot and shoe findings include principally lasts, last blocks, shoe forms, shoe trees, fillers, and pegs. Sugar maple is the principal last stock for all factories and contributes 90 per cent of the wood used. The list of last woods includes persimmon and beech, but these woods are not important in the industry. Basswood is used occasionally for lasts, generally as a filler, in the blocks, and for hollow forms. Sugar maple so admirably meets the requirements of the last industry that comparatively little other wood is used. All the woods used are home-grown except persimmon, which is brought from Arkansas, Tennessee, and other States. The short haul and the use of bolts or logs at the factory instead of rough-turned last blocks are factors of great aid in keeping down the cost of the high-grade wood demanded. Maple is preferred because it is hard, smooth-grained, tough, capable of high polish, does not warp or shrink, holds metal clamps well, and resists the severe wear to which it is subjected. The fact that New York's woodlots and forests contribute 84 per cent of the maple consumed in the manufacture of lasts is evidence of the natural economic location of these factories. The industry is growing and will need all the bolts and rough dimension blocks available from our local woods.

One of the features of remark in this industry is the increase of factories making wooden heels for women's shoes, of which there are about 15 in New York and Brooklyn. This branch of the industry demands large quantities of high-grade hard



Boot and Shoe Findings

Successive steps in manufacture of a wood heel.

maple which is cut into small blocks before being fed to turning machinery. The waste in turning amounts to 70 per cent or more on account of the deeply curved surfaces. This is apparently a line of work which might use to advantage clear maple blocks, the by-product from other industries.

As seen in one factory the procedure is as follows: The raw material consists of rough hard maple, No. 1 Common, 12 inches wide and 1-7/16 inches in thickness. The planks are sawed lengthwise into strips 2¼ inches wide, and these strips are then cut off into blocks of dimensions which will just enclose the largest size of heel. The diagram above illustrates the plan on which the sawing is done, while figure 1 in the illustration shows the block immediately after it has been sawed. These blocks are taken one at a time by workmen and fed into a machine which quickly cuts out the curved surface of the front face of the heel, as shown in figure 2. The block is then fed to a second machine in which it passes before curved revolving knives. These produce the graceful curved surfaces of the rear side of the heel, leaving it with the usual narrow neck. This neck is a weak spot, and although care is taken to have the grain of the wood follow the most advantageous planes, there would not be sufficient strength to withstand the strains to which a heel is subjected if it were not for the additional stiffness rendered by the dowel shown in figure 4. A hole is bored vertically through the heel, and the dowel dipped in glue and driven into the hole as shown in figure 5. Following this process the bearing surface of the heel is sawed off, dowel and all, at the proper plane to meet the ground squarely in the act of walking, as illustrated in figure 6. In this stage the upper surface of the heel is flat, which would be uncomfortable to the foot of the wearer. Therefore it is passed through another machine which produces a suitable hollow to receive the heel of the wearer as shown in figure 7. Figure 8 shows the small piece of sole leather which is used as a cap to receive the wear of the pavement and also aid in preventing splitting in the vertical plane. This is put in place and fastened securely with a screw and several nails. In figure 9 we see the finished heel, which has been covered with an enameled metal jacket, or else with leather, as in the case of white kid heels. The heels are then assorted for size, wrapped in tissue paper, and packed in paper boxes for sale to users of boot and shoe findings.

The statement is made by manufacturers that approximately 60 per cent of the wood purchased goes into waste, but as far as might be judged by noting the reduction in weight from a block to a finished heel, 78 per cent of the block goes into chips, in addition to the considerable loss resulting from the numerous saw kerfs when the plank is cut into blocks. In the diagram, figure 2 is a side elevation of one of the blocks, the shaded portion indicating the part which is cut away by the machines and goes into waste. Figure 3 is a rear elevation of the same block indicating the waste in that plane. It would seem probable that only about one-fourth of the lumber purchased for this industry ever becomes part of the finished product. The rest is chips and sawdust.

TABLE 15

BOOT AND SHOE FINDINGS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	14,705,000	100.00	$65 44	$962,280	12,465,000	2,240,000
Hard maple	13,090,000	89.01	$66 15	$865,903	10,960,000	2,130,000
Basswood	1,055,000	7.17	56 22	59,312	1,050,000	5,000
Beech	385,000	2.61	52 00	20,020	385,000	....
Persimmon	105,000	.72	123 71	12,990	....	105,000
Birch	40,000	.27	73 00	2,920	40,000	....
Elm	25,000	.18	35 00	875	25,000	....
Hickory	5,000	.04	52 00	260	5,000	....

In view of the large percentage of waste, this industry would seem to be one in which the waste hardwood blocks from other industries might be utilized to advantage, because the increasing price of material might now warrant the sorting, shipping, and resawing.

Matches

Wood for the production of matches and match splints must be easily worked and capable of producing a moderate flame and must also have the capacity of holding the dipping material well. Many types of machinery are used for match making. To produce the matches, the boxes into which they are packed and the labeling of boxes requires a very ingenious mechanism. There must be machines for cutting the lumber into strips and small blocks, for dipping the sticks, drying the matches, and packing and labeling the boxes. Some inventors have devoted the whole of their lives to the perfection of apparatus for the manufacture of matches. It is reported that the machine for filling the boxes with sticks alone took ten years' time of one skilled inventor.

The United States is the only country in the world which makes and uses a round match. For this purpose white pine is used in great quantities by large match factories in the northern portion of the State. This industry calls for 2-inch boards or deals of clear stock free from all defects, and it is largely shipped from Canada, the Lake States, and the far West. The soft wood of clear white pine is necessary for this process because the machines in common practice punch the sticks from blocks of the proper length.

The square matches of the "safety" type, which are commonly used throughout foreign countries, and to an increasing extent in the United States, are made by turning logs into veneer and then chopping the veneer into suitable sizes for the splints. Basswood and aspen are the species mainly employed, derived from Canada, New York, and Vermont. No aspen was reported in 1919.

The subsequent process of placing the chemical tip on the splints is carried on in specialized factories, which also make up the boxes from veneer and paper. The United States produces its own square matches to some extent but imports over 5,000,000 gross of boxes annually from Scandinavia, Japan, and other foreign countries, where very many styles of matches and match-box attachments are produced. New York, however, uses many millions of feet of lumber in her own factories for the production of matches and vies with other States for first place in the industry. Square match splints are exported to England, France, Mexico, Venezuela, and other South American countries. The use of spruce in the industry is accounted for by the consumption of veneer in the manufacture of the match boxes. The average price of $52.32 per M. quoted in the table is very moderate, as it is known that white pine of high grade cost up to $200 per M. at the period of this report and shortly thereafter, while the other species, in the log, went as high as $80. The most remarkable aspect of the situation in this industry is that New York State should be compelled to import all of the white pine and spruce used. Is it not an absurd situation, for a state which once stood foremost in production of these species?

TABLE 16

MATCHES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	14,250,000	100.00	$52 32	$745,500	300,000	13,950,000
White pine.........	10,000,000	70.18	$52 50	$525,000	....	10,000,000
Western white pine..	2,000,000	14.03	52 50	105,000	....	2,000,000
Spruce.............	1,500,000	10.53	50 00	75,000	....	1,500,000
Basswood..........	750,000	5.26	54 00	40,500	300,000	450,000

Woodenware and Novelties

Probably no industry in the whole report contains so many separate, distinct articles of commerce as are tabulated under the above heading of Woodenware and Novelties. The ordinary household articles known as "woodenware" and the more ornamental article known as a "novelty" are not so much confused in their makeup and uses as in their production. Establishments that make one are so frequently manufacturers of both classes of material, consuming similar stock and reporting their consumption of raw material together, that it is not an easy matter to compile the data separately. The best way to outline the scope of this classification is to enumerate many of the articles included in the total of 13,000,000 feet reported in Table 17. The principal wood-consuming products are: Bread boards, buckets, butter dishes, butter moulds, cloth boards, coat hangers, clubs for policemen, cutting boards, scoops, doilies, ladles, door knobs, drain boards, gavels, reels, rolling pins, snow shovels, tent stakes, tent toggles, small tubs, and sugar tubs and boxes. Thus the industry includes all kinds of serving utensils and other culinary articles of the smaller size, together with semi-useful and more ornamental articles such as wooden candle sticks, paper weights, carvings, jewel boxes, etc. Much of the material going into these articles, especially such as dishes, is made of rotary-cut veneer, produced directly from the log, and is very cheap since the finished articles are intended to be used only once and then thrown away. Among such articles are dishes used by grocerymen for the handling of butter and lard. The hardwoods that are cheap, easily veneered, free from odor and stain, are in general demand, the principal contributing species being basswood, beech, and sugar maple. In some novelty lines the softwoods are very important, most of the southern yellow pine and white pine reported going into such articles as small flag poles. The hardwoods, particularly ash and maple, are turned into rustic novelties. The major portion of the consumption of birch, sassafras, and black walnut goes for the production of rustic and other novelties. Ladders are manufactured by many firms, and the principal contributing species are ash, maple, and oak. Most of the ash and maple is used for ladder rungs. The foreign woods are used for carvings of the more ornamental kind and for gavels, police clubs, etc. New York manufacturers expend annually over $250,000 for the raw material going into these small wares and most of this money goes into the purses of the woodlot owners of the State.

TABLE 17

WOODENWARE AND NOVELTIES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	13,745,000	100.00	$39 94	$548,981	9,270,000	4,475,000
Hard maple	4,404,000	32.04	$31 23	$137,537	3,705,000	699,000
Beech	2,649,000	19.27	27 42	72,636	2,568,000	81,000
Birch	2,340,000	17.02	28 70	67,158	2,226,000	114,000
Spruce	1,798,000	13.08	33 42	60,089	75,000	1,723,000
Basswood	746,000	5.43	59 32	44,254	347,000	399,000
White pine	435,000	3.16	69 16	30,085	150,000	285,000
Ash	235,000	1.71	48 65	11,433	106,000	129,000
Yellow poplar	190,000	1.38	66 93	12,717	....	190,000
Loblolly pine	176,000	1.28	32 00	5,632	....	176,000
Mahogany	131,000	.96	250 00	32,750	....	131,000
Lignum-vitae	121,000	.88	300 00	36,300	....	121,000
Southern yellow pine	100,000	.73	100 00	10,000	....	100,000
Cypress	90,000	.65	50 00	4,500	....	90,000
Buckeye	75,000	.55	71 50	5,363	....	75,000
Douglas fir	70,000	.51	68 00	4,760	....	70,000
Cherry (black)	56,000	.41	38 13	2,135	56,000	....
White oak	44,000	.32	117 14	5,154	....	44,000
Elm	37,000	.27	25 81	955	37,000	....
Chestnut	25,000	.18	50 00	1,250	....	25,000
Black walnut	21,000	.15	200 00	4,200	....	21,000
Sassafras	1,000	.01	21 00	21	....	1,000
Arborvitae	1,000	.01	52 00	52	....	1,000

HANDLES

New York, though not a leading State, is an important one in the production of handles. The Lake States and other central western States have the principal factories of the larger well known corporations manufacturing fork, hoe, and axe handles. Nearly every large manufacturing establishment has need for handle stock in one form or another. A number of industries like broom factories and cutlery stock occupy a prominent place. Establishments producing farm tools, files, saws, cutlery, and other metal implements call for a great variety of woods.

Maple and beech lead all species in the amount of wood consumed because the principal handle business from a standpoint of quantity is that of brooms. Broom handles also consume a large amount of birch and white ash. Shovel handles are made largely of sugar maple, while snow shovels consume a great deal of white ash. Axe handles are made of hickory, brush handles of sugar maple, pick and peavy handles of white ash, hickory and yellow birch; while handsaws consume only applewood and beech. Fork and hoe handles are rarely ever made of any wood except white ash, of which a large amount is consumed for this purpose in other States, and most of the two million feet reported in New York goes into these articles. White ash is used for fork and hoe handles because it is tough, strong, and white. Hammer handles are made of hickory generally, this wood being almost indispensable for slender tool handles where strength and elasticity must be combined with toughness. Hickory is used in the rougher forms for mop handles, handrakes, sledge hammers and pick handles, along with white oak, white elm, and ash, where strength and resistance to sudden shock are essential requirements. Handles for coal sieves are made of basswood, beech, soft maple, and white ash. Many of the firms reported several woods under the general use of "handles" and the relative importance of each wood in the production of a given style of handle cannot be accurately determined. Broad conclusions are easily reached, however, relative to the specific uses of such woods as ash and hickory, the former being very generally used here for fork and hoe handles, while hickory is used universally for small tool handles and for axe handles. Saw handles also depend largely upon apple and beech, while the ordinary cutlery or knife handles consume all of the foreign woods such as cocobola, ebony, rosewood, granadilla, and lignum-vitae. Cocobola is rather oily and not subject to much swelling or shrinkage in water and when exposed to heat.

The form of the raw material going into handle factories is so varied, owing to the extremes in the dimensions of the finished articles, that detailed descriptions cannot be given. The class of handles, including the stock for hoes, forks, rakes, spades, and shovels, calls for squares of about 2 to 2½ inches and the extreme length of 5 feet. One large plant producing fork, hoe, and rake handles uses clear white ash in the form of rough squares or strips 1⅝ by 1⅝ inches and 5 feet in length. Saw handles, on the other hand, are made from rectangular squares about 4½ inches wide, 1¼ inches thick, and only 12 inches long, while from this small block two saw handles are cut. Broom handles are usually made from 2-inch squares about 5 feet long. Axe handles call for an entirely different class of raw material, which is generally purchased by the cord and in the form of billets or bolts, either split or in round timbers, and cut 40 inches long. Small tool handles, cooking utensil holders, brush and pump handles, all call for different forms of raw material, according to their special needs.

TABLE 18

HANDLES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	11,986,250	100.00	$37 95	$454,814	11,293,000	693,250
Hard maple	3,402,000	28.38	$31 98	$108,796	3,359,000	43,000
Beech	2,876,000	23.99	32 13	92,406	2,876,000	....
Birch	2,616,000	21.83	30 58	79,997	2,616,000	....
Ash	2,342,000	19.53	49 67	116,327	2,192,000	150,000
Hickory	468,000	3.90	58 57	27,411	16,000	452,000
Basswood	76,000	.63	27 68	2,104	76,000	....
Applewood	33,000	.28	36 36	1,200	33,000	....
Cherry (black)	27,000	.23	35 18	950	20,000	7,000
Yellow poplar	25,000	.21	17 00	425	25,000	....
Spruce	23,000	.19	33 05	760	20,000	3,000
Cocobola	21,000	.18	525 00	11,025	....	21,000
White birch	20,000	.17	20 00	400	20,000	....
Hemlock	20,000	.17	23 00	460	20,000	....
White oak	11,000	.09	100 00	1,100	10,000	1,000
Ebony	11,000	.09	900 00	9,900	....	11,000
Elm	8,000	.07	20 00	160	8,000	....
Black walnut	4,000	.03	92 50	368	2,000	2,000
Granadilla	1,000	.01	400 00	400	....	1,000
Lignum-vitae	1,000	.01	300 00	300	....	1,000
Cypress	1,000	.01	100 00	100	....	1,000
Rosewood	250	*	900 00	225	....	250

* Less than 1/100 of 1 per cent.

There is much waste in some branches of this industry, especially the manufacturing of handle stock from bolts. The public has always demanded an ivory-white axe handle to the exclusion of all heartwood. Specifications calling for all clear sapwood results in extreme waste. Exhaustive experiments conducted by the United States Forest Service have shown red hickory to be just as strong, weight for weight, as white hickory and highly suitable when of proper density for all types of hickory handles. Specifications that cover this point and also the inspection of hickory handles on the basis of rate of growth have been prepared by the Forest Service, and have been adopted by the War and Navy Departments, the Panama Canal Commission, and several of the leading railroads. On the other hand, some lumber mills in this State are manufacturing handles from stock which would otherwise go to the slab pile. The handle industry offers excellent opportunities for the utilization of small waste pieces.

Refrigerators and Kitchen Cabinets

This industry includes ice chests, kitchen cabinets, kitchen safes, dumb-waiters, kitchen counters, ice-cream freezers, and refrigerators. Seventeen species are reported and the consumption amounts to nearly 12,000,000 feet. Five species, chestnut, white oak, red oak, spruce and white pine, contribute over 80 per cent of the raw material.

Table 19 is designed to cover that class of articles used in the storage and preparation of foodstuffs for cooking, excepting the woodenware articles such as tables and spoons. Much of the wooden material used in refrigerators and kitchen cabinets and similar receptacles for food must be free from stain and odor. In addition to these qualities, especially for such uses as inside parts of refrigerators, woods must stand dampness and must scour well and give effective service where constant washing is necessary. Thus woods of quite different qualities are consumed in the production of these articles.

A large percentage of all the lumber used goes into refrigerators. Here, especially for outer parts, the combination of strength and capability of taking a good finish is essential. The oaks are best suited with ash following closely. Outside finish also consumes a small amount of mahogany, maple, birch, and chestnut. Ash and elm are especially suited for slats in refrigerators, for ice counters or frames, where great strength, stiffness, and damp-resistance must be found in slender strips of wood. For inside partitions where the wood is hidden by metal linings, chestnut, spruce, and white pine are generally used. There has been recently a heavy increase in the amount of chestnut used for this purpose. Ordinary ice boxes for cellar use are sometimes made entirely of spruce. Ice-cream freezers are made of redwood, this species coming all the way from the Pacific Coast as the sole raw material going into this article. Ice-cream cabinets are made of the various pines. A large amount of white pine is used for refrigerator backs, and much of the yellow pine reported is also used for this purpose.

The second largest item in the table is that of kitchen cabinets, the rather modern carry-all or storage place for cooking utensils and dry foodstuffs. Generally speaking, the principal species used for this branch of the industry are white oak, red oak, yellow poplar, sugar maple, basswood, birch, red gum, and yellow pine. There is much confusion in the uses of the woods, but the particular uses of some can be pointed out. Red gum, for example, is very generally used for drawer bottoms. Maple, basswood, birch, and ash are generally used for inside construction, and the oaks for exterior finish. A large amount of yellow poplar is consumed for kitchen-cabinet tops.

Spruce is, next to ash, the most important home-grown wood in the industry, and the principal wood used for interior walls and partitions of refrigerators. It is the lowest priced wood in the list.

There is not much waste in this industry. Larger firms report the manufacture of brackets of various kinds from refrigerator dimension stock. Small blocks for brackets, carvings, and turnery for decorative purposes make close utilization of the odds and ends of the valuable domestic and imported woods.

TABLE 19

REFRIGERATORS AND KITCHEN CABINETS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	11,562,000	100.00	$71 59	$827,767	145,000	11,417,000
Chestnut...........	2,665,000	23.04	$77 07	$205,392	....	2,665,000
Red oak...........	2,000,000	17.29	87 00	174,000	....	2,000,000
Spruce............	1,912,000	16.54	41 40	79,157	30,000	1,882,000
White pine.........	1,545,000	13.38	56 81	87,771	....	1,545,000
White oak..........	1,525,000	13.18	98 21	149,770	....	1,525,000
Ash...............	1,085,000	9.38	80 50	87,342	115,000	970,000
Yellow poplar.......	397,000	3.43	47 20	18,738	....	397,000
Western yellow pine.	250,000	2.16	38 00	9,500	....	250,000
Red gum...........	50,000	.43	102 00	5,100	....	50,000
Hemlock...........	32,000	.28	48 00	1,536	....	32,000
Hard maple........	26,000	.23	35 05	911	....	26,000
Cypress............	15,000	.13	71 00	1,065	....	15,000
Black walnut.......	15,000	.13	175 00	2,625	....	15,000
Cherry (black)......	15,000	.13	125 00	1,875	....	15,000
Mahogany.........	10,000	.09	190 00	1,900	....	10,000
Birch..............	10,000	.09	47 00	470	....	10,000
Loblolly............	10,000	.09	61 50	615	....	10,000

FIXTURES

The manufacturers of fixtures consume 26 kinds of wood, using nearly 11,000,000 feet and paying for it the handsome average price of $85.44 per thousand feet f. o. b. factory. The industry is closely allied to those of furniture and interior house finish. The products referred to in Table 20 include articles that are at least temporarily fixed to the interior part of the house and not readily movable like furniture. Fixtures herein tabulated include equipments of banks, offices, stores, lodgerooms and churches and consist of altars, counters, drug cabinets, pews and pulpits, shelving, show cases, blackboards, billiard racks, wall cases, special telephone booths, window seats, specially made desks, tables and racks, glass-and-sash partitions, and other articles made to order for a particular room and not to be used elsewhere. The fixtures occupy a middle place between furniture and interior finish. The latter, when put in place, is permanent and becomes part of the building; fixtures may be moved with more or less remodeling. Still another industry, "General Millwork" overlaps "Fixtures," because many woodworking establishments have included special orders for cheap fixtures in their reports of annual consumption for "General Millwork."

White oak leads all other species in quantity. Under ordinary market conditions oak is one of the most expensive woods, its cost being exceeded only by the cost of black walnut and imported woods such as mahogany, Circassian walnut, and rosewood. Yellow poplar occupies second place and its workableness and smooth, even grain and texture recommend it for backing, shelving, drawers, counters and interior parts of store fixtures. Chestnut is used along with many other cheaper woods for interior frames, shelving, and cores for veneer panels, forming the middle sheets upon which high-grade veneer woods are glued. It is also used for blackboards, mission fixtures, and telephone booths.

Fixtures consume many of the high-grade woods in the form of veneer, the broad panels of show cases and tops of many articles calling for veneers from white oak, red oak, black cherry, mahogany, red gum, black walnut, Circassian walnut, and rosewood for use as outside finish. Sugar maple is used in every way for the exterior parts of store and office fixtures, but by far the larger items are reported for the production of church and school furniture. Birch and cherry are used largely for cabinet work in connection with wall fixtures, but a considerable amount goes into solid parts in imitation of mahogany. Red gum occupies the same position, in imitation of Circassian walnut.

Much of the Circassian walnut used in New York comes from the shores of the Black Sea. Its high price of $800 per thousand feet limits its use to the very finest fixture, furniture, and cabinet work, and it was naturally difficult to obtain during the war period. The wood weighs almost forty-five pounds per cubic foot, is hard, compact, easy to work and split, moderately tough, durable, shrinks little in seasoning, and does not warp or crack. Burled and other highly figured forms of the wood take a beautiful polish.

There are about seventy-five establishments in the State that specialize in the manufacture of fixtures and the industry is an important user of several home-grown species, including white oak, red oak, chestnut, birch, and white pine. Substitution has been general in the industry, the combination of metal strips and glass for show cases having become most extensive. The fixture industry used only half as much wood as in 1912,

TABLE 20

FIXTURES

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	10,739,000	100.00	$85 44	$917,587	1,929,000	8,810,000
White oak	2,023,000	18.83	$135 47	$274,056	120,000	1,903,000
Yellow poplar	1,652,000	15.38	87 95	145,303	....	1,652,000
Birch	1,585,000	14.82	70 68	102,028	432,000	1,153,000
Hard maple	1,125,000	10.48	27 39	30,814	532,000	593,000
Loblolly pine	880,000	8.19	50 49	44,431	....	880,000
Chestnut	600,000	5.58	57 27	34,362	120,000	480,000
Red oak	500,000	4.65	65 00	32,500	500,000	....
Spruce	498,000	4.64	48 10	23,954	75,000	423,000
Mahogany	462,000	4.30	233 63	107,937	....	462,000
Douglas fir	310,000	2.89	51 84	16,070	....	310,000
Basswood	210,000	1.96	50 83	10,674	40,000	170,000
White pine	183,000	1.70	87 99	16,102	42,000	141,000
Cypress	145,000	1.35	55 00	7,975	....	145,000
Red gum	139,000	1.29	150 86	20,970	....	139,000
Black walnut	123,000	1.15	209 09	25,718	....	123,000
Cherry (black)	79,000	.74	22 50	1,778	....	79,000
Soft maple	75,000	.69	52 00	3,900	25,000	50,000
Southern yellow pine	72,000	.67	197 22	14,200	....	72,000
Ash	39,000	.36	32 82	1,280	35,000	4,000
Buckeye	20,000	.18	52 00	1,040	....	20,000
Hemlock	8,000	.07	35 00	280	8,000	....
Butternut	5,000	.04	75 00	375	....	5,000
Southern red cedar	2,000	.02	110 00	220	....	2,000
Witchhazel	2,000	.02	160 00	320	....	2,000
Rosewood	1,000	*	500 00	500	....	1,000
Circassian walnut	1,000	*	800 00	800	....	1,000

* Less than 1/100 of one per cent.

but the cost of the material was nearly as great. No doubt the high cost of wood as well as the decrease in demand for barroom fixtures had a great deal to do with the apparent shrinkage of the industry.

Professional and Scientific Instruments

This industry consumes nearly 10,000,000 feet, at an average cost of $82.47 per thousand feet f. o. b. factory. Table 21 refers to such articles as are used by artists, engineers, mechanics, professional and scientific men, among them being photographic equipment, drawing boards, blackboards, erasers, geometrical blocks, gauges, calculating machines, mallets, map globes, mathematical instruments, mitre boxes, pencils, pencil boxes, palettes, penholders, pointers, leveling rods, rulers, measuring scales, recording instruments, spirit levels, T-squares, transit tripods, etc.

Southern red cedar contributes approximately one-fifth of the wood consumed by the industry and costs $150.00 per thousand feet. Red cedar is not suitable for most of the articles reported. Its use, however, is found in the production of lead pencils, and several establishments consume large quantities in the manufacture of this article. Southern red cedar (*Juniperus virginiana*) meets the requirements of the best lead pencils. Its commercial range extends from the Ohio River on the north as far east as eastern Tennessee and central Georgia, as far south as Tampa Bay on the west coast of Florida, and as far west as eastern Texas and central Arkansas. The requirements for lead-pencil material are very exacting — a soft wood, fine and straight-grained, free from defects, which will not warp or check. The heartwood of red cedar meets these requirements and has the additional special qualities of being light in weight, non-resinous, slightly aromatic, whittling well and having an agreeable taste. One of the earliest woods used for lead pencils abroad was red cedar grown in Virginia and Florida. After red cedar became the expensive pencil-wood, foreign manufacturers forfeited their position of importance to America.

The first successful plant in this country was started by Eberhard Faber in 1861 in New York City. His cedar-and-graphite pencil deposed the quill pen. The raw material for pencils is known as pencil slat and is 7¼″ x 2½″ x ¼. These slats are manufactured in the southern States and are shipped in bundles or crates to the manufacturers, a crate containing the raw material for 100 gross of pencils. The details of the manufacture of a pencil are simple but interesting. A slat is first run through a machine which makes six grooves in it. Six pieces of lead are then laid in the grooves and a coating of glue applied. Another slat is then laid over the top. The whole is then run through another machine which cuts out the material between the leads, producing a pencil in the rough state. The pencil is then polished, painted, stamped, and graded. Several large factories are located in the vicinity of New York City and Brooklyn. The scarcity of the raw material and the enormous consumption of wood have resulted in a very serious depletion of the supply. Nearly 16,000,000 feet of southern red cedar were used in 1912 as compared with the 2,000,000 feet reported in 1919. The result has been an eager search for all the remaining supply and the introduction of western red cedar (incense cedar — *Libocedrus decurrens*) in large quantities. Its cost was only one-third that of the southern species.

The next most important industry in the table is that of cameras. Rochester and Lestershire have camera works of international reputation, consuming for camera boxes and parts much gum, white pine, birch, cherry, beech, basswood, cypress, ash, mahogany, sugar maple, white oak, and yellow poplar.

Penholders are made almost exclusively from red gum; level blocks are made from cherry; thermometers from white oak; planes from beech; easels from beech and soft maple; surveyor stakes from oak, longleaf pine, chestnut and hickory; drafting tables and equipment from white ash, basswood, beech, mahogany, yellow birch and white pine. The best wood for surveyors' tripods and rods is hard maple.

Basswood is used for many of the articles enumerated, especially for yardsticks, rulers, drafting tables, and alphabet blocks. The manufacture of advertising novelties is very important in the largest cities and in several smaller places, including Bliss, Seneca Falls, Silver Springs, and Tonawanda, where the major portion of the basswood and sugar maple reported is turned into yardsticks and rulers as advertising novelties.

TABLE 21

PROFESSIONAL AND SCIENTIFIC INSTRUMENTS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	9,754,000	100.00	$82 47	$807,358	534,000	9,222,000
Southern red cedar..	2,000,000	20.51	$150 00	$300,000	....	2,000,000
Western red cedar...	2,000,000	20.51	50 00	100,000	....	2,000,000
Red gum...........	1,343,000	13.77	75 00	100,725	....	1,343,000
Basswood..........	1,102,000	11.30	62 31	68,666	212,000	890,000
Beech..............	715,000	7.33	60 00	42,900	100,000	615,000
White oak..........	614,000	6.29	84 28	51,748	4,000	610,000
Sycamore..........	468,000	4.79	80 00	37,440	....	468,000
Hard maple........	447,000	4.58	66 55	29,748	11,000	436,000
Yellow poplar.......	400,000	4.10	72 00	28,800	....	400,000
Birch..............	176,000	1.81	58 46	10,289	125,000	51,000
Cherry (black)......	175,000	1.79	65 00	11,375	75,000	100,000
Tupelo.............	162,000	1.66	66 00	10,692	....	162,000
Ash...............	62,000	.64	40 00	2,480	3,000	59,000
Hickory............	30,000	.31	60 00	1,800	4,000	26,000
Mahogany.........	28,000	.29	235 90	6,605	....	28,000
White pine.........	18,000	.18	145 00	2,610	....	18,000
Cypress............	10,000	.10	100 00	1,000	....	10,000
Spruce.............	2,000	.02	55 00	110	....	2,000
Butternut..........	1,000	.01	70 00	70	....	1,000
Lignum-vitae.......	1,000	.01	300 00	300	....	1,000

BASKETS AND FRUIT PACKAGES

The products referred to in Table 22 include crates for the shipment of bananas, celery, peaches, potatoes, small berry and lettuce boxes, hop-picking boxes, bushel crates, and the lighter class of fruit and vegetable packages. It was impossible to clearly separate in every instance these figures from the kindred industry of "Dairymen's, Poulterers' and Apiarists' Supplies," nor from the larger industry of "Packing Boxes and Crates." Baskets is the only item easily distinguished. Much of the consumption of raw material was doubtless reported under the general description of packing boxes and crates. Berry boxes and small crates are generally thin veneer. Only the bottoms, tops, and corner parts of the heavier articles, such as potato and cabbage crates, are made of ordinary lumber, while even these pieces are generally 1/4 to 1/2 of an inch thick, lightness being necessary to avoid excessive freight rates on cheap produce.

New York is normally foremost in the production of vegetables and apples. The total of 8,527,000 feet is probably far short of the actual amount consumed for the marketing of the State's horticultural and garden products. The stimulus to home gardening given by the war-garden movement, in a time when all produce was very dear, may have served to reduce materially the consumption for this industry.

Hardwoods predominate in the industry because strength and toughness are needed in the small dimension stock used. Hard maple, beech, and basswood are used for covers and bottoms of baskets. Hoops, handles and potato-crate slats are largely made of elm, basswood and beech, while the corner pieces, sills, and posts of crates are generally made from chestnut, elm, oak, and ash. The standard rims for baskets are frequently made of white or red oak, while the heart pieces of oak sometimes go into basket handles. Bushel crates consume birch, cherry, soft maple, ash, and elm. Soft maple is used for lettuce boxes and is available generally wherever truck gardening is extensive. Elm also forms bands for baskets. Yellow poplar, hard maple, and ash are used extensively for basket staves. White pine and spruce are preferred for the more fancy apple and fruit package, but their use has apparently fallen off tremendously. The large proportion of local raw material consumed throughout the State is noticeable, which results in the low average cost of $35.85 per thousand feet, the cost being lower than any other industry except excelsior.

TABLE 22

BASKETS AND FRUIT PACKAGES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	8,527,000	100.00	$35 85	$305,746	7,499,000	1,028,000
Hard maple	2,327,000	27.29	$34 25	$79,700	2,079,000	248,000
Beech	2,183,000	25.61	39 05	85,246	2,035,000	148,000
Elm	1,761,000	20.65	36 37	64,049	1,532,000	229,000
Birch	748,000	8.77	33 15	24,796	673,000	75,000
Basswood	609,000	7.15	33 02	20,109	557,000	52,000
Yellow poplar	192,000	2.25	52 22	10,026	126,000	66,000
Ash	165,000	1.94	34 52	5,696	150,000	15,000
Black ash	125,000	1.46	32 00	4,000	30,000	95,000
Cottonwood	109,000	1.27	17 24	1,879	104,000	5,000
Chestnut	90,000	1.06	27 85	2,507	90,000	....
White oak	56,000	.66	40 40	2,266	35,000	21,000
Cherry (black)	45,000	.53	24 55	1,105	45,000	....
Red gum	45,000	.53	43 33	1,950	....	45,000
Soft maple	38,000	.45	26 90	1,022	38,000	....
Hemlock	10,000	.11	40 00	400	3,000	7,000
White pine	10,000	.11	40 00	400	2,000	8,000
Spruce	7,000	.08	41 00	287	....	7,000
Southern yellow pine	7,000	.08	44 00	308	....	7,000

VEHICLES AND VEHICLE PARTS

Great changes have taken place in this industry since 1912. The gasoline motor has effectively displaced the horse in the larger cities, both for pleasure driving and the purposes of delivery and hauling. A similar change has come about in the small cities and towns, though perhaps to a less extent, and the last remaining stronghold of the horse is for hauling and field labor on the farms, especially where roads have not yet been brought up to modern standards of excellence. Consequently the number of horse-drawn vehicles and the necessary repairs of such vehicles have decreased to a marked extent.

The former report (which included motor-drawn vehicles) accounted for over 30 million feet of wood consumed, while only one-fourth of that quantity is now reported by manufacturers of horse-drawn vehicles. In this report, Table 13, a separate statement of the wood used by automobile and truck manufacturers has been presented, indicating a consumption of nearly 21 million feet in 1919. The total consumption for both horse-drawn and motor-driven vehicles is therefore slightly less than in 1912, and the latter industry has expanded at the expense of the former.

The general wagon industry includes all business and pleasure vehicles from the light delivery wagon of the bakery to the heavy trucks employed in hauling stone and timber, dump carts, sleighs, and trailers.

Vehicles drawn by horses consume the major portion of the raw material, but warehouse trucks, push carts, sleds, wheelbarrows, and small wagons are included in the industry.

Only a few firms in New York still actually make heavy wagons, carts, or sleighs from lumber. There is also at least one large plant which specializes on the manufacture of wooden wheels. Farm wagons and buggies are made by centralized plants in the middle west, and shipped complete. There are, however, shops which carry on an extensive business in assembling vehicles from finished and unfinished parts imported from other States.

Much of the heavy turned stock comes from the central southern States in a partly finished condition to be used for spokes, rims, shafts and tongues. In Arkansas and other central southern States many factories specialize in vehicle stock.

A large part of the industry now consists of local repair shops. Many of these call themselves wagon factories, but speaking accurately they never build a wagon, although some of them assemble completed parts, much as some piano factories do, and finish them.

Such shops are numerous in the large cities, and some of them also build delivery bodies for the transformation of old motor cars into trucks. It is therefore somewhat difficult to separate accurately the wood used for wagon repairs and for motor repairs.

As a general rule high-grade material is demanded. Clear stock of the best species of hard wood is in great demand, and increasingly difficult to get. It is noticeable that New York woodlots still supply almost 50 per cent of the amount consumed. The manager of one factory states that for quality the New York-grown hardwoods, particularly hickory, have never been excelled. Therefore it will be of interest to state some of the requirements of the industry in order that the local sources of supply may align themselves with the needs.

Hickory is perhaps the most nearly indispensable wood in the United States, and none is known anywhere that will satisfactorily take its place for slender handles and certain parts of vehicles. Its scarcity is attracting national attention among wood users. Other woods should be substituted wherever possible and thus reserve the hickory supply for the production of such articles as depend entirely upon this species. Many parts of vehicles depend entirely upon hickory. Among its important uses are the following: Buggy poles, cross-bars, doubletrees, neck yokes, rims, shafts, singletrees, wagon gear (reaches), and small vehicle spokes. It is very strong, very heavy, very hard, and very stiff, and is capable of withstanding the severest thrust or twist. White oak and ash are now used in many places where hickory was deemed indispensable, except that they are used in larger dimension stock where resiliency and slenderness are not so important. Wagon hounds, felloes, bolsters, and poles are favorite uses for oak and ash. Yellow poplar is used along with several other woods for wagon boxes, and elm is a favorite material for hubs.

The form of the raw material required varies so greatly that details cannot be given. A few specifications for wagon stock will give a general idea of certain grades and dimensions required which should be supplied by local woodlots.

Article.	*Dimensions required.*
Wagon axles	Squares 2¾″ x 3¾″ to 6″ x 7″ and 6′ long.
Wagon bolsters	Squares 3″ x 4″ to 4″ x 6″ and in lengths 4′ 1″ to 4′ 6″.
Wagon reaches	Squares 2″ to 4″ to 2½″ x 5″ and in lengths 8′ 10″ to 14′.
Wagon poles	Squares 2½″ x 4″ tops to 4″ x 4″ butts and 12′ long to 3¼″ x 3¼″ tops to 3¼″ x 5″ butts and 12′ long.

Article.	*Dimensions required.*
Wagon eveners	Squares 2″ x 4″ to 2½″ x 5″ and in lengths 4′ 2″ 4′ 6″.
Singletrees	Squares for turning to be 2½″ x 3″ and 36″ long.
Neck yokes	Squares for turning to be 4″ x 4″ and 44″ to 48″ long.
Felloes	Squares for sawing may be made from short, clear cuttings 10″ to 14″ wide and from 24″ to 30″ long.
Hub stock	In the round for turning. Blocks to be 9½″ to 12″ in diameter inside of bark and 12″ to 15½″ long.
Spokes	Squares for turning to be approximately 2″ to 2½″ and 30″ in length.
Boxboards	9″ to 17″ in width and 12′ to 16′ in length.

The fact that the State still supplies nearly fifty per cent of the wood consumed is a tribute to the quality of the local supply. The displacement of hickory, which formerly occupied first place in the list, into the fifth place is a serious warning of the need of more general production of this well-nigh indispensable wood.

TABLE 23

VEHICLES AND VEHICLE PARTS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	7,660,000	100.00	$89 20	$683,270	3,690,000	3,970,000
Ash	2,697,000	35.20	$114 48	$308,753	940,000	1,757,000
Birch	1,290,000	16.84	50 19	64,745	1,067,000	223,000
Hard maple	886,000	11.57	63 84	56,562	497,000	389,000
White oak	785,000	10.25	86 85	68,177	560,000	225,000
Hickory	772,000	10.07	123 34	95,218	123,000	649,000
Elm	219,000	2.86	53 02	11,611	139,000	80,000
Basswood	213,000	2.78	38 68	8,239	151,000	62,000
Spruce	169,000	2.21	51 38	8,683	151,000	18,000
Red gum	165,000	2.16	125 00	20,625	....	165,000
Southern yellow pine	132,000	1.72	98 09	12,948	....	132,000
Buckeye	100,000	1.31	35 00	3,500	....	100,000
Yellow poplar	91,000	1.19	158 55	14,428	10,000	81,000
White pine	77,000	1.01	74 62	5,746	17,000	60,000
Beech	43,000	.56	65 00	2,795	25,000	18,000
Chestnut	10,000	.13	40 00	400	10,000	....
Loblolly pine	10,000	.13	75 00	750	....	10,000
Cypress	1,000	.01	90 00	90	....	1,000

Dairymen's, Poulterers' and Apiarists' Supplies

Table 24 includes beehives, bee supplies, butter ladles, butter moulds, butter tubs and pails, cattle stanchions, dairy supplies, cheese boxes, chicken coops, cheese vats, milk cases, egg carriers, and incubators. The production of cheese boxes consumes almost every species enumerated in the table. The consumption of home-grown wood is nearly two-thirds of the 7,556,000 feet reported and nearly all of the species are found in the State, the exceptions being western white pine and cypress. These imported woods are especially useful for certain articles; cypress, for instance, being particularly suited for incubators.

For egg carriers, used in transporting eggs by parcel post, yellow poplar is the favored material. Chestnut, formerly the leading wood in quantity, although restricted to use in incubators made by a few firms, seems to have fallen away in popularity.

For cheese boxes almost any wood can be used, either for headings, hoops, or staves, but the other products require wood of certain species. Beehives use white pine very generally for outer boxes, while basswood is preferred for honey boxes. Butter boxes are generally made of either spruce, yellow birch, hard maple or oak; and butter tubs are largely made of basswood, ash, white oak, red oak, spruce and hemlock. Cypress is demanded for tanks, tubs, well buckets, and other articles coming in contact with water. Elm is one of the more important woods for this class of products, used in the form of hoops and sides for cheese boxes, with a small amount for veneer for cheese-box siding. For cattle stanchions strong woods such as maple, beech, ash, and oak have been found best adapted.

The average cost of the raw material is $37.79, which is very low for the year 1919 and is accounted for by the fact that the industry consumes such material in the form of logs, the manufacturing consisting principally of simple reduction of billets and bolts into staves and heading suitable for local industries.

TABLE 24

DAIRYMEN'S, POULTERERS', AND APIARISTS' SUPPLIES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	7,556,000	100.00	$37 79	$285,578	4,683,000	2,873,000
Basswood..........	2,749,000	36.38	$32 36	$88,958	2,052,000	697,000
Western white pine..	1,003,000	13.28	55 00	55,165	....	1,003,000
Hard maple........	937,000	12.40	34 62	32,439	813,000	124,000
Elm..............	886,000	11.73	35 60	31,542	836,000	50,000
Chestnut..........	432,000	5.72	32 33	13,967	....	432,000
Beech............	345,000	4.57	36 91	12,734	308,000	37,000
Birch............	315,000	4.16	27 41	8,634	315,000	....
Yellow poplar.......	250,000	3.30	65 00	16,250	....	250,000
Spruce............	228,000	3.02	32 84	7,488	163,000	65,000
Cypress............	156,000	2.06	54 89	8,563	....	156,000
Hemlock..........	101,000	1.33	32 80	3,313	100,000	1,000
White oak..........	70,000	.93	37 22	2,605	27,000	43,000
White pine.........	49,000	.65	44 28	2,170	49,000	....
Cottonwood........	15,000	.20	15 00	225	5,000	10,000
Balsam fir..........	15,000	.20	80 00	1,200	15,000	....
Red oak...........	5,000	.07	65 00	325	....	5,000

TANKS AND SILOS

Table 25 includes silos, all kinds of water tanks, such as cisterns, vats, rough tanks, wagon tanks, sprinkling boxes, water troughs, and framework supporting tanks. The modern silo and its construction are important items in farm management today. Its history dates back to those of French construction sixty years ago. Several forms have been used, but the round silo is considered to be the most nearly perfect, being free from accumulations of decaying and poisonous ensilage in corners. Most silos in this country are made of wood, but the high price of wood has led to the substitution of other material, such as metal, stone, and cement. A typical silo has a diameter of about 16 feet, a height of 23 feet, and a capacity of 100 tons of ensilage, consisting of mixed corn, grain, and hay, which will feed about 30 cattle for 180 days. It requires about 114 staves and a total of about 3,000 feet of lumber to produce it. It is said that a silo will more than pay for itself in economy

RESULTS OF LUMBERING IN THE NORTHERN APPALACHIANS.

Hundreds of thousands of acres in New York and Pennsylvania look like this. When the people decide to abandon the old careless ways and enforce forest management, these lands can be made to produce better timber than the original stand.

the first year. Besides the great advantage of increasing the fattening capacity of the food there is the great economic saving of long daily trips for feed through the fields in mud, snow, and cold.

Retail lumbermen have developed a prosperous industry in farming communities. Formerly extensive silo manufacturers went into the south, purchased their lumber, manufactured the articles, and sold directly to the farmer through their agents. Today many retail lumberyards devote their slack time to the production of these farm articles. There is not much additional space required for the storage of a few silos within the lumberyards.

Bald cypress is the most desirable tank and silo wood. It is found in commercial quantities in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North and South Carolina, Tennessee, and Texas. The cut has been far in excess of its slow growth. It is claimed for it that the wood imparts no taste and that it is sufficiently dense to prevent leakage, strong enough to withstand rough usage, and has the greatest capacity to resist dampness, excessive heat, and all the elements that hasten decay. Water and feed troughs for farm stock are made of it.

Owing to the high cost of cypress and the difficulty of transportation in 1919 somewhat more spruce than cypress was employed for this purpose, but this change may not be permanent.

Spruce is used largely as supports and framework for tanks. Hemlock, ash, and several other woods are also thus used. White oak goes into slats for tanks and water elevators or supports. White pine is used largely in the construction of ordinary rough tanks and for frame cisterns. One user of hemlock, spruce, fir, and cypress says that he could use New York spruce, white pine, and hemlock almost exclusively if he could secure them at competitive prices and in sufficient quantities for this industry. The form of stock that this industry uses ranges from 1 inch to 6 inches thick, most of it being 2 inches to 4 inches thick.

TABLE 25

TANKS AND SILOS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	7,471,000	100.00	$66 65	$497,950	632,000	6,839,000
Spruce	2,043,000	27.35	$54 46	$111,215	....	2,043,000
Cypress	1,995,000	26.70	85 33	170,235	....	1,995,000
Douglas fir	1,858,000	24.87	63 75	118,400	....	1,858;000
White pine	677,000	9.06	60 52	40,975	257,000	420,000
Hemlock	450,000	6.02	44 33	19,950	350,000	100,000
Southern yellow pine	200,000	2.68	62 00	12,400	....	200,000
White oak	85,000	1.14	126 47	10,750	....	85,000
Yellow poplar	50,000	.67	100 00	5,000	....	50,000
Arbor vitae	40,000	.54	92 50	3,700	....	40,000
Redwood	28,000	.38	92 86	2,600	....	28,000
Chestnut	25,000	.33	35 00	875	25,000	....
Southern red cedar	10,000	.13	125 00	1,250	....	10,000
Tamarack	10,000	.13	60 00	600	....	10,000

TOYS

Toys may be divided into a dozen general classes as follows: Amusement, architectural, educational, games, household furniture, kitchen, musical, natural history, trade, wagons and sleds, watercraft, and wheelbarrows. The industry was slow to develop in the United States, because much of the work was done by hand in years past and America did not have the skilled workmen, and also because German manufacturers in the vicinity of Nuremburg had an advantage over the American employer in that they could employ German peasants who worked in their homes for almost nothing, thus enabling the German manufacturers to quote prices far below the cost of production in this country. With the advent of improved machinery, however, New York manufacturers found a field of good business venture along certain lines and embarked successfully upon the manufacture of toy blocks, dominoes, checkers, handsleds, children's wagons, doll carriages, coasters, toy shovels, carriages, etc.

As the result of the world war much of the former supremacy of Germany was taken from her in certain industrial lines, such as chemical manufactures. The toy business is another instance. America demanded toys, and was cut off from the German supply for several years. The result was a stimulation of this industry, which may be roughly measured by the increase in wood consumed, amounting to nearly 130 per cent. Our local factories, it will be noted, produce articles that are largely made of hardwoods and from raw material that comes in the form of lumber or small, sound strips. Much of our product may be made from the waste of certain larger industries, such as that from furniture factories. Some other classes of wood users report the sale of small-dimension waste to toy manufacturers, while others utilize their own waste by manufacturing toys. Manufacturers of piano actions, for example, report the use of a large amount of birch and basswood waste for toys and games. Thus, the toy industry is a natural by-product of wood-using industries and has become of great importance in New York, where wood-using industries are prominent and where problems of closer utilization are becoming of great interest. With modern machinery and raw material in abundance that is now practically waste, New York wood-users should make a close study of the opportunities afforded in this large and growing field of manufacture. Paris supplies many of the metal toys, Germany and other nations do much hand work, but there is an excellent field here for profit in closer utilization of wood waste.

Table 26 lists eleven species, all of which may be obtained in abundance in New York, and but one of which was purchased from outside the State entirely, yellow poplar having been shipped in from West Virginia. Hardwood toys have gained in importance of late years in response to the demand for more durable and substantial playthings. The species used must have the general qualities of being easily worked and of being tough. Much of the economy of utilization consists of preparing the stock in dimensions so that the machines, lathes, swing cut-off saws, rip saws, etc., may work on standard lines and on pieces of wood that will turn out toys designed to utilize every inch of the wood. Toy blocks exemplify the most perfect utilization attained in toys, especially where a thin board is made into puzzles, and there is no loss of wood except the kerf loss of a very thin saw. Wood users could hope for no closer utilization than toys.

Table 26 shows the consumption of nearly 7,000,000 feet, approximately one-third of which is basswood. The principal product is children's wagons and carts, in which basswood forms largely the bottoms, while sugar maple contributes the seats and sides. In this branch almost all of the woods take part, red and white oak going into axles, spokes and rims, ash into spokes and frames, and chestnut into sled tops. Dominoes and checkers consume great quantities of sugar maple and basswood, one firm using basswood only for dominoes. Toy blocks are chiefly made of basswood and small amount of yellow poplar. Much of the birch used is paper birch and goes with basswood into toys and games. Toy snow shovels, and garden tools, in imitation of the man's working implements, utilize mainly white ash, just as do the large hoe and fork-handle plants. A small amount of yellow poplar is also used in these manufactures.

TABLE 26

TOYS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	6,864,000	100.00	$45 79	$314,313	3,195,000	3,669,000
Basswood	2,315,000	33.72	$51 71	$119,699	900,000	1,415,000
Ash	1,500,000	21.86	51 00	76,500	600,000	900,000
Hard maple	1,253,000	18.26	40 88	51,223	1,000,000	253,000
Red gum	650,000	9.47	33 46	21,749	....	650,000
Beech	353,000	5.12	37 57	13,262	350,000	3,000
Chestnut	260,000	3.79	40 77	10,600	100,000	160,000
Yellow poplar	250,000	3.65	35 00	8,750	....	250,000
Birch	138,000	2.01	40 00	5,520	135,000	3,000
Red oak	100,000	1.46	50 00	5,000	100,000	....
White oak	40,000	.59	45 00	1,800	10,000	30,000
White pine	5,000	.07	42 00	210	....	5,000

Picture Frames and Moldings.

The products included in Table 27 are mirror frames, picture frames, mirror backs, picture moldings, and picture backs. As can be seen by the nature of the article produced, there is comparatively little waste. Indeed, much of the material consumed by this industry is the waste of the larger woodworking establishments, such as planing mills products, sash, doors, blinds and general millwork. While the latter establishments sometimes produce these smaller articles from the waste of their mills, there are many minor plants in the cities and towns that specialize in such articles. A great many of the small picture-frame shops of New York buy their moldings from molding factories in Chicago, with the finish already on them. The total of 6,647,000 feet is probably far short of the total consumption for such articles in the State, but the real consumption of wood cannot be separately shown because planing mills and general millwork establishments make their reports without distinguishing the exact amount going into such by-products. These figures indicate, however, that the aggregate production of the State for picture frames and moldings is enormous when such a large total can be accounted for through the reports of the small specialty factories. The industry consumes 14 woods and pays the average price of $83.57 per M. feet f. o. b. factory.

Yellow poplar is by far the most important species contributing to the industry, white oak having fallen to fourth place in quantity consumed. Basswood is reported in second place. Other woods that are used entirely for moldings are sugar maple, mahogany, and black walnut. White pine is suitable both for the facing and for the backs of picture frames because it is light and very workable. When used as moldings it takes oils, paints, and enamels well. The white oak is generally stained in such a way as not to interfere with the naturally pleasing appearance of the grain of the wood. It is generally quarter-sawn from No. 1 stock free of defects. Birch, chestnut, sugar maple, red gum, mahogany, black walnut, and cherry are popular in the manufacture of hand mirrors where both the facing and backing must be highly ornamental. The industry is rapidly growing in the State and the consumption is far in excess of the amount reported in any other State for such articles.

The amount of wood reported as consumed has decreased only 11 per cent since the previous report, but the amount of raw material supplied by the State has decreased by 90 per cent.

In 1912 the State imported two-thirds of its picture frames and moldings. In 1919 it imported thirty-three times as much of the material as it supplied, though 77 per cent of the wood is of species indigenous to New York.

TABLE 27

PICTURE FRAMES AND MOLDINGS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	6,647,000	100.00	$83 57	$555,474	186,000	6,461,000
Yellow poplar	1,784,000	26.83	$63 29	$112,909	....	1,784,000
Basswood	1,401,000	21.07	64 66	90,590	135,000	1,266,000
Red gum	902,000	13.57	88 13	79,493	....	902,000
White oak	900,000	13.53	93 42	84,078	15,000	885,000
Cypress	465,000	7.00	76 87	35,745	....	465,000
Birch	262,000	3.94	185 14	48,507	28,000	234,000
Witch hazel	240,000	3.62	62 00	14,880	....	240,000
White pine	208,000	3.12	80 31	16,704	5,000	203,000
Hard maple	144,000	2.18	136 44	19,647	3,000	141,000
Chestnut	140,000	2.11	56 78	7,949	....	140,000
Mahogany	134,000	2.03	277 77	37,221	....	134,000
Ash	50,000	.75	80 00	4,000	....	50,000
Black walnut	16,000	.24	228 33	3,653	....	16,000
Cherry (black)	1,000	.01	98 00	98	....	1,000

PLUMBERS' WOODWORK.

A few firms specialize in the production of woodwork for the plumbing industry in the State. The industry includes toilet tanks, seats, washtray frames, drain-boards, bathroom cabinets, and general plumbers' equipment. Formerly the bath tub was the principal wooden article manufactured, but the advent of the more sanitary metal substitute for bath-tub material brought about a decrease in the total consumption of wood. Other articles, such as toilet tanks, grew in importance for a while, but are now being replaced by china or metal construction. The utilization of wood in this class of goods still makes the industry a factor in the sales of high-grade oak. White oak together with birch (the latter often being stained in imitation of mahogany) supply the closet toilet seats and fronts or visible parts of the tanks. Ash is a favorite wood for seats, tanks, washtray rims or frames. Chestnut is reported for use as backs for tanks. Sugar maple is used extensively for bathroom cabinets and minor equipments. The white pine goes mainly into drain boards.

Since the woodwork is relatively a very minor item in the plumbing industry in New York, the 5,424,000 feet reported is indicative of a very large manufacturing business in the State. The increase of over 200 per cent in the amount of wood consumed is probably an evidence of the extension of more and better plumbing in residences of all grades. The average cost of $85.13 per thousand feet for the raw material used by this class of manufactures is an increase of $47.79 per thousand since 1912.

TABLE 28

PLUMBERS' WOODWORK

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	5,424,000	100.00	$85 13	$461,792	1,170,000	4,254,000
White pine	2,340,000	43.14	$44 00	$102,960	1,170,000	1,170,000
White oak	1,110,000	20.47	120 00	133,200	....	1,110,000
Ash	950,000	17.51	80 00	76,000	....	950,000
Cypress	284,000	5.23	38 00	10,792	....	284,000
Birch	280,000	5.16	270 00	75,600	....	280,000
Beech	200,000	3.69	110 20	22,040	....	200,000
Hard maple	200,000	3.69	125 00	25,000	....	200,000
Chestnut	60,000	1.11	270 00	16,200	....	60,000

Any one firm, no matter how large, is scarcely justified in obtaining the raw material in large quantities, and almost all of the stock is purchased from wholesale dealers in the larger centers, who have to select good, clear stock and charge somewhat extra for the culling process necessary to oblige plumbing establishments.

Pumps and Piping

The manufacturers of pumps in the State consumed 4,833,000 feet of lumber and expended $226,000 for their wood, an average price of $46.84 per thousand. The comparatively low average price is due to the use of much stock in the rougher platforms and coverings where ordinary grades of lumber will suffice. All of the wood used in this industry cannot be accounted for in a wood-using study. To begin with, metal substitutes of all parts of pumps, including piping, rods and handles, has become so general that the proportion of wood to the total raw material consumed by the industry is relatively unimportant. Many large pump manufacturers are not even listed as wood-using establishments and their utilization of wood is necessarily lost sight of in this study. Again, some pump-handle stock is doubtless accounted for in the returns from handle factories and cannot be identified as pump handles. The amount of wood reported is about 50 per cent less than was used in 1912.

TABLE 29

Pumps and Piping

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	4,833,000	100.00	$46 84	$226,388	866,000	3,967,000
White pine..........	4,530,000	93.73	47 57	$215,492	713,000	3,817,000
Hard maple........	301,000	6.23	36 00	10,836	151,000	150,000
Ash...............	1,000	.02	30 00	30	1,000	....
White oak..........	1,000	.02	30 00	30	1,000	....

White pine overshadows all other species and supplies 93 per cent of the raw material, the major portion of it going into steam pipe casing, water pipes, pump tubing, siding, curbing and covering. Well buckets are made of white oak, ash, and beech; water pipes of white pine and maple.

Laundry Appliances.

The figures combined in Table 30 include the reports of establishments using wood for the manufacture of clothes hampers, clothes pins, clothes racks, clothes wringers, curtain stretchers, ironing boards, laundry mangles, sleeveboards, washboards, washtubs, washing machines, frames of washing machines, and miscellaneous equipment for the general laundry business, such as spiral tables, benches, tanks, rollers for handles, etc.

The tub and tank parts of the industry consume the greater amount of wood and this accounts for the large amount of bald cypress reported, its contribution being 71 per cent of the quantity used, nearly all of which went into tanks and tubs. This species has the commendable quality above all others of resisting decay in contact with water.

The next most important item is that of washboards, made of beech and sugar maple. The advent of the electric washer has greatly reduced the production of hand-washing equipment, including old-style tubs and corrugated boards. Clothes pins are made largely of hard maple and beech. Reels for machinery consume a small amount of hard maple. Special kinds of tables and boards needed for laundry offices and workrooms consume white pine and yellow poplar. For many uses sugar maple takes precedence over all other woods, including such articles as wheel repairs and all kinds of handles used in connection with the laundry business. It is very important for mangle rollers. General machine construction for laundries consumes cypress, sugar maple, poplar, and white oak.

New York stands well to the fore in this industry, but it is regrettable to note that the manufacturers imported all of the material used, although cypress is the only species not grown in the State.

TABLE 30

LAUNDRY APPLIANCES

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	4,241,000	100.00	$59 23	$251,189	....	4,241,000
Cypress	3,010,000	70.97	$60 85	$183,159	....	3,010,000
White pine	1,000,000	23.57	52 22	52,000	....	1,000,000
Hard maple	90,000	2.13	72 00	6,480	....	90,000
Beech	75,000	1.77	60 00	4,500	....	75,000
White oak	50,000	1.18	85 00	4,250	....	50,000
Yellow poplar	16,000	.38	50 00	800	....	16,000

TRUNKS AND SUITCASES.

New York is prominent in the manufacture of trunks, her consumption of 3,984,000 feet b. m. placing the State among the leaders. The principal centers of manufacture are Binghamton, Buffalo, Rochester, Utica, and New York. In New York the trunk slats are made of white elm and white ash; the backs are made of basswood, white pine and red gum; white elm and white ash supply the clips and cleats, while basswood is the chief material for trays. Most of the body of the trunk is made of wood, but very little is visible except the strengthening slats, which are placed transversely or longitudinally to brace the body. These slats are preferably made of white ash because this wood is strong, elastic, and not easily split. The body of the trunk, the tray, and partitions should be of the lightest woods that possess in a moderate degree the qualities of toughness, strength, and elasticity. Many woods that possess these qualities are apt to warp greatly, a very objectionable quality in trunk lumber. Basswood is preferred by New York manufacturers for the manufacture of family trunks. The wood is not strong enough for heavy sample cases used by commercial travelers. These are usually made of built-up wood with the grain alternately crossed and firmly glued. Originally white pine and basswood were the principal woods used by trunk manufacturers, but lately they have tried yellow poplar, cottonwood, cypress, and other similar woods. Manufacturers are now having difficulty in getting poplar and cottonwood of proper dimensions, while basswood is becoming very very hard to get. Although not reported in time for inclusion in the table it is known that large quantities of three-ply built-up panels of red gum and also of western yellow pine are used for trunk construction.

Over 90 per cent of the wood reported came from outside the State, all of the species mentioned (except gum) being native to New York forests. The high average price of $82.16 per thousand results in part from the freight charges on long hauls. Why not grow basswood at home?

TABLE 31

TRUNKS AND SUITCASES

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	3,984,000	100.00	$82 16	$327,430	185,000	3,799,000
Basswood	2,244,000	56.32	$104 30	$234,049	130,000	2,114,000
White pine	1,620,000	40.66	52 76	85,471	....	1,620,000
Ash	90,000	2.26	68 33	6,120	30,000	60,000
Birch	25,000	.63	60 00	1,500	25,000	....
Elm	5,000	.13	58 00	290	....	5,000

CIGAR BOXES.

The cigar-box industry is one that consumes a small variety of woods. Spanish cedar, as will be noted, supplies 57 per cent of the 3,295,000 feet consumed. Cotton gum or tupelo, as it is sometimes called, is the only other wood of importance from the standpoint of quantity. Spanish cedar is generally converted into very thin lumber or veneer and used as an outside material with other woods as cores or backing. A very small amount of cotton gum and yellow poplar are made into boxes without being overlaid with cedar. Generally the

Spanish cedar is glued on the cheap domestic woods, such as yellow poplar; but the great body of cigar-box material is in the form of two-ply veneer with Spanish cedar as principal wood for this use. Except for cheaper boxes, Spanish cedar is used almost exclusively. It is bought by superficial measure, usually between 1/8 and 3/16 of an inch in thickness. For purposes of showing comparison of quantities, the veneer has been reduced to board measure, which accounts for the high price of $175 per thousand feet. Spanish cedar is best for cigar boxes not only because of its beautiful grain and fine texture, but because of its aromatic odor. The gum, yellow poplar, and other imitations are stained to give the proper color, while the odor is artificially applied by treating the veneered lumber with a decoction of cedar shavings and sawdust. Cotton gum is sometimes made to imitate the Spanish cedar by passing the thin lumber between rollers having minute teeth by which the wood is indented so that it has the appearance and characteristics of cedar.

The industry has comparatively little waste because most of the lumber can be used by thin slicing of the board or log, and by using the cedar shavings and sawdust in covering other woods. Most of the Spanish cedar is imported from Mexico, Central America, and the West Indies. This is the only extensive industry in the State that draws on the outside world for every foot of its raw material. Next to airplanes this industry paid the highest price for its raw material, the average being $164.66 per thousand feet, while airplane material costs $230.34 per thousand. The high price of the material going into the industry is realized when we compare its cost with the average of 60.78 for all industries in New York State.

The saw mills supplying cigar-box lumber generally take the round logs in the rough and manufacture dimension stock sawed to thickness and width but random length, and shipped in the rough, wet or air-dried, and planed as the consumer of the material desires. The dimension stock is frequently cut into multiples of the sizes desired for specified cigar boxes. Every inch of lumber that is available from the log for cigar boxes is used up to the point where the value of labor and the value of the stock balance. In the vicinity of New York City and other large municipalities of the State the sawdust and shavings from a large mill are sometimes sold on a monthly contract at a fair price to concerns who sort and regrade and who job in sawdust and shavings. Spanish-cedar sawdust is used for smoking meat, lining ice boxes, and making explosives. No other industry in the State utilizes more closely the raw material brought into the factory. New York is one of the largest importing States for logs and rough stock of this kind, and close utilization for by-products is essential to economical administration of the plant engaged in this industry. The high cost of the stock compels economy, and the same influences will apply more and more to other industries hereafter.

TABLE 32

CIGAR BOXES

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	3,295,000	100.00	$164 66	$541,859	....	3,295,000
Spanish cedar.......	1,849,000	57.32	$175 40	$331,331	....	1,849,000
Tupelo..............	601,000	18.23	141 52	85,054	....	601,000
Yellow poplar.......	350,000	10.63	140 90	49,315	....	350,000
Red gum............	338,000	10.26	164 11	55,469	....	338,000
Basswood..........	100,000	3.04	175 40	17,540	....	100,000
Redwood...........	17,000	.52	185 30	3,150	....	17,000

PATTERNS AND FLASKS

Table 33 includes general flask patterns, foundry patterns, hat blocks, machine shop patterns and models. The industries reporting the data include agricultural implement plants, iron working establishments, railroad shops, locomotive works, electric power companies, and general manufacturing establishments. A few firms are engaged exclusively in the manufacture of patterns, hat blocks, and flanges for hat blocks, while other establishments have pattern departments for the exclusive use of their own plants. General foundries and railroad shops have thir own pattern departments. Much of the raw material consumed, however, is reported by the general manufacturing establishments that have no pattern departments in the strict meaning of the term.

Pattern makers need a soft, workable wood for forms such as hat blocks and pressing blocks, and generally demand a high-grade stock of yellow poplar, basswood, or white pine. White pine contributes nearly 70 per cent of the raw material consumed in this industry and its average price f.o.b. factory is $72.21. It is used in every kind of establishment reporting and cannot be identified as particularly preferred as a pattern wood for any special kind of article. Yellow poplar, however, is especially suitable for hat blocks. The lower priced woods reported, such as beech, birch, and hemlock are used for the roughest purposes in connection with general foundry and machine shop work.

Maple and white oak are used for all kinds of patterns and models because of their capacity to resist the wearing action of sand. Cherry is regarded as a high-grade pattern wood. The stock required for patterns is usually plain, rough, clear, 1 to 2 inches thick, while the models demand a clear surfaced stock ¼ to 4 inches thick. There is comparatively little waste in the industry because dimensions include very short lengths.

As in the trunk industry it appears that there is a notable falling off in the quantity of basswood used. This valuable species was once common in certain counties, such as Sullivan and Delaware. One manufacturer took pains to state that New York-grown basswood is superior in texture, color, and quality to that from northern, southern, or western sources. It grows faster and larger than that from Canada, finishes better than the "linn" of the South, and in drying loses none of its elasticity. Apparently this is a wood which New York woodlots should produce to great advantage. At present the freight charges on basswood from other States add $7.50 per thousand to its cost.

TABLE 33

PATTERNS AND FLASKS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	3,039,000	100.00	$75 95	$230,809	219,000	2,820,000
White pine.........	2,109,000	69.39	$72 21	$152,281	30,000	2,079,000
Hard maple........	373,000	12.28	85 70	31,966	136,000	237,000
Yellow poplar.......	359,000	11.82	75 00	26,925	....	359,000
Southern yellow pine	50,000	1.65	73 00	3,650	....	50,000
Cherry (black)......	30,000	.98	143 28	4,298	10,000	20,000
Mahogany.........	24,000	.78	241 52	5,796	....	24,000
Sugar pine.........	20,000	.65	100 00	2,000	....	20,000
Birch.............	20,000	.65	50 00	1,000	20,000	....
Hemlock...........	20,000	.65	41 00	820	8,000	12,000
Beech.............	10,000	.34	40 00	400	10,000	....
White oak..........	5,000	.17	60 00	300	5,000	....
Ash...............	5,000	.17	58 00	290	....	5,000
Basswood..........	5,000	.17	78 00	390	....	5,000
Locust............	5,000	.17	80 00	400	....	5,000
Spruce............	3,000	.10	71 00	213	....	3,000
Cypress...........	1,000	.03	80 00	80	....	1,000

BRUSHES AND BROOMS

Table 34 includes brush backs, small brush and duster handles, and broom splints. The figures are separate from those showing the general production of Handles, the latter being a very large industry in the State. Most of the products of the following table are small articles used in the household and for the care of the person. An exception is in the broom splint, which is a long, thin sliver of wood used in coarse brooms for sweeping. Backs of hand mirrors form part of the industry, although the larger mirror backs, made of cheaper woods, are reported under picture frames and moldings. The backs of hand mirrors are of high-grade stock similar to the stock used for brushes. Both mirrors and brushes are often real works of art, made of ebony, mahogany, satinwood, holly, cherry, walnut and birch, and very ornamental, being turned into varied forms. Paint brush blocks are made of maple, beech and birch, named in the order of their importance. Wood for brushes must be very strong and tough and have the capacity to resist splitting when nailed or bored. The woods are used interchangeably in the production of so many of the articles reported that no conclusion can be drawn relative to the special qualities demanded for many of the uses. Hard maple, however, while used for all of the articles, is the only one reported for the production of broom splints. Duster handles consume hard maple, beech, birch and cherry. Generally speaking, maple, beech and basswood go mainly into the rougher, unpolished handles, while the others are used in the manufacture of ornamental or high-grade articles. Beech is particularly recommended for backs of scrub brushes and stable brooms, and whitewash and kalsomine brushes. Much of the birch is white birch which is bought in the form of boards, bolts, and partly finished blocks.

The low average cost of $43.19 for the 2,713,500 feet consumed is the result of the large amount of woods going into the

TABLE 34

BRUSHES AND BROOMS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	2,713,500	100.00	$43 19	$117,208	2,124,000	589,500
Hard maple	1,127,000	41.54	$26 56	$29,933	1,063,000	64,000
Birch	895,000	32.97	42 05	37,634	629,000	266,000
Beech	334,000	12.30	41 01	13,704	297,000	37,000
Basswood	151,000	5.57	27 00	4,077	120,000	31,000
Holly (American)	38,000	1.40	150 00	5,700	....	38,000
Mahogany	30,000	1.11	60 00	1,800	....	30,000
Cherry (black)	27,000	1.00	36 66	990	6,000	21,000
Black walnut	24,000	.89	170 00	4,080	....	24,000
Elm	21,000	.77	85 00	1,785	....	21,000
Cottonwood	20,000	.74	17 00	340	....	20,000
Rosewood	19,000	.71	120 00	2,280	....	19,000
Ash	9,000	.33	25 00	225	9,000	....
Satinwood	5,000	.18	980 00	4,900	....	5,000
Cocobola	5,000	.18	950 00	4,750	....	5,000
Ebony	5,000	.18	920 00	4,600	....	5,000
Yellow poplar	2,000	.07	95 00	190	....	2,000
White oak	1,000	.04	95 00	95	....	1,000
Boxwood	500	.02	250 00	125	....	500

rougher articles such as broom splints. Of the eighteen kinds of wood reported the native species were quoted by manufacturers at prices so low as to suggest that parts of the stock were purchased before the war conditions raised the cost. On the other hand the foreign luxury woods — satinwood, cocobola, and ebony — cost upward of $900 per thousand.

Shuttles, Spools, and Bobbins

New York is becoming increasingly important in this industry with a consumption of considerably over 2,000,000 feet of beech, maple, birch, yellow poplar, basswood, and dogwood which cost nearly $100,000 in 1919. The quantity consumed and the price per thousand are almost exactly double the amounts reported in 1912. The industry as reported in New York does not include shuttle blocks, which are commonly made of dogwood and persimmon.

Bobbins are reels used to hold yarn or thread, having a hole bored through their length by which they may be placed on a pivot and used on spinning or warping machines. The rough stock is generally small dimension squares of birch, beech, sugar maple, and dogwood. The manufacture of spools is more peculiarly a New England industry, and is centered in Maine. Spool factories of that State turn out very large quantities of spools annually. Good quality white birch is used very extensively. It reaches the factory in small squares from short lengths up to four feet and free of all defects. The birch is cut in winter and sawed by small portable mills which operate along the railroad lines. One thousand feet of bars require about two and one-half cords of wood. At the portable mills the bars are piled criss-cross for thorough seasoning. In June the stock is ready for shipment to factories. The machines for making spools are complicated. The finished articles drop from the lathe at the rate of about one per second, and are perfectly uniform and true. Finished spools are marketed largely in the northeast.

In this industry beech is listed as the leading wood, a large amount of which is used in making reels for the cordage and textile trade. Maple, the next wood in amount used, is made into spools, bobbins, and reel work. Yellow poplar is used for spool heads, basswood for reels, and dogwood for bobbins and spool heads. Beech, maple, and birch — the important Adirondack hardwoods — are still the leading woods in this industry, but notwithstanding the fact that these woods are native, still a little over 50 per cent came from outside the State. In 1912 the State supplied three-fourths of the amount used.

TABLE 35

SHUTTLES, SPOOLS, AND BOBBINS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	2,310,000	100.00	$42 55	$98,280	1,125,000	1,185,000
Beech	1,000,000	43.28	$35 00	$35,000	500,000	500,000
Hard maple	750,000	32.36	45 00	33,750	350,000	400,000
Birch	400,000	17.31	44 00	17,600	200,000	200,000
Yellow poplar	60,000	2.47	53 00	3,180	....	60,000
Basswood	50,000	2.29	35 00	1,750	50,000	....
Dogwood	50,000	2.29	140 00	7,000	25,000	25,000

Electrical Machinery and Apparatus

Some of the largest electrical supply houses of the Nation are located in this State. While these establishments work primarily in metal, yet they consumed 2,216,000 feet of lumber in 1919.

This material is used in the manufacture of signal devices of which the railroads are large consumers, and in making parts of electrical machines and devices, such as base blocks, switch handles, and other small parts. The report for 1912 included material used for wire reels, under "Electrical Machinery and Apparatus." In this report it has been thought best to place reels under the "Miscellaneous" heading. These reels which formerly drew heavily upon spruce are now using much beech. In 1912 there was a total of 4,602,860 feet of all species reported as used in the industry. The amount today is only one-half as great, but a large amount can be accounted for in the reel industry. Consequently the use of wood in this electrical industry is not decreasing as much as it would appear from Table 36.

Pine, arborvitae, and cypress are used mostly for signal devices because they can resist severe weathering conditions. Hard maple makes excellent baseboards for all kinds of small electrical instruments.

In 1912 23 species were reported in use and now but 7 are listed. This is a marked falling off in variety. Although 95 per cent of the wood used is native to New York only about one-third of the white pine reported was home grown, while all the other species are reported as imported. The average price has risen from $29.10 to $70.94, a large increase due partly to the reclassification of reels, which can use lower and therefore cheaper grades of wood.

TABLE 36

ELECTRICAL MACHINERY AND APPARATUS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	2,216,000	100.00	$70 94	$157,209	162,000	2,054,000
White pine	684,000	30.86	$49 92	$34,145	162,000	522,000
Hard maple	597,000	26.95	74 00	44,178	....	597,000
Ash	420,000	18.95	84 55	35,511	....	420,000
Soft maple	200,000	9.03	70 05	14,010	....	200,000
Arborvitae	200,000	9.03	110 00	22,000	....	200,000
Cypress	100,000	4.51	60 90	6,090	....	100,000
White oak	15,000	.67	85 00	1,275	....	15,000

MACHINE CONSTRUCTION

Table 37 is made up of reports from the establishments that manufacture and repair machinery of various kinds. The uses of wood in such establishments are confined principally to sills, bases, platforms, bins, walks, bodies, cabs, and other parts of machines that are made largely of metal. It is impossible to obtain complete data from the innumerable machine works that use small amounts of wood. Unless the establishment buys as much as a carload during a season it can scarcely be called a wood-using plant; yet the aggregate of consumption by machine shops and foundries, and general metal-manufacturing industries, would doubtless be many times the total reported in Table 37.

The principal items reported come from manufacturers of road-building machinery, ice and coal-handling machinery, hoists and cranes, looms, rice and coffee machinery, wood-sawing and wood-working machinery and tractors. Some kinds of machinery require but a small amount of wood, while others use considerable quantities.

Sugar maple, as in 1912, is still the leading wood in machine construction, though only half as much is used now as formerly. Hemlock, which in 1912 took second place, is today in ninth place at a cost of $50.00. Seven years ago it cost $15.55. Yellow poplar, formerly in third place, is now in second place. White pine formerly in sixth place is now third. The first report listed red oak, hickory, and cottonwood. In 1919 they were not reported and chestnut appears as a new wood. This slight change in species shows a marked stability in the preferences of the industry.

The total amount consumed decreased from 4,555,900 feet to 1,779,000 feet, while the average price increased from $34.37 to $53.76, which is not a remarkable rise compared with other industries. More of the raw material came from without the State than from New York, while in 1912 nearly twice as much was home-grown as was imported from other states. The only species reported which cannot be grown in New York are southern yellow pine and cypress. The stock used in this industry is mostly for heavy work, with thicknesses from 1 inch to 8 inches and upward.

TABLE 37

MACHINE CONSTRUCTION

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	1,779,000	100.00	$53 76	$95,644	812,000	967,000
Hard maple	295,000	16.58	$43 71	$12,894	278,000	17,000
Yellow poplar	266,000	14.95	80 90	21,519	....	266,000
White pine	212,000	11.92	59 03	12,514	127,000	85,000
White oak	175,000	9.83	43 07	7,537	161,000	14,000
Basswood	144,000	8.09	56 66	8,159	21,000	123,000
Spruce	122,000	6.86	49 00	5,978	....	122,000
Beech	119,000	6.69	32 91	3,916	60,000	59,000
Ash	91,000	5.13	56 35	5,128	28,000	63,000
Hemlock	85,000	4.78	50 00	4,250	30,000	55,000
Southern yellow pine	71,000	3.99	58 88	4,180	....	71,000
Birch	59,000	3.31	33 33	1,966	45,000	14,000
Elm	50,000	2.81	34 80	1,740	50,000	....
Loblolly pine	43,000	2.42	71 00	3,053	....	43,000
Cypress	31,000	1.74	73 87	2,290	....	31,000
Chestnut	12,000	.68	30 00	360	10,000	2,000
Cherry (black)	2,000	.11	40 00	80	....	2,000
Soft maple	2,000	.11	40 00	80	2,000	....

PULLEYS AND CONVEYORS

There are so many different kinds of pulleys and conveyors that a detailed discussion is impracticable in a report of this kind. Table 38 contains the data relative to two rather distinct classes of articles, the one having to do with the amount of wood consumed for the conveyance of belting, while the second class shows the amount consumed in the manufacture of "tackle blocks" and tackle-block shells used for construction purposes.

Pulleys were formerly very crude articles consisting of rough boards nailed and glued together. With the development of modern mechanics, great ingenuity was brought to bear on his branch of shop equipment and several factories put improved wood pulleys on the market. It required much time to construct them properly and for a while iron made great inroads as a substitute. Good dry-kilns, modern woodworking machinery, and special lathes developed the modern wood pulley, with interchangeable bushings. It has certain advantages generally recognized. The wood is much lighter than iron, much less apt to break through high-speed centrifugal force, it does much less injury in the event of a break of a large fly-wheel and complies with the insurance and accident regulations of many States. On the other hand, the iron pulley has some advantages, one of them being that it does not warp or twist so much as wood in outdoor places and where exposed to extreme moisture. The general class of pulleys and conveyors consists of the larger fly-wheels in factory work and what are known as "cone pulleys" or graduated steps or blocks on which the smaller leather belts are carried. Large fly-wheels 20 to 30 feet in diameter and 5 to 9 feet across the face are built up with a great deal of care. The lumber entering these large wheels must be thoroughly kiln-dried in order to hold its shape, and many courses of lumber are necessary to build up these wheels which are subjected to great centrifugal strains at high speeds.

Cone pulleys to be really strong and serviceable need to be "built-up" also, on a regular raceplate and of very thin material. The article thus produced is non-shrinkable and designed to stand the wear and tear of many years. The smaller ones generally consist of at least six segments. White pine may be used because it takes glue well and holds nails without splitting, but in New York hardwoods are preferred. Maple will stand very satisfactorily the severe wear and tear of the industry.

Tackle-block shells use a large part of the raw material in this industry. They are the hollow forms in which metal strips and rollers are placed for lifting heavy weights, their usefulness consisting of their capacity to multiply the pulling power of machinery and animals. Metal has been used extensively for the smaller block shells, but in the larger compound tackle blocks metal is entirely too heavy. Wood is generally recognized as the most satisfactory tackle-block shell.

Birch is the wood reported as used to the greatest extent in the manufacture of tackle-block shells, nearly one-half of the amount reported having been devoted to this purpose. Ash was the wood formerly used; but, because of increased prices and difficulty in obtaining required widths, birch has been substituted. Good block wood should be straight-grained and easy to work, should air-dry readily, and have a good color when covered with shellac. Also it should not warp, twist, or check when cross-cut into small pieces.

The Adirondack hardwoods and basswood contribute heavily to this industry, red gum being the only wood which is not native in New York, but in spite of this fact little of this wood is reported as home-grown. This industry has nearly doubled in amount of lumber used since 1912, while the number of manufacturing plants is the same. These facts seem to indicate that there has been an increase of industry and that metal substitutes are not making an inroad upon wood in this field. The average price paid in 1912 was $46.45, while in 1919 it was $53.42, a surprisingly small increase. Lignum-vitæ, beech, and ash were reported in 1912; but these are absent now, while basswood and red gum have been introduced.

TABLE 38

PULLEYS AND CONVEYORS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	1,614,000	100.00	$53 42	$86,221	33,000	1,581,000
Birch..............	700,000	43.38	$66 00	$46,200	18,000	682,000
Hard maple........	427,000	26.46	45 04	19,232	15,000	412,000
Basswood..........	250,000	15.48	45 00	11,250	....	250,000
Red gum...........	237,000	14.68	40 25	9,539	....	237,000

AIRPLANES

The industry which has made the most rapid strides since 1912 is airplane construction. In 1912 this industry reported 31,400 feet of lumber, used by three manufacturers, while in 1919, 1,427,000 feet are reported as used by five manufacturers. If this study had been made during the war the quantity would have been very much larger, and instead of five builders of airplanes and airplane parts dozens would have been listed. Although the airplane industry is still in the formative period, it is certain that it has come to stay. Some manufacturers believe that metal will be substituted for wood to a very large extent, while others are uncertain whether, after a trial of substitutes, wood will not yet be the substance finally chosen as the best all-round material.

The airplane industry is highly specialized, each firm getting many of its parts from numerous other makers. Not only must the workmanship of a plane be of the highest grade and very carefully inspected, but the wood used must be of the very best quality possible to obtain, and selected with the utmost care. At the opening of the war the industry knew little about the proper kiln-drying of airplane wood, the proper construction of laminated or built-up parts, the proper use of glues, the detection of hidden defects, and the weakening effect of spiral grain. All of these points and many more were studied during the war, especially by the Forest Products Laboratory of the United States Forest Service, at Madison, Wisconsin, where a large force of men with good equipment was constantly at work to help perfect military planes. Considerable quantities of veneer are used in airplanes; but this material does not appear in the table, veneers being discussed in the appendix.

Strength and lightness are two prime requisites of the airplane, and the woods used are selected on that basis. The cost of the wood is a secondary consideration. In order to obtain certain qualities, laminated wood, always stronger than single grain, was resorted to and cut from clear stock of the species listed in the table.

Sitka spruce, which is abundant in Washington and Oregon, contributed over two-thirds of the wood reported. This wood is favored because it is more uniform than many others. It contains few hidden defects and surface indications are generally a good criterion of the quality of the piece. It is possible that some eastern red spruce from the Adirondacks has been reported as Sitka spruce, but the quantity is relatively small. Sitka spruce is a much larger tree and yields larger pieces of clear stock.

During the war period experts searched the Adirondacks for air-plane spruce, as it was termed. These men worked at spruce operations, marking logs which they thought were of airplane quality. Generally the butt log only was chosen from the tree, as the next log above was often knotty. The logs had to be not only free from knots and other defects but straight-grained as well. The grain of a board generally shows, but it is an entirely different matter to tell whether a tree will cut clear boards as it stands on the stump. Straight-grained spruce trees can, however, be chosen with a high percentage of accuracy after a considerable amount of practice and close inspection and a checking up of results. A study carried on in the Adirondacks during the war period shows that on the areas examined 52 per cent of the trees were straight-grained enough to pass the airplane specifications; but, because of knot conditions, few trees under 14 inches in diameter were of value, and of these trees about one-third were defective from other causes. Consequently the amount of timber actually available for airplane purposes in the Adirondacks is probably comparatively small.

Spruce is used largely in the fuselage shell, wing beams, wing posts, cap strips, engine beds, struts, and all other beams. Ash is used to a large extent in longerons and in parts requiring toughness and elasticity. Mahogany is used largely for propellers in the form of built-up stock of several thicknesses, from which the propeller is carved. White pine, both eastern and western, is used mainly in ribs and webs. Douglas fir is substituted for spruce in beams.

Mahogany is the only propeller wood reported in New York, but black walnut and oak are also desirable material. Experience shows that stock for this use should be quarter-sawn. Propellers or "screws," as they are called, are built up of laminations, each being sawed to size and carefully chosen so as to

Scene in the Black Forest of Western Germany.

What Europeans have accomplished under pressure of necessity can be duplicated by Americans as a measure of sound economics. The Black Forest is a low mountainous region much like the Adirondacks and has the same disadvantages as to accessibility and markets. Yet this forest is managed under the selection system and reproduced by natural methods with profit. New York forests will look like this when New York determines to utilize all her forest lands to the best advantage.

avoid all defects and to have the grain and density at each end the same. In some plants each lamination is weighed, matched, and balanced against the others, and by this means it is possible to make the blades of the same propeller uniform as to weight, grain, texture, and yielding of the wood under stresses. At the high speeds used, the matter of accurate balance is essential to prevent racking vibrations. The laminations are glued up in a certain temperature and dried for a certain period. By means of a rotary cutter with a guide following a form whose outlines are exactly the same as the screw, the curved surfaces are formed much in the same way as gunstocks. The screw now goes from the outline machine to the duplicator, which turns out the screw with a shape very nearly as desired. The screw is again dried, surfaced, balanced, sanded, and inspected in detail, and is then ready for finishing, which is a careful, detailed series of applications and inspections.

Spruce and ash as reported in 1912 hold the same relative place today; the other woods listed were introduced since the previous study. The average price paid in 1912 was $30.83 while in 1919 it is $230.34. This is the greatest increase in cost seen in any industry, and is the highest average paid by any industry listed.

TABLE 39

AIRPLANES

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	1,427,000	100.00	$230 34	$328,693	105,000	1,322,000
Sitka spruce	1,066,000	74.70	$250 00	$266,500	....	1,066,000
Ash	109,000	7.64	148 81	16,220	105,000	4,000
Mahogany	100,000	7.01	250 00	25,000	....	100,000
White pine	74,000	5.19	140 00	10,360	....	74,000
Western white pine	50,000	3.50	150 00	7,500	....	50,000
Douglas fir	20,000	1.40	95 00	1,900	....	20,000
Basswood	5,000	.35	150 10	751	....	5,000
Port Orford cedar	3,000	.21	154 00	462	....	3,000

Elevators

Under this head are included passenger and freight elevators and the necessary accompanying parts, such as guides, frames, gates, and platforms. The 1,288,000 feet credited to these uses is less than the actual quantity consumed, because a considerable amount of the material is the product of the planing mill and is listed under that industry. In 1912 the pines contributed about 50 per cent of the total amount used, but this percentage is now much lower. Pitch pine which was reported in by far the largest amount in 1912 was not reported in 1919. Hard maple, which held third place in 1912, is the principal wood now used. This species contributes nearly one-half of the total amount entering the elevator industry and is used principally for elevator floors, guides, and frames. Spruce stands next in amount consumed and has risen from ninth place in 1912 to second place in 1919. This wood also finds use as flooring and framing. Yellow pine occupies the third place of importance, being used to a large extent for guides and frames. Chestnut, hemlock, cypress, and elm are species listed which were not reported in 1912 and those reported in 1912 which do not appear in the accompanying table are pitch pine, red oak, silver maple, birch, and basswood.

The total consumption of wood by the elevator industry is less than half that of 1912, while during the same period there has been only a small reduction in the number of establishments. It is probable that metal has displaced wood to a considerable extent in the industry, which may account for the decrease in wood consumption. There has been a considerable change in the order of importance of the different kinds of wood used since the last report in 1912. This is doubtless owing to the difficulty of securing suitable stock, at a period when manufacturers found it necessary to adapt to their needs the timber which they found available. The average price of raw material has increased from $31.06 to $79.93, which is a relatively greater increase than took place in many other industries during the same period.

TABLE 40

ELEVATORS

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	1,288,000	100.00	$79 93	$102,078	160,000	1,128,000
Hard maple	524,000	40.69	$114 39	$59,940	35,000	489,000
Spruce	222,000	17.24	55 00	12,210	....	222,000
Southern yellow pine	185,000	14.36	50 00	9,250	....	185,000
Chestnut	68,000	5.27	51 53	3,504	30,000	38,000
White oak	63,000	4.89	66 66	4,200	50,000	13,000
Hemlock	50,000	3.89	41 00	2,050	....	50,000
Cypress	40,000	3.11	65 00	2,600	....	40,000
Loblolly pine	38,000	2.96	49 00	1,826	....	38,000
White pine	32,000	2.48	45 00	1,440	15,000	17,000
Elm	30,000	2.32	30 00	900	30,000	....
Ash	26,000	2.02	125 30	3,258	....	26,000
Yellow poplar	10,000	.77	90 00	900	....	10,000

Clocks

New York is one of the most important States in respect to the amount of wood consumed for clocks, although the total amount of wood used for this purpose is not large when compared with other industries. Connecticut probably holds first place in the clock industry. During the past several years the substitution of wood for metal and marble in clocks has become quite popular. Clock cases with a variety of decorations, such as leaves, flowers, scrolls, and other figures require a high class of cabinet work. Ease in working and attractive appearance are desirable qualities for woods used for this purpose. Table 41 includes clock cases only, and not shipping cases as in the report of 1912, when nearly a million feet for the latter purpose was included.

Black walnut, cherry, mahogany, gum, and birch are used mainly for the decorative parts of the cases. Birch is especially valued for turned pieces. Oak is used largely for exterior work which may be given a natural finish or darkened by fuming or stains to produce a mission finish. Yellow poplar, which heads the list, was not reported at all in 1912. This wood is used for backs and bottoms of cases, because it holds its shape well and is easy to nail and work. Yellow poplar is also much used for enamel work. White pine, the second wood in quantity used, is also employed for enamel-finished clocks. The bottoms of clocks are generally of high-grade white pine, because the softwood bottom improves the tone of the striker which is fastened to the bottom part.

This industry like many others has shown a decided falling off, the amount used for cases being less than one-third the amount used in 1912, although the same number of firms reported. Loblolly pine, red oak, basswood and beech which were used in 1912 are not now reported, while yellow poplar, which was not reported in 1912, now holds first place in importance. The average price paid in 1912 was $31.93 and in 1919 $82.17, a very decided increase. Only 8,000 feet of material is reported as grown in New York, while in 1912 the home-grown wood amounted to 171,227 board feet. Mahogany is the most expensive wood reported at $250 a thousand board feet.

TABLE 41

CLOCKS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	896,000	100.00	$82 17	$73,625	8,000	888,000
Yellow poplar.......	354,000	39.50	$94 93	$33,605	....	354,000
White pine.........	250,000	27.91	58 00	14,500	....	250,000
White oak..........	200,000	22.33	80 00	16,000	....	200,000
Birch..............	40,000	4.46	90 00	3,600	....	40,000
Red gum...........	20,000	2.24	90 00	1,800	....	20,000
Black walnut.......	20,000	2.24	140 00	2,800	....	20,000
Cherry (black)......	8,000	.88	40 00	320	8,000	....
Mahogany.........	4,000	.44	250 00	1,000	....	4,000

Sporting and Athletic Goods

Eight firms have reported their activities as manufacturers of sporting and athletic goods. The articles manufactured are bowling-pins, dumb-bells, skiis, billiard tables, and cues. The study in 1912 included wood used for bowling alleys, but in the present report this material is mainly included with millwork.

The woods used for billiard cues are maple, walnut, hickory and mahogany. Billiard tables are made up of chestnut and poplar frames, with oak tops and ash rails. Ash is used largely in the making of skiis. Maple, because of its hardness, close grain, strength, toughness, and ease in turning, is used largely for bowling pins. Experiments are being made by the Forest Products Laboratory in the use of bowling pins of laminated construction.

Athletic goods, as reported, require but a small number of woods for their manufacture. Special qualities are necessary, however, to meet the requirements of these products. In 1912 the study listed twenty-one woods used in this industry. In 1919 but ten were reported, and the total quantity dropped from 4,230,100 feet to 429,000 feet, while the number of manufacturers reporting decreased from twenty to eight. Hard maple, as in 1912, still holds first place; and birch, which is now second, was not included in the earlier report. White oak which formerly held second place is now eighth, and shortleaf pine and red oak which were formerly used in considerable amounts are not now included. All of the woods now reported are native except mahogany. The species not native to New York State, as reported in 1912, were shortleaf pine, lignum-vitae, ebony, mahogany, Circassian walnut, rosewood, long-leaf pine, and teak. The average price now is $74.62, while in the former report it was $61.04. The increase in cost would have been greater had it not been for the reduction in use of the more expensive imported woods. Stock used in this industry generally ranges from 1 inch to 4 inches in thickness.

TABLE 42

SPORTING AND ATHLETIC GOODS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	429,000	100.00	$74 62	$32,010	212,000	217,000
Hard maple	304,000	70.86	$66 43	$20,195	166,000	138,000
Birch	30,000	6.99	30 00	900	15,000	15,000
Yellow poplar	30,000	6.99	150 00	4,500	....	30,000
Ash	25,000	5.82	60 00	1,500	25,000	....
Black walnut	10,000	2.34	90 00	900	....	10,000
Mahogany	10,000	2.34	100 00	1,000	....	10,000
Chestnut	6,000	1.39	90 00	540	2,000	4,000
White oak	5,000	1.17	175 00	875	....	5,000
Hickory	5,000	1.17	160 00	800	....	5,000
Spruce	4,000	.93	200 00	800	4,000	....

DOWELS AND SKEWERS

Dowels are small wooden pins or rods, usually circular in cross section, used to connect pieces of wood by being sunk in the edges of each to keep them permanently in their proper relative position. They are made of many diameters and various lengths and generally used by chair and furniture makers and door and sash manufacturers. The major portion of this product goes into the manufacture of chairs, but the tops of tables and counters and parts of doors are joined edge to edge by the employment of these dowels or pegs. This method of joining parts is older than the use of iron and copper. The art of manufacturing wooden pins was highly developed many centuries ago. A striking modern instance of the use of dowels is seen in the great Tabernacle of the Latter Day Saints at Salt Lake City, Utah, which structure, including the very extensive arched roof, is stated by the Mormons to have been built, after the plan of Solomon's Temple, without the use of metal fasteners. The product today is no more finished than in ancient times, but the introduction of modern machinery has made it possible for one unskilled man in charge of a machine to produce more pins than a large force of skilled workmen who cut them by hand. Dowels are made in long rods and then re-cut to suit the exact use to which they are to be put. Sometimes they are threaded to hold like screws, but instead of being turned into the wood they are driven in like pegs, the threads giving a better hold upon the sides of the auger holes. New York State is an important producer of cooperage stock, and dowels naturally assume importance as an allied trade. Some minor industries, such as the production of shipping crates and poultry-coops, are also important in the State and consume much of the dowel stock. Some shipping crates are made wholly of these small rods and give great strength to the crate. It is estimated that a good coop or crate made of birch rods is approximately twice as strong and only half as heavy as the small lumber formerly used. Chairs, cribs, and small beds consume much dowel stock.

Skewers are pointed wooden pins or rods similar to dowels, used by the meat trade to hold meat to a spit or for keeping it in form while roasting. The manufacture of skewers, like dowels, is a machine operation. Thin boards are fed into the machine and the skewers come out at the other end.

Dowels and skewers must be of hardwood and all of that used in 1919 came from within the State. Beech, birch, maple, ash, and basswood all furnish suitable material. These species are so readily obtainable that the cost of dowel stock was low, the average price being $55.94. The price in 1912 was $34.38. The quantity reported has decreased over 50 per cent and the number of firms reporting diminished in about the same ratio. Metal skewers are now used in large quantities.

TABLE 43

Dowels and Skewers

Kind of Wood	Quantity Used Annually		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	377,000	100.00	$55 94	$21,080	377,000	....
Ash	200,000	53.05	$70 00	$14,000	200,000	....
Hard maple	67,000	17.77	40 00	2,680	67,000	....
Birch	65,000	17.24	40 00	2,600	65,000	....
Beech	45,000	11.94	40 00	1,800	45,000	....

Firearms

Black walnut is the only wood reported for the production of gunstocks, with the exception of 2,000 feet of Circassian walnut. The selection of the most suitable gunstock wood has been carefully considered, and American black walnut has always been given preference for arms of the ordinary grade. For high-grade shotguns and rifles the beautiful Circassian and Italian walnut is imported. Black walnut is easily worked, moderately heavy, polishes well, and has a pleasing appearance. The rough blanks are first rough-sawed from thick lumber and the ends painted to prevent checking. The blanks are then shipped to the factory where they are seasoned in dry kilns. A large number of operations are required to produce the finished stock, including, in addition to these preliminary steps, shaping edges for guide surfaces, routing and chambering, cutting of recesses for attaching the butt swivel-plates, routing out the space for the magazine, trigger guards, or tangs, and the final staining, hard finishing, polishing and dipping in linseed oil. They are then ready for the assembling room. The turning of the curved surfaces of stocks is accomplished by the most ingenious automatic machinery.

Black walnut for gunstocks generally comes from the wood-lot areas of the Central West, the original heavy stands having long since been cut over for furniture for which the demand has been very large. The main walnut supply is now located in Missouri, Illinois, Kentucky, Ohio, Iowa, Tennessee, and West Virginia. Sapwood is now used as well as heartwood for most rifle stocks, and staining gives it a uniform color. It will serve the purpose, but is not nearly as satisfactory in feel and appearance as the denser heartwood. In the old Missouri muzzle-loaders curly maple was sometimes used.

Yellow birch and red gum are also used for gunstocks but are not reported in New York State. The difficulty in using birch is that it is hard to find a satisfactory method of staining the stock a walnut color which will penetrate and not wear off. Experimentation has been made upon laminated construction for use in military stocks, which are subject to heavy strain both from recoil and during use of the bayonet.

Establishments making sporting firearms receive their wood as plank or in rough-sawn blank stocks approximately 2 inches thick, 6 inches wide and 18 inches long. When the stock is bought in blank form, it is paid for on a piece basis and not according to the thousand board feet. Military stocks, which include the fore-end, are about 3 feet 10 inches long and require much larger stock in order to secure satisfactory blanks. It would seem feasible to construct all rifles with separate butt-stock and fore-end, since one of the British military rifles was built on this plan; yet the general preference of ordnance experts is apparently for the long one-piece stock. The change to the use of short stocks would permit the utilization of a large amount of material which otherwise could not meet the specifications.

The number of reporting firms is greater than in 1912, but the quantity of wood reported is 30 per cent smaller. The price of $147.78 is an increase roughly proportional to that noted in the other industries.

TABLE 44

FIREARMS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	258,000	100.00	$147 78	$381 30	....	258,000
Black walnut	256,000	99.22	$145 31	$37,210	....	256,000
Circassian walnut	2,000	.78	460 00	920	....	2,000

WHIPS AND UMBRELLA STICKS

A large proportion of the wood listed in the table is used in making umbrella handles and a small amount goes into whip butts. In 1912 2,237,000 board feet of material were used for these purposes. The present figures show a decided decrease, although one more firm is listed than in 1912. Beech furnished over 90 per cent of the wood material in the former report but is now superseded by birch and maple, which contributed equal quantities. Several woods given in the 1912 table do not now appear, including hickory, ash, basswood, walnut oak, mahogany, ebony, and red cedar. Many of these woods are now much higher in price than the average cost given for those in the table. Rattan and reed used in the whip industry are bought by weight and are not included in this table. The price for this material ranged from 14 to 32 cents per pound, while the hardwoods listed cost $50 per thousand.

Statistics for canes were included with whips and umbrella sticks in the 1912 study, but no wood was reported for this use in 1919.

TABLE 45

WHIPS AND UMBRELLA STICKS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total..........	250,000	100.00	$50 00	$12,500	250,000	....
Birch..............	100,000	40.00	$50 00	$5,000	100,000	....
Hard maple........	100,000	40.00	50 00	5,000	100,000	....
Beech..............	50,000	20.00	50 00	2,500	50,000	....

Wood bought by weight — Rattan.

PRINTING MATERIAL

This industry is relatively unimportant, largely because the wood is in the form of small pieces and for small articles. Black cherry is the most important wood, as it also was in 1912, but yellow pine, birch, beech, and hickory, which were reported in 1912, were not reported this time. The articles included in this industry are printers' supplies, wood type, bases for mounting cuts, electrotype blocks, engraving boards, engraving blocks, and printing-press attachments. The essentials of woods for bases of electrotypes and cuts include the qualities of being hard, free from warping, and capable of holding nails without splitting. There has been a pronounced decrease in the amount of material consumed since 1912, although the number of reporting firms is the same. This industry, though small, offers a good opportunity for the utilization of small and otherwise waste pieces of lumber Blocks of the more expensive woods, such as cherry and hard maple, can sometimes be worked out of stock which has been discarded by another factory.

TABLE 46

PRINTING MATERIAL

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	own out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	72,000	100.00	$87 29	$6,285	48,000	24,000
Cherry (black)	21,000	29.16	$140 00	$2,940	14,000	7,000
Chestnut	15,000	20.84	40 00	600	15,000	....
Basswood	15,000	20.84	35 00	525	15,000	....
White oak	10,000	13.88	75 00	750	....	10,000
Hard maple	5,000	6.95	230 00	1,150	....	5,000
Yellow poplar	4,000	5.55	35 00	140	4,000	....
Mahogany	2,000	2.78	90 00	180	....	2,000

MISCELLANEOUS

The miscellaneous table includes the reports from a number of minor industries in which the annual consumption of wood is too small to justify the publication of separate tables. It also includes larger industries, some of which are of much importance in the State, but the number of firms engaged is so small that the publication of their figures separately would reveal the identity of those making the report. These data include the manufacture of playground equipment, signs and supplies, florists' sticks, bottle stoppers, artificial limbs, hinges, mouse traps, butchers' supplies, mop wringers, cores, plugs, and reels. (See paragraph 2, Electrical Machinery and Apparatus.) The 1912 report included playground equipment in a separate table as well as signs and supplies, but owing to the small number of firms reporting for 1919 these two tables are now included under the miscellaneous heading in order that the reports may be kept confidential.

The report of 1912 shows a total consumption of 30,790,300 feet reported by 24 firms; in this report 3,708,000 feet are reported by 18 establishments. This marked decrease in consumption is due in part to the smaller number of firms reporting and to the exclusion of dynamite made of wood-flour and fibre-board made of spruce, both of which were included in the former report. These industries are now included in census reports. Matches, formerly included in the miscellaneous table, are now tabulated separately, which makes a difference of over 14,000,000 feet.

White pine still holds first place in the miscellaneous table with 785,000 board feet purchased at a cost of $156.27, a price which indicates that a good grade of material was used. This is a marked increase over $32.80 in 1912. Hard maple is the second wood of importance; this wood was in ninth place in the former report at $30.04 a thousand and now is $33.76, which is a surprisingly small increase. The reason for this small increase probably is that formerly it was all brought in from outside the State, but now it is all State-grown, coming largely from small timber tracts. Beech is now in third place instead of sixth as formerly; in this case also a much larger proportion of the material was home-grown with only a slight increase in price.

The woods used principally for florists' sticks and plant supports are beech, birch, maple, and chestnut. Cork is received in rough form from Portugal and is 2 to 3 inches thick. It is used principally for bottle stoppers; and the waste goes into composition material, such as floor coverings, and is used also for refrigeration purposes. Willow is utilized almost exclusively in the manufacture of artificial limbs. The principal requisites of wood for this use are freedom from checking and warping under varying moisture conditions. The manufacture of artificial limbs requires a long period of drying, as thick stock is necessary for this use and the drying must be sufficiently gradual to prevent checking of the wood in the round. The manufacture of artificial limbs is practically all hand work and each part must be made to measure. Quite a large amount of material is reported as being used in the bung trade, and yellow poplar and spruce are the favorite woods in this industry. Beech and basswood are the main woods contributing to the mouse trap industry. Spruce, ash, and maple are used for butchers' supplies, and the hard maple goes mainly into built-up butchers' blocks, because of its white, clean appearance and its hardness, toughness, and fine grain. Adirondack birch and maple contribute largely to the mop-wringer industry. Beech, birch, maple, elm, and basswood are used in about equal amounts for the manufacture of reels for wire used in conduits. Beech, birch, maple, and elm are utilized largely for cores and plugs used in the paper industry. Signs and supplies draw upon sycamore, tupelo, and red gum; and playground equipment requires yellow poplar, white pine, Douglas fir, ash, and basswood.

The average cost of material listed in this table is now $72.32, as compared with $29.80 in 1912; and the three notable increases are in white pine, yellow poplar, and ash. It is encouraging to note that the beech, birch, and maple, the staple hardwoods of New York, were nearly all obtained within the State. On the other hand there is food for serious reflection in the fact that in New York, once the home of the white pine, it was necessary to import every foot of the 740,000 feet consumed. Is not something seriously wrong with our economic planning?

TABLE 47

MISCELLANEOUS

KIND OF WOOD	QUANTITY USED ANNUALLY		Average cost per 1,000 feet	Total cost f. o. b. factory	Grown in New York. (Feet b. m.)	Grown out of New York. (Feet b. m.)
	Feet b. m.	Per cent				
Total	3,708,000	100.00	$72 32	$268,153	1,652,000	2,056,000
White pine	785,000	21.16	$156 27	$122,675	....	785,000
Hard maple	603,000	16.25	33 76	20,357	603,000	....
Beech	460,000	12.40	30 80	14,168	434,000	26,000
Birch	362,000	9.76	33 20	12,018	362,000	....
Sycamore	300,000	8.09	48 00	14,400	....	300,000
Tupelo	250,000	6.74	45 00	11,250	....	250,000
Yellow poplar	240,000	6.47	135 62	32,550	....	240,000
Spruce	225,000	6.07	60 00	13,500	150,000	75,000
Southern yellow pine	160,000	4.32	48 00	7,680	....	160,000
Red gum	150,000	4.05	45 00	6,750	....	150,000
Elm	51,000	1.38	25 10	1,280	51,000	....
Basswood	48,000	1.30	32 60	1,565	41,000	7,000
Ash	48,000	1.30	172 29	8,270	8,000	40,000
Douglas fir	20,000	.54	65 00	1,300	....	20,000
Willow	3,000	.08	40 00	120	3,000	....
Southern red cedar	2,000	.06	110 00	220	....	2,000
Chestnut	1,000	.03	50 00	50	....	1,000
Cork*	....	......	......	....	....	....

* 300,000 pounds.

APPENDIX

The foregoing tables show what becomes of the lumber after it leaves the sawmill, following the various steps in manufacture until the finished commodities are produced as furniture, toys, handles, etc. There are various other forms of forest products in addition to lumber, and the purpose of the following pages is to give a brief synopsis showing the production of some of these other forms, the data being taken from the latest available sources as indicated.

FOREST PRODUCTS OF NEW YORK

The following tabulations are copied from the 1919 report of the New York State Conservation Commission, showing the production of lumber in 1918 from the principal softwoods and hardwoods. The last table shows the consumption of wood in the production of shingles, lath, heading, staves, posts, poles, ties, pulpwood, and wood for acid, excelsior, kilns, etc. It includes both lumber and round wood expressed in board feet.

Lumber Production of New York

Table A. 1918

	Feet B. M.
Spruce	25, 874, 690
Hemlock	75, 005, 150
Pine	62, 653, 500
Balsam	1, 505, 094
Cedar	227, 568
Tamarack	91, 114
Maple	55, 789, 225
Beech	37, 196, 320
Oak	26, 895, 820
Birch	25, 505, 900
Chestnut	15, 370, 950
Basswood	14, 533, 350
Ash	9, 696, 750
Elm	7, 314, 180
Locust	2, 085, 690
Poplar	1, 167, 300
Hickory	898, 270
Cherry	763, 885
Gum	223, 165
Sycamore	160, 900
Minor species	74, 075
	363, 132, 896

Pieces

Shingles	5, 712, 000
Lath	4, 179, 300
Heading	8, 296, 366
Staves	453, 000
Posts	91, 462
Poles	19, 218

Cordwood

For acid, excelsior, kilns, etc	225, 420 Cords

Forest Products by Years

1908	1, 226, 754, 365
1909	1, 091, 164, 710
1910	927, 933, 291
1911	972, 596, 685
1912	942, 545, 269
1913	851, 391, 367
1914	855, 658, 389
1915	804, 142, 388
1916	863, 932, 860
1917	861, 870, 781
1918	762, 289, 934

With regard to lumber, as recorded by the Forest Service in 1918, New York does not occupy the lead in the production of any single species, but has third place in the production of birch, fourth in maple and basswood, fifth in beech, sixth in ash and hemlock, seventh in balsam fir, eighth in white pine, spruce, and chestnut, and ninth in elm. In 1919 over 1,200 sawmills were in operation.

Pulpwood Consumption

The pulp industry in New York is enormously important. In 1918 New York consumed 1,003,742 cords of pulpwood, one-half of which was imported from Canada or other States. The only State consuming more pulpwood is Maine, which used 1,234,929 cords. New York, however, has over twice as many mills as Maine, and probably the greater capitalization. The ever-increasing demand for pulpwood is one of the important factors which must be reckoned with in planning the future forest policy of the State. The pulp mills utilize small and inferior trees as well as those which are large and mature, but in certain species the pulp mills compete with the sawmills as to which shall obtain and manufacture the wood. For instance, in 1912 the secondary wood-using industries used 76,000,000 feet of home-grown spruce and in 1919 only 20,000,000 feet. This very appreciable decrease in seven years is no doubt due in part to the consumption of this valuable tree for pulpwood. The industries of the State are still using large quantities of spruce, but much of it is now necessarily imported. Spruce once occupied a distinctly inferior position to white pine in the estimation of lumbermen, but the excellence of spruce fibre for pulp purposes has now made it very valuable.

In these days the pulpwood is often transported from distances of 500 miles or more, the supplies near the mills having been exhausted in previous years. It is reported that 60 per cent of the New York mills have no supplies of their own, but must depend upon purchase, largely from sources outside the State. Canada has always been the main reliance for imported spruce, but since 1910 several Canadian Provinces have found it desirable to forbid the export of pulpwood cut from their

Crown lands. Sixty per cent of the remaining spruce pulpwood in New York is on the State Preserves, where no cutting is allowed.

Pulpwood Consumption in New York

Year	Mills	Wood consumed, (cords)	Total cost, (dollars)	Pulp produced, (tons)
1909	90	921,882	9,630,575	686,323
1916	75	1,094,513	12,098,608	787,397
1917	79	1,056,556	15,270,142	798,616
1918	75	1,003,742	17,954,934	749,176

The amount of pulpwood produced annually by the State is now utterly insufficient to supply the mills, as indicated by the following statistics of the Conservation Commission for 1918, being less than 50 per cent of the annual consumption.

Species	*Cords*
Spruce	335, 423
Balsam	54, 460
Hemlock	85,054
Poplar	22, 925
Basswood	3, 780
	501, 642

Like the secondary industries, the wood-pulp manufacturers are already restricted in their operations for the lack of raw material. Some firms are moving to other regions where a greater supply of pulpwood is in sight. The last great areas of forest remaining are in Washington, Oregon, and Alaska. Apparently New York must eventually lose to the other States a large part of this great industry, with all the laborers, wages, and wealth production incident to such loss. The only way to win back this source of prosperity is through reforestation on a large scale. Many years will be required to increase the annual supply to its maximum, and the New York mills can always handle any amount which the forests of the State could conceivably produce. Therefore the market for pulpwood will always be active and its production profitable upon the farm woodlots or on larger forest tracts.

A Pulp and Paper Mill in Northern New York.

The great mills of this type consume enormous quantities of wood. No forest is inexhaustible to them and the large modern sawmills. New York is now unable to produce half the pulpwood needed for her mills. It is therefore time from the eco-
[illegible] area in the State which is not essential for recreation should be devoted to forest pro-

Slack Cooperage

In 1918 New York produced 33,853,000 slack staves, about 3 per cent of the production of the United States. Nearly 3 per cent of the total slack heading also comes from New York. In slack cooperage the State ranks in the eighth place.

The three principal hardwoods of New York, namely, birch, maple, and beech are the important slack-cooperage species of the State in the order mentioned. Most of the cooperage is made by a few large cooperage plants. However, there are a considerable number of small firms which manufacture an appreciable quantity of cooperage. These small shops are located principally in central and western New York. New York receives a great deal of cooperage in the form of hoops, heading, and staves from outside sources and this material is assembled in a large number of shops throughout the State. The larger portion of the slack cooperage is used in the marketing of agricultural and horticultural products. The introduction of cotton, jute, and paper bags, and various cardboard containers reduced the former demand for slack cooperage to a considerable extent. Flour, formerly sold almost entirely in barrels, is now marketed mainly in paper bags which cost much less.

Woods which dry quickly, steam well, retain their form when bent, and are comparatively free from resin and odor make the best stave material. Care in cutting the stave bolts into the right sizes (quarters, fifths, or sixths, as the bolting-saw operator sees fit) means the reduction of waste and the production of better staves. Judgment and care in the handling of the bolts under the stave cutting knife are also necessary to avoid losses of raw material or the production of inferior work.

Elm is the principal hoop stock, its superior tensile strength recommending it above all others. Coiled elm hoops are made by slicing or sawing, the former methods being less wasteful because there is not even the loss of saw kerf. Most barrel hoops, however, are sawed, and are generally between 1 and 2 inches wide, 3/16 of an inch thick on the thick edge, 1/16 of an inch thick on the thin edge, and range from 4 to 7 feet in length.

Tight cooperage is unimportant in New York, the principal centers of that industry being in Arkansas, Mississippi, Tennessee, Alabama, Louisiana, Missouri, Kentucky, and the Pacific States.

Veneers

The raw material which goes into the veneer plant is in the form of logs. There are three processes of manufacturing. In one process the logs are cut into square blocks called flitches, and then passed through the usual process of sawed lumber, except that a special equipment is required for producing very thin lumber, whereby guide ways are used to hold the very thin boards upright and in proper position while the saw passes very slowly along the side of the log.

Another process is that of slicing, wherein the log is thoroughly steamed, squared, and then dropped against a sharp knife extending the full length of the log.

The third process is called "rotary cut" which is similar to the slicing method except that the log is prepared in round form, and after being steamed is revolved rapidly against a fixed knife, which peels off a thin, continuous sheet. This latter process is the most economical, requires less skill, and is in more general use than the others.

Veneers are cut into many thicknesses from 5/16 to 1/120 of an inch. The domestic rotary cut woods range from 1/50 to 5/16 of an inch in thickness. The imported woods are cut mostly from 3/16 to 1/34 of an inch. The mahogany veneers are cut mostly to 1/28 of an inch with a good proportion of 3/16 of an inch. The extremely thin mahogany veneers find such uses as tobacco-can linings and coverings.

The growing tendency to market many commodities, such as fruits and vegetables, in light-weight packages has opened a wide field for thin lumber and the future promises extensive growth. Large quantities of the Adirondack rotary veneers are made into wire-end dishes for containing butter, lard, pickles, etc.

Built-up lumber, consisting of several layers firmly glued together with the grain crossed, is becoming more important every year in many industries. Furniture tops, panels and backs, drawer fronts and bottoms, chair seats, trunks, store and office fixtures, pianos, packing boxes, vehicle and automobile bodies, and the finish of passenger cars are examples of the product of veneer and built-up lumber. The built-up lumber, or plywood, has the advantage of being much stiffer and stronger than solid lumber for the same weight, and is also less liable to warp or check. In the shipment of fruit and vegetables, where strength is unimportant and lightness is essential, the introduction of rotary-cut veneer lumber has made possible the utilization of many comparatively inferior species, and the same cheaper woods are used as cores in connection with the high-grade sliced and sawed veneers in the manufacture of furniture and fixtures. Species such as cottonwood were considered of little value owing to the tendency to warp, until utilized in the form of veneers. In built-up lumber they may be used for the middle layer with other woods for the external layers.

In the United States red gum is the principal veneer wood, but many other species are used. Mahogany, Circassian walnut, and English oak are the imported species in greatest demand, while gum, hard maple (especially the rich figured wood) and white oak, are among the most popular domestic finishing woods.

With the exception of Spanish cedar, which generally goes into cigar boxes, the foreign woods are mostly used for the best grades of cabinet work, furniture, and fixtures.

In 1911 New York led in the veneer industry. Although there are no recent reports from other States showing veneer production, it is believed that New York still stands well toward the head of the list as regards the quantity produced.

Wood Distillation

Valuable commercial products are obtained through wood distillation by two distinct processes, destructive distillation and steam distillation. In the former process the wood fiber is broken down and charred and new compounds are formed, while in the steam process the wood retains its original form. In destructive distillation direct heat is applied below the vessel containing the wood and the heat vaporizes the volatile compounds, such as turpentine, and breaks down the non-volatile compounds, such as wood gums, and forms a number of new compounds, leaving a residue of charcoal. The decomposition of wood in this process is complicated and not yet fully understood.

In obtaining the products from steam distillation the process is simpler. The wood is chipped and placed in a closed receptacle into which steam is blown from a boiler, and the volatile compounds are vaporized and carried out of the retort with the steam. Although the wood is at times so much overheated that its fiber is slightly decomposed, it is substantially correct to say that in steam distillation there is no decomposition of the wood fiber, while in the destructive distillation the fiber is destroyed. In the one process the wood is only steamed, while in the other the wood is charred or burned.

As there are two different processes of obtaining distillates, so there are two different classes of products obtainable from the various woods. The hardwoods, for example, such as beech, birch, and maple, yield acetic acid, wood alcohol and charcoal; while the softwoods, such as longleaf pine, yield turpentine, tar, oils and charcoal. This difference in the products is due to the fact that pine woods are resinous, while hardwoods are non-resinous.

New York is not within the softwood distillation area. Hardwood distillation plants are found principally in New York, Pennsylvania, and Michigan, where an adequate supply of beech, birch, and maple is available. These three woods produce nearly all of the commercial products. The Forest

Service has conducted experiments to determine the comparative value, not only of birch, beech, and maple, but also of red gum, oak, hickory, chestnut, and tupelo gum, for their distillation products. In New York the oak and hickory may ultimately be utilized profitably, but the distillation of chestnut is not at present a success on account of its low yields of the desired products.

The distillation plants demand wood which is allowed to season for a year in five-foot cordwood length. The products obtained have a variety of uses. The charcoal is used in blast furnaces for the production of pig iron, in copper and sugar refineries, in the production of gunpowder, and as fuel. Wood alcohol is sold under a variety of trade names, and most widely used as a solvent in the production of shellacs and varnishes. Acetic acid is used in the manufacture of wood vinegar. The calcium acetate resulting from the action of acetic acid on milk of lime ($Ca(OH)_2$) is the basis of many commercial acetates. Both ethyl alcohol (C_2H_5OH) and methyl alcohol (CH_3OH) are commercially produced from wood. Denatured alcohol, with its admixture of wood alcohol, has become a market article of high importance. Distillation is comparatively a new utilization of forest products in the United States, and the business is growing rapidly. Owners of farm woodlots having an abundance of the principal species needed for hardwood distillation, including beech, birch, and maple, should obtain substantial benefits by the further growth of this industry; but the practice of allowing distillation operators to strip woodlots of all valuable young growing stock, which has been too common in some southern counties, should be discouraged as far as possible. It is a short-sighted policy, both for the owner and the welfare of the State.

Excelsior

In New York, as elsewhere, cottonwood is the favorite excelsior wood. Any soft wood that has a fairly long or tough fibre will make excelsior. Several woods, among them being chestnut, are soft enough and have the quality of workableness, but are not suitable for excelsior because they become too brittle after drying. Many kinds of wood are used in the United States, including in addition to those listed in New York, yellow poplar, birch, maple, white ash, cherry, yellow pine, white pine, tamarack, cypress, hemlock, black gum, and red gum. New York has a great abundance of raw material suitable for excelsior, especially of that ideal excelsior material, cottonwood. This industry is supplied almost entirely from timber grown in New York, and the average cost of the raw material quoted in 1919 was $12.85. Basswood is even better than cottonwood, but it is not so generally available at local points. All cottonwood does not make good excelsior but many species are excellent. The stock must be free from knots, but use may be made of small timber and of short lengths, and thus utilization can be had of much material that is not fit for the sawmill. There is not much timber left on an acre where the excelsior machines have taken all they can use. The utilization is close in the factory also and everything is salable, even the roughest product being sold to liverymen for stable bedding or to nurserymen for shipping young trees. Some thickened slabs in the mill can be worked, but other mill waste, such as strips and shavings, cannot be converted into excelsior because the process involves shaving the wood into strings from the face of the block. The logs for excelsior must be perfectly dry. They should be seasoned for six months or more and then cut into blocks and quartered. The blocks are fastened into the machines and automatically fed. A series of sharp spurs, generally set less than an inch apart are forced along the surface of the block, cutting grooves to a depth less than the thickness of a match. A knife follows these spurs, cutting loose the scorings made by them and causing a bunch of curly excelsion fibres to fall from the block. The machines may be regulated to cut coarse strands or fine. The finest grades are called wood-wool. Excelsior is readily colored by aniline dyes for ornamental uses.

Besides constant use in general packing, excelsior is in demand by upholsterers of furniture and by manufacturers of carriages, mattresses, and chairs. It is also used extensively for shaping dolls and toy animals. Mattress factories use a great deal of excelsior for the centers of low-grade mattresses, which are then faced with quilted cotton.

The excelsior industry, like the newsprint industry, gives the closest utilization of raw material placed at the door of the factory. The armies of the world used excelsior for filling mattresses; the manufacturers of china and glass not only protect shipments from breakage but avoid dampness which formerly existed when straw and hay were used. Wood-wool has only one-third the weight of hay, and is crowding the older packing material out of the markets through its lightness of weight, cleanness, and assortable condition for packing. Kennel and stable bedding, filtering mediums for beer, packing fancy goods, ornamenting shop windows, and innumerable other uses requiring elastic, pliable, clean, and bright packing material all invite the establishment of excelsior plants in the several woodlot areas of the State of New York.

EXCELSIOR

Kind of Wood	Quantity Used Annually		Average cost per cord	Total cost f. o. b. factory	Grown in New York, cords	Grown out of New York, cords
	Cords	Per cent				
Total	14,380	100.00	$12 85	$184,728	12,910	1,470
Cottonwood	9,105	63.32	$12 80	$116,544	8,200	905
Basswood	5,075	35.29	13 12	66,584	4,510	565
Butternut	200	1.39	8 00	1,600	200	....

RELATIVE UTILITY OF SPECIES.

A merely superficial knowledge of the industries would be sufficient to rate white pine at once as the most useful wood in New York State. It would not be so easy, however, to place many of the other species in the relative order of their usefulness, unless some method of rating were adopted.

Usefulness depends first upon those qualities which the wood possesses which render it especially fit to perform service under exacting conditions. But no matter how distinctive and how numerous the qualifications might be, if the wood were so scarce or so costly as to be unobtainable or nearly so, it could not be deemed useful in a broad sense of the word. Therefore, the rating must depend not only upon the capacity to perform service, but the physical presence or availability of the species. For example, hickory and black walnut have qualifications which rendered them exceedingly useful so long as they were obtainable in quantity; but now that they are scarce and difficult to obtain, their use, and consequently their usefulness, has greatly diminished.

The following classification is based upon both these principles. The number of articles made from each species was counted and adopted as the index of its qualities. This number was then multiplied by the per cent of the wood consumption of the State supplied by that species. The products of these multiplications were then arranged in order of size, giving the following list in order of usefulness:

Approximate Relative Utility of Species

Species	*Rating factor*	*Species*	*Rating factor*
1. White pine	17.5	11. Cypress	1.5
2. Hard maple	7.4	12. Ash	1.3
3. Spruce	6.7	13. Red gum	1.2
4. Birch	3.5	14. Hemlock	.8
5. White oak	3.0	15. Chestnut	.6
6. Southern yellow pine	2.7	16. Mahogany	.3
7. Basswood	2.3	17. Douglas fir	.3
8. Loblolly pine	1.8	18. Elm	.2
9. Beech	1.7	19. Red oak	.1
10. Yellow poplar	1.7	20. Black walnut	.1

No doubt this list is subject to criticism in some respects. Usefulness is a quality which can not be precisely rated by mathematics or conventional means, especially where it is impossible to take cognizance of all the facts which should have a part in the conclusion. Yet in the lack of a better, the list above will serve as a fairly reliable guide in appraising the service performed by these species. Out of the twenty species listed, thirteen, including the first five, are the natural product of New York's splendid forest soils.

KINDS OF WOOD USED BY THE INDUSTRIES

Applewood

Handles
Handles, saw

Arborvitae (Northern white cedar)

Boat bottoms
Boat decking
Furniture
General millwork
Planing mill products
Roof tanks
Row boats
Shiplap
Siding
Signal devices
Woodenware
Yachts

Ash

Aeroplanes
Agricultural implements
Automobiles
Baskets
Bodies
Bolsters
Bows, auto-tops
Boxes
Box springs
Brush backs
Buggies
Butcher fixtures
Butter packages
Butter tubs
Cabinets
Candy pails
Car construction
Carts
Caskets
Chairs
Cheese boxes
Coal screen frames
Crates
Curtain poles
Desks
Dowels
Dumb-waiters
Elevators
Finish
Fixtures, store, office
Furniture
Handles
Hand rakes
Hoops
Interior trim
Ladders, round
Machinery, frames
Machinery, rods
Motor vehicles
Musical instruments
Novelties
Organs, frames
Panels
Patterns
Picture frames
Playground equipment
Plow beams
Plumbers' woodwork
Plywood
Poles, vehicle
Pump rods
Refrigerators
Rollers, farm machinery
Scientific instruments
Ships
Singletrees
Skiis
Skids
Sleds
Sleighs
Snow shovel handles
Sofas
Souvenirs
Stakes, wagon
Stanchions
Steering wheels
Threshers
Toilet tanks
Toilet seats
Tongues
Toys
Tripods
Trunk slats
Trunk strips
Turnery
Wagon poles
Wagon, coasters
Whiffletrees
Woodenware

Balm of Gilead

Boxes
Crates
Packing

Balsawood

Boat equipments
Life preservers
Refrigeration, cars
Refrigeration, ships
Refrigeration, trucks

Balsam Fir

Boxes
Cheese box heads
Crates
Dairy supplies
Planing mill products

Basswood

Aeroplanes
Agricultural implements
Automobiles
Baby carriages
Bank fixtures
Basket covers
Basket splints
Beehives and bee supplies
Berry baskets
Billiard-table beds
Boats
Bookcases
Boxes, fancy
Brooms
Brushes
Butter tubs
Cable reels
Cameras
Candy buckets
Cars
Car construction
Casing
Caskets
Ceiling
Chairs
Checkers
Cheese box heading
Children sled tops
Cigar boxes
Corn planters
Crates
Dominoes
Drawer bottoms
Drafting furniture
Drills
Dumb-waiters
Egg carriers
Egg cases
Excelsior
Filing cabinets
Fixtures
Furniture
Games
Go-carts
Graders, peach
Grain hoppers
Grass seeders
Handles
Hand sled tops
Hay racks
Hobby horses
Ice tools
Incubators
Indian clubs
Instrument cases
Ladders
Lasts
Lawn furniture
Machine construction
Matches
Milk racks
Molding
Mousetraps
Motor vehicles
Musical instruments
Novelties
Packing boxes
Pails
Panels
Patterns
Pianos
Piano players
Picture frames
Playground equipment
Plywood
Printers' cabinets

Pulleys
Reels, cordage
Rulers
Scientific instruments
Scoops
Shade rollers
Shirt waist boxes
Shoe-trees
Shoe forms
Shop patterns
Showcases
Skids
Sleigh bodies
Spools
Store fixtures
Threshing machines
Toys
Trunks
Turnery
Wagons
Wagon boxes
Wheelbarrows
Window frames
Woodenware
Yardsticks

Beech

Agricultural implements
Automobile seat frames
Baskets
Beater paddles, paper mills
Bobbins
Boxes
Brick molds
Broom handles
Brushes
Built-up panels
Bushel crates
Butchers' blocks
Butter dishes
Cable reels
Camp furniture
Cars
Caskets
Chairs
Chair bottoms
Cheese boxes
Clothespins
Coat hangers
Cores
Crates
Crating
Dowels
Farm machinery
Fixtures
Flower supports
Furniture
Handles
Hat racks
Kodaks
Ladders
Ladles
Lasts
Laundry appliances
Lawn swings
Machine construction
Map rollers
Meat boards
Motor vehicles
Mousetraps
Musical instruments
Novelties
Pails
Panels
Patterns
Pencil boxes
Pianos, backs and bottoms
Pipe organs
Plugs, paper mill
Plumbers' woodwork
Reels, cross
Reels, rope
Refrigerators
Rulers
Sash
Sectional bookcases
Scientific instruments
Showcases
Shuttles
Stanchions
Tables
Toys
Trunks
Umbrella handles
Vehicles
Wardrobes
Washing machines
Wheelbarrows
Whip butts
Window screens
Woodenware
Yardsticks

Birch

Agricultural implements
Automobile rims
Baskets
Boat finish
Bobbins
Bookcases
Bowling pins
Boxes
Brick molds
brush backs
Built-up panels
Butter boxes
Butter molds
Cabinets
Cable reels
Cameras
Camp furniture
Car finish, vestibules
Carts
Casing
Caskets
Ceiling
Chairs
Cheese boxes, hoops
Clocks, turnery parts
Clothespins
Couch frames
Cores
Crates
Crating
Desks
Dowels
Duck pins
Dumb-waiter cars
Fixtures, exterior parts
Flooring
Furniture
Games
Handles, broom, umbrella
Hand sleds
Harvesters
House trim, general
Hubs, wheelbarrow
Hubs, wagon
Interior finish
Ladders
Machine construction
Mantels
Meat boards
Mirror backs
Molding
Mop wringers
Motor vehicles
Musical instruments
Office fixtures
Panels
Parlor furniture
Partitions
Patterns
Peavey handles
Picture frames
Plugs, paper mill
Plumbers' woodwork
Pulleys
Reels, cordage
Refrigerators
Scientific instruments
Scoops
Screen frames
Settees
Shoe-trees
Showcases
Shuttles
Sleds, hand
Sleighs
Sofas
Spools
Store fixtures
Swings
Tables
Thresher parts
Toilet seats
Toilet tanks
Toys
Tripods
Trunks
Wagon bodies
Wheelbarrows
Whip butts
Woodenware

Black Cherry

Baskets
Beds
Boat finish
Bookcases
Boxes
Brick molds
Brushes
Bushel crates
Cabinets
Camera boxes

Cars, finish
Casing
Chairs, posts, rounds
Clock cases
Counters
Desks
Doors
Dressers
Electrotype blocks
Engraving blocks
Fixtures
Flasks
Flooring
Furniture
Handles
Interior finish
Kitchen cabinets
Kodaks
Library furniture
Machine boxes
Molding
Musical instruments
Office fixtures
Panels
Partitions
Patterns
Piano actions
Piano cases
Piano players
Piano rails
Picture frames
Pipe organ, cases, actions
Printing material
Sash
School furniture
Scientific instruments
Scoops
Settees
Spindle stock
Store fixtures
Tables
Table drawers
Table legs
Trim
Typewriter tables
Woodenware

Black Walnut

Billiard cues
Bookcases
Brush backs
Bureaus
Cabinet work
Caskets
Chairs
Chair legs
Chiffoniers
Clock cases
Coffins
Couches, legs
Desks
Doors
Fixtures, exterior parts
Fixtures, office
Fixtures, store
Furniture
Gunstocks
Handles
Interior finish
Miter boxes
Molding
Organ cases
Parquetry flooring
Pianos
Piano benches
Piano cases
Piano players
Picture frames
Plywood
Ship trim
Sideboards
Side tables
Vehicles
Woodenware

Boxwood

Brush backs
Scientific instruments

Buckeye

Boxes
Caskets
Chairs
Fixtures
Furniture
Interior finish
Ladders
Trim
Vehicles
Woodenware

Butternut

Boat decks
Boat finish
Boat seats
Cabinets
Excelsior
Furniture
Instrument cases
Interior finish
Panels
Scientific Instruments

Chestnut

Agricultural implements
Automobiles
Baskets
Billiard tables
Car construction
Caskets
Chairs
Cheese boxes
Coffins
Doors
Dumb-waiters
Elevators
Fixtures
Flooring
Florists' sticks
Incubators
Machine construction
Molding
Musical instruments
Picture frames
Planing mill products
Plywood
Printers' Cabinets
Printing material
Refrigerators
Ships
Toilet seats
Toilet tanks
Toys
Toy wagons
Vehicles
Woodenware

Circassian Walnut

Casing
Doors
Fixtures
Furniture
Furniture, office
Interior finish
Kitchen cabinets
Office fixtures

Cocobola

Brush backs
Cutlery handles, general
Knive handles

Cottonwood

Agricultural implements
Berry boxes
Boxes
Brush backs
Bushel crates
Cheese boxes, heads
Crates
Excelsior
Grape trays
Matches

Cypress (Bald)

Agricultural implements
Baseboards
Blinds
Boat doors
Boat frames
Boat lockers
Boat panels
Boxes
Burial caskets, outer boxes
Cabinets
Cab tops, locomotive
Cameras
Car roofing
Cars
Car siding
Caskets
Cheese vats
Churns
Coffins
Cornices

Doors
Elevators
Exterior finish
Finish
Fixtures
Furniture
Greenhouses
Gun cases
Handles
Interior trim
Launches, sides
Laundry tubs and appliances
Machine construction
Machine walkways
Motor vehicles
Moldings
Musical instruments
Office fixtures
Patterns
Picture frames
Plumbers' woodwork
Pump covers
Refrigerators
Sash
Scientific instruments
Screen frames
Ships, sash, panels
Siding
Signaling devices
Silos
Store fixtures
Store fronts
Tanks
Trim, boat
Vehicles
Washing machines
Window frames
Woodenware

Dogwood

Bobbins
Shuttles

Douglas Fir

Aeroplanes
Agricultural implements
Boat decking
Boat flooring
Boat siding
Boxes
Car construction
Caskets
Ceiling
Derrick poles
Doors
Exterior finish
Fixtures
Interior finish
Ladders
Musical instruments
Piano backs
Playground equipment
Sash
Ship beams
Ship siding
Ship sills
Silos
Spars, ship and boat
Woodenware

Ebony

Brushes
Cutlery, handles
Knife handles

Elm

Agricultural implements
Baskets, bottoms, covers
Boxes
Broom handles
Butter tubs
Bushel crates
Chairs
Cheese boxes, heads, hoops
Cable reels
Crating
Couch frames
Elevators
Fruit cases, handles, hoops
Furniture
Go-devils
Handles
Hayracks
Hub, vehicle
Instruments, musical
Ladders
Lasts
Machine construction
Motor vehicles
Planing mill products

Plugs, paper mill
Plywood
Rockers
Sash
Ships
Sleighs
Stanchions
Trunks, slats
Vehicle poles
Whiffletrees
Woodenware

English Oak

Furniture
Interior finish
Interior trim

Granadilla (Cocowood)

Cutlery handles
Knife handles

Hemlock

Agricultural implements
Baskets
Blinds
Boxes
Car construction
Cheese boxes
Crates
Doors
Electrical machinery and apparatus
Elevators
Flasks
Flooring
Fixtures
Furniture
Handles
Machine construction
Patterns
Refrigerators
Ships

Hickory

Agricultural implements
Automobile wheels
Axles
Billiard cues
Boats
Bolsters
Buggies
Buggy shafts
Buggy spokes
Doubletrees
Eveners
Handles, tool
Instruments, tripods
Lasts
Mallets
Motor vehicles
Rakes, hand
Singletrees
Skiis
Sleighs
Spokes
Vehicles
Wagon rims
Wagon tongues

Holly

Brush backs
Musical instruments
Piano actions

Lignum-vitae

Bowling balls
Bushings
Caster wheels
Handles
Mallets
Rollers
Scientific instruments
Woodenware

Loblolly Pine

Agricultural implements
Automobiles
Boxes
Crates
Doors
Elevators
Finish
Fixtures
Furniture
Garden implements

Kitchen cabinets
Ladders
Machine construction
Musical instruments
Packing boxes
Refrigerators
Sash

Brick molds
Flasks

Aeroplanes
Automobile trim
Beds
Billiard cues
Bookcases
Brushes
Cameras
Car finish
Caskets
Chairs
Clock cases
Engraving blocks
Fixtures, exterior
Furniture
Instrument cases
Instruments, musical

Agricultural implements
Automobile steering wheels
Axletrees
Axles
Baskets
Bedroom furniture
Billiard cues
Billiard tables
Blueprint frames
Boat finish
Bobbins
Bobsleds
Bolsters
Bowling alleys and pins
Boxes
Brick molds
Bridge sticks
Brush backs
Butcher blocks
Butter ladles
Butter molds
Camp furniture
Car finish
Car flooring

Ships
Silos
Tanks
Trim
Vehicles
Woodenware

Locust

Patterns
Ships, treenails

Mahogany

Instruments, scientific
Interior finish
Kitchen cabinets
Lamps
Machinery, electrical, bases
Mantels
Molding
Parquetry
Patterns
Picture frames
Plywood
Printing material
Ships
Smokers' furniture
Vehicles
Woodenware

Maple (hard)

Caskets
Ceiling
Chairs
Chair bottoms
Chair rods
Checkers
Cheese boxes
Children's wagons
Clothespins
Coat hangers
Corn planters
Corn shellers
Cot frames
Crates
Curtain poles
Desks
Dishes
Doors
Dominoes
Dowels
Drill frames
Dumb-bells
Dumb-waiters
Dump-wagon boxes

Electrotype blocks
Elevator guides
Eveners
Fixtures
Flasks
Flooring
Furniture
Gears, wagon
Handles:
  cultivator
  broom
  brush
  parasol
  umbrella
Interior finish
Kitchen cabinets
Ladders
Lasts
Laundry appliances
Machine frames
Map rollers
Matches
Meat boards
Milk racks
Mop wringers
Motor vehicles
Molding
Musical instruments
Novelties
Office fixtures
Organs
Paddles, boat
Parquetry flooring
Patterns
Pianos
Piano bottoms
Piano bridges
Piano players
Picture frames
Plugs, paper mill
Plumbers' woodwork, seats and tanks
Plywood
Printing material
Pulleys
Pumps
Pump buckets
R. R. signal boards
Reels, cable
Reels, cordage
Refrigerators
Rollers, caster
Rollers, land
Rollers, road
Rules
Sash
Scientific instruments
Scoops
Shoe forms
Showcases
Skids
Skiis
Sleds, hand
Sleighs
Spools
Sporting goods
Stanchions
Surveying rods
Toys
Toy wagons
Tripods, surveyors'
Turnings
Vehicles
Wagons
Washing machines
Wedges
Wheelbarrows
Whiffletrees
Whip butts
Woodenware
Wood heels
Wood pulleys, split
Wood type
Yardsticks

Maple (Soft)

Baskets
Bassinets
Fixtures
Furniture, drafting
Instruments, musical
Washing machines

Persimmon

Shoe lasts
Shoe lasts, infants

Pitch-Pine

Finish
Trim

Port Orford Cedar

Ships

Rattan

Aeroplanes
Furniture
Whips

Red Cedar

Boats
Caskets, burial
Chests
Fixtures
Furniture
Interior finish
Marine borer plugs
Pencils
Sash
Siding

Red Gum

Agricultural implements
Automobiles
Baskets
Boat finish
Bookcases
Boxes
Cabinets
Cars
Chairs
Clocks
Curtain poles
Desks
Doors
Drawer panels
Dressers
Finish
Fixtures
Furniture
Instrument cases
Instruments, musical
Instruments, professional
Kitchen cabinets
Kodak film spools
Machinery, frames
Mantels
Office fixtures
Pianos, actions
Piano benches
Piano players
Picture frames
Plywood
Signs
Smokers' furniture
Refrigerators
Tables
Threshing machines
Tool chests
Telephone stands
Toys
Vehicles
Weather strips
Wheelbarrows
Wood pulleys

Red Oak

Automobiles
Bows, auto tops
Boxes
Car construction
Caskets
Chairs
Coffins
Interior finish
Fixtures
Flooring
Furniture
Machine construction
Magazine cases
Motor vehicles
Molding
Musical instruments
Refrigerators
Sash
Ships
Toys
Toy wagons

Red Pine

Boxes
Car construction
Ladders
Mill work
Shade rollers

Redwood

Boats
Caskets
Cigar boxes
Coffins
Doors
Flasks
Interior finish
Musical instruments
Patterns
Sash
Shirt waist boxes
Whips, reed

Rosewood

Automobile trim
Brush backs
Fixtures
Fixtures, store
Knife handles
Musical instruments

Sassafras

Novelties
Souvenirs
Woodenware

Satinwood

Brush backs
Inlaid work

Sitka Spruce

Aeroplanes
Musical instruments, backs
Sounding boards

Southern White Cedar

Ships

Southern Yellow Pine

Agricultural implements
Automobiles
Boats
Boxes
Box car decking
Box car framing
Box car siding
Car sills
Coffins
Crates
Doors
Dump wagons
Elevators
Flooring
Fixtures
Furniture
Harvesting machines, poles
Interior finish
Machine construction
Partitions
Patterns
Reels, wire
Road-building machines
Sash
Ship spars
Silos
Spraying machines, poles, tanks
Tanks
Threshing machines
Trim
Vehicles
Woodenware

Spanish Cedar

Cigar boxes

Agricultural implements
Aeroplanes
Baskets
Boats
Boat oars
Boxes
Box springs
Bungs
Butcher fixtures
Cable reels and spools
Car sheating
Caskets
Chairs
Cheese boxes
Crates
Doors
Elevator platforms
Farm machinery
Fixtures, backing
Fixtures, linings
Fixtures, office
Fixtures, store
Flooring
Furniture, hidden parts
Handles
Ice boxes
Instruments, musical
Instruments, scientific
Ladder sides

Blinds
Doors
Interior finish
Millwork, general
Moldings
Musical instruments

Blackboards
File boards

Ships

Flooring
Ships, bearings

Boxes
Caskets
Cigar boxes
Crates

Spruce

Laundry appliances
Machine construction
Moldings
Molding flasks
Motor vehicles
Paddles
Patterns
Piano backs
Piano benches
Piano cases
Piano ribs
Piano sounding boards
Pipe organs
Player, actions
Refrigerators, inside partitions
Road machinery
Shade rollers
Ships
Shiplap
Silos
Skids
Spars
Tanks
Tripods
Vehicles
Wagon bottoms
Wedges
Woodenware

Sugar Pine

Organs
Patterns
Sash
Ships
Trim
Window frames

Sycamore

Scientific instruments
Signs

Tamarack

Ship knees

Teak

Ships, decks
Parquetry

Tupelo

Packing cases
Shipping cases
Scientific instruments
Signs

Western Red Cedar

Blinds
Boats
Doors
Interior finish
Musical instruments
Pencils
Professional instruments
Rowboats
Sash
Ship hulls
Siding

Western White Pine

Aeroplanes
Agricultural implements
Boxes
Car construction
Caskets
Matches
Ships

Western Yellow Pine

Refrigerators

White Oak

Aeroplanes
Agricultural implements
Athletic goods
Automobile wheels
Baskets
Bookcases
Boxes
Brushes
Butter tubs
Car construction
Caskets
Chairs
Clocks
Coffins
Dressers
Dumb-waiters
Elevators
Instrument cases
Interior finish
Fixtures
Flooring
Furniture
Handles, plow
Harvesters
Ladders
Laundry appliances
Locomotive bolsters and bumpers
Machine construction
Mallets
Molding
Motor vehicles
Musical instruments
Parquetry
Patterns
Picture frames
Plow beams
Plumbers' woodwork, toilet seats and tanks
Plywood
Pool tables
Pool table tops
Printing material
Pumps
Refrigerators
Rollers, land
Sash
Scientific instruments
Ships
Sleighs
Spokes
Telephone stands
Threshing machines
Typewriter tables
Toys
Vehicles
Woodenware

White Pine

Aeroplanes
Agricultural implements
Automobile bodies
Backing, pictures
Baskets
Battery boxes
Bee supplies
Blinds
Boat flooring
Boxes
Buckets
Burial boxes

Car construction
Caskets
Ceiling
Clocks
Doors
Drafting furniture
Drawing boards
Egg cases
Elevators
Fixtures
Flooring
Foundry flasks
Frames
Furniture
Interior finish
Kitchen cabinets
Ladders
Laundry appliances
Machine construction
Matches
Molding
Motor vehicles
Musical instruments
Office fixtures
Patterns
Piano key beds
Picture frames
Pipe covering
Plumbers' woodwork
Playground equipment
Porch columns
Pumps
Reels
Refrigerators
Sash
Scientific instruments
Shade rollers
Ships
Siding
Silos
Store fixtures
Tanks
Threshers
Toys
Trunks, boxes
Tubs
Vehicles
Washing machines
Water pipe
Well curbs
Wheelbarrows
Wire reels
Woodenware

Willow

Artificial limbs
Boxes

Witch Hazel

Fixtures
Furniture
Molding
Musical instruments
Partitions
Picture frames
Trim

Yellow Poplar

Aeroplanes
Agricultural implements
Automobile bodies
Baby carriages
Bamboo novelties
Baskets
Billiard tables
Boxes
Brushes
Bungs
Butter tubs
Cabinets
Cameras
Caskets, boxes
Cars, finish
Chairs
Cheese boxes
Churns
Cigar boxes
Clocks
Clothes hangers
Drafting furniture
Drills
Dumbwaiters
Egg carriers
Elevators
Excelsior
Fixtures
Furniture
Handles
Hat blocks
Instruments, musical
Instruments, professional
Interior finish

Kodaks
Ladders
Lamp standards
Laundry appliances
Mantels
Molding
Picture frames
Playground equipment
Plywood
Pool tables
Printing material
Refrigerators
Sash
Ships
Spool heads
Toys
Vehicles
Wheelbarrows
Woodenware

LOCATION OF COUNTIES IN NEW YORK STATE

Directory of Manufacturers

The following is a list of the manufacturers who cooperated in the collection of the data contained in this report. Manufacturers who produce several products will appear in this list under more than one industry. Many manufacturers make boxes and crates for their own use only.

Aeroplanes

Curtiss Aeroplane & Motor Corp., 65 Churchill st	Buffalo, Erie Co.
The Curtiss Engineering Corp	Garden City, Nassau Co.
Thomas-Morse Aircraft Corp	Ithaca, Tompkins Co.
Loening Aeronautical Eng. Corp., 351–355 W. 52d st	New York, New York Co.
Smith & Smith	Springville, Erie Co.

Agricultural Implements

Stapleton Bros.	Akron, Erie Co.
Boggs Potato Grader Co., Inc	Atlanta, Steuben Co.
Henry & Allen	Auburn, Cayuga Co.
International Harvester Co	Auburn, Cayuga Co.
Quick & Thomas Co	Auburn, Cayuga Co.
Batavia Machine Co	Batavia, Genesee Co.
Massey–Harris Harvester Co., Inc	Batavia, Genesee Co.
Warsaw–Wilkinson Co.	Batavia, Genesee Co.
Wiard Plow Co	Batavia, Genesee Co.
P. E. Kennehan Son & Co	Brasher Falls, St. Lawrence Co.
Bean Harvester Co	Caledonia, Livingston Co.
L. Knott & Co	Cassadaga, Chautauqua Co.
S. K. Campbell Co., Inc	Central Bridge, Schoharie Co.
Louis H. Day	East Pembroke, Genesee Co.
M. E. True & Son	East Pembroke, Genesee Co.
Ontario Drill Co	East Rochester, Monroe Co.
Field Force Pump Co	Elmira, Chemung Co.
Friend Mfg Co	Gasport, Niagara Co.
Gowanda Agrl. Works	Gowanda, Cattaraugus Co.
Stuart Thomas	Greenport, Suffolk Co.
W. Eddy Plow Co	Greenwich, Washington Co.
W. A. Perkins	Harford Mills, Cortland Co.
R. H. Bates	Hemlock, Livingston Co.
Wm. Fletcher	Hemlock, Livingston Co.
W. A. Wood M. & R. M. Co	Hoosick Falls, Rensselaer Co.

The Babcock Mfg. Co.................... Leonardsville, Madison Co.
Le Roy Plow Co........................ Le Roy, Genesee Co.
Richmond Mfg. Co...................... Lockport, Niagara Co.

E. U. Scoville Co...................... Manlius, Onondaga Co.
Munnsville Plow Co.................... Munnsville, Madison Co.

Coldwell Lawn Mower Co................ Newburgh, Orange Co.
Newfane Lumber & Mfg. Co.............. Newfane, Niagara Co.

Garley Heater Co., Inc.................. Olean, Cattaraugus Co.

Crown Mfg Co.......................... Phelps, Ontario Co.
Moline Plow Co........................ Poughkeepsie, Dutchess Co.

F. B. Pease Co......................... Rochester, Monroe Co.

Clark Machine Co...................... St. Johnsville, Montgomery C

Westinghouse Co. .... Schenectady, Schnectady Co.
Papec Machine Co...................... Shortville, Ontario Co.
Star Seeder Co......................... Shortville, Ontario Co.
Syracuse Chilled Plow Co............... Syracuse, Onondaga Co.

E. F. McIntyre .... Union, RFD 2, Broome Co.
Eureka Mower Co....................... Utica, Oneida Co.

E. S. Benham .... Warsaw, Wyoming Co.
S. M. Hart............................ Webster, Monroe Co.
C. E. Mott............................ Westdale, Oneida Co.

Baskets and Fruit Packages

Albert Sparrow .... Amagansett, Suffolk Co.
Attica Package Co..................... Attica, Wyoming Co.

Big Indian Wood Products Co............ Big Indian, Ulster Co.
Melford Calkins .... Brant, Erie Co.

Bly Bros. .... Central Square, Oswego Co.
W. F. Stetson Co...................... Cherry Creek, Chautauqua Co.
F. W. Barker .... Coopers Plains, Steuben Co.

A. A. Hamlin .... Demster, Oswego Co.

East Aurora Basket Co.................. East Aurora, Erie Co.
M. E. True & Son...................... East Pembroke, Genesee Co.
Geo. Brasser & Son..................... East Rochester, Monroe Co.

W. M. F. Miller, Mill.................. Forestville, Chautauqua Co.

Bacon & Co............................ Gasport, Niagara Co.
Gloversville Woodenware Co............. Gloversville, Fulton Co.

W. A. Perkins	Harford Mills, Cortland Co.
R. H. Bates	Hemlock, Livingston Co.
Wm. Fletcher	Hemlock, Livingston Co.
Geo. W. Pratt & Son	Highland, Ulster Co.
M. G. Terwilliger	Highland, Ulster Co.
St. Regis Indian Trading Co	Hogansburg, Franklin Co.
Bellair & Son	Holland, Erie Co.
King Ferry Mill Co	King Ferry, Cayuga Co.
Geo. L. Relyea	Loyd, Ulster Co.
Wellington Stisser	Lyndonville, Orleans Co.
Courbot Co., Inc	Mallory, Oswego Co.
Royalton Basket Co	Middleport, Niagara Co.
Wm. Downs	New Haven, Oswego Co.
C. S. Hally	New Haven, Oswego Co.
Acme Veneer Package Co., Inc	Orchard Park, Erie Co.
Eastern States Pack. Co	Orchard Park, Erie Co.
Oxford Basket & Mfg. Co	Oxford, Chenango Co.
Barden Robeson Corp	Pen Yan, Yates Co.
Guile & Windnagle	Pen Yan, Yates Co.
Yates Lumber Co	Pen Yan, Yates Co.
Pierce & Coryell	Prattsburg, Steuben Co.
W. B. Rickenbrode Son	Ripley, Chautauqua Co.
W. F. Royce	Ripley, Chautauqua Co.
J. H. Simmons & Son	Sherman, Chautauqua Co.
Lyon–Washington Lbr. Co	Sherman, Chautauqua Co.
Sodus Crate & Basket Co	Sodus, Wayne Co.
Dratt & Fanning	So. Butler, Wayne Co.
Hibbard Basket Works	So. Butler, Wayne Co.
Frederickson Bros.	Stockton, Chautauqua Co.
Excelsior Carriage Co	Watertown, Jefferson Co.
S. M. Hart	Webster, Monroe Co.
Webster Basket Co	Webster, Monroe Co.
Francis Piquet	West Monroe, Oswego Co.
E. L. Rupracht	West Monroe, Oswego Co.

Boot and Shoe Findings

Albany Last Co	Albany, Albany Co.
Wallace McCoy	Allegany, Cattaraugus Co.
Seger–Prindle Mfg. Co	Belvidere, Allegany Co.
J. S. Charles	Bliss, Wyoming Co.
American Wood Heel Co., 62 Glenmore av.	Brooklyn, Kings Co.
Atlantic Wood Heel Co., 322 Van Buren st.	Brooklyn, Kings Co.
French Wood Heel Co., 20 George st	Brooklyn, Kings Co.
R. S. McNeill Co., 57–59 Jay st	Brooklyn, Kings Co.

Manhattan Wood Heel Co., 600 Kent av...	Brooklyn, Kings Co.
P. Meyer Wooden Heel Co., 1906 Atlantic	Brooklyn, Kings Co.
av.	Brooklyn, Kings Co.
N. Y. Wood Heel Co., 29 Quincy st........	Brooklyn, Kings Co.
Williamsburg Wood Heel Co., Inc., 641–643 Lexington av....................	Brooklyn, Kings Co.
Ellicottville Mfg. Co....................	Ellicottville, Cattaraugus Co.
Fitzpatrick & Weller (also at Salamanca).	Ellicottville, Cattaraugus Co.
E. K. Washburne......................	Franklinville, Cattaraugus Co.
Alfred P. Kingston......................	Little Falls, Herkimer Co.
Jasper Johnson	Machias Junction, Cattaraugus Co.
Natural Bridge Mfg. Co..................	Natural Bridge, Jefferson Co.
Daush Wood Heel Co., 519 W. 30th st....	New York, New York Co.
New York Last Co., 431–11th st..........	New York, New York Co.
Simon Roth Wood Heel Co., 10 Ferry st...	New York, New York Co.
The Stewart & Potter Co., 191 Worth st...	New York, New York Co.
Empire Last Works — Branch United Last Co.	Rochester, Monroe Co.
Rochester Last Works..................	Rochester, Monroe Co.
Fitzpatrick & Weller (also at Ellicottville).	Salamanca, Cattaraugus Co.

Boxes and Crates

William Smith	Addison, Steuben Co.
H. W. Draper	Albany, Albany Co.
F. C. Huyck & Sons....................	Albany, Albany Co.
T. F. Romeyn..........................	Albany, Albany Co.
C. M. Mallory	Albion, Orleans Co.
Bennett Mfg. Co.......................	Alden, Erie Co.
Emblem Mfg. Co........................	Angola, Erie Co.
Merrill Soule Co......................	Arcade, Wyoming Co.
Oak Knitting Co.......................	Arcade, Wyoming Co.
Westinghouse Electric & Mfg. Co.........	Attica, Wyoming Co.
Henry & Allen	Auburn, Cayuga Co.
International Harvester Co..............	Auburn, Cayuga Co.
David Wadsworth & Son.................	Auburn, Cayuga Co.
W. R. Prouty	Bainbridge, Chenango Co.
Morris Machine Works..................	Baldwinsville, Onondaga Co.
L. M. Tappen	Baldwinsville, Onondaga Co.
William Carroll & Co., Inc...............	Beacon, Dutchess Co.
Dutchess Tool Co......................	Beacon, Dutchess Co.
National Oven Co......................	Beacon, Dutchess Co.
C. A. Buffington & Co..................	Berkshire, Tioga Co.
W. J. Cowee	Berlin, Rensselaer Co.
Big Indian Wood Products Co............	Big Indian, Ulster Co.
Binghamton Chair Co...................	Binghamton, Broome Co.

Kroehler Mfg. Co., Inc	Binghamton, Broome Co.
The Wilkinson Mfg. Co	Binghamton, Broome Co.
W. G. Case & Co	Black River, Jefferson Co.
Shields Bros.	Bombay, Franklin Co.
Milford Calkins	Brant, Erie Co.
Charles Vail	Broadalbin, Fulton Co.
E. J. Armstrong, 373 Flushing av	Brooklyn, Kings Co.
W. R. Coffee, 281 Plymouth st	Brooklyn, Kings Co.
Eclipse Box & Lumber Co., Inc., Greenpoint av. & Newton Creek	Brooklyn, Kings Co.
J. Friedland Co., 295 Greenpoint av	Brooklyn, Kings Co.
Gasau-Thompson Co., 16 Ashland pl	Brooklyn, Kings Co.
Greenpoint Box & Lumber Co., 43 Dobbin st.	Brooklyn, Kings Co.
Chas. H. Gimpel, 230 39th st	Brooklyn, Kings Co.
J. D. Johnson Co., Inc., Boerum pl. & State st.	Brooklyn, Kings Co.
National Packing Box Co., 298 Nevins st.	Brooklyn, Kings Co.
New York Bottle Box Co., 470–472 Rodney st.	Brooklyn, Kings Co.
Queensboro Box & Lumber Co., 300 Richard-	Brooklyn, Kings Co.
son st.	Brooklyn, Kings Co.
Geo. H. Reeves, Inc., 290 Green st	Brooklyn, Kings Co.
O. S. Richards Corp.	Brooklyn, Kings Co.
Unity Box & Lbr. Co., Inc., 668 Driggs av.	Brooklyn, Kings Co.
Wood Packing Box Co., 370 Johnson av	Brooklyn, Kings Co.
Brownville Paper Co	Brownville, Jefferson Co.
Brownville Ventilated Column Wks	Brownville, Jefferson Co.
American Radiator Co	Buffalo, Erie Co.
Barcalo Mfg. Co., 225 Louisiana st	Buffalo, Erie Co.
C. M. Bott Furniture Co., 170 Leslie st	Buffalo, Erie Co.
Buffalo Lounge Co	Buffalo, Erie Co.
Buffalo Pitts Co., 27 Carolina st	Buffalo, Erie Co.
F. N. Burt Co., Ltd., Seneca & Hamburg sts.	Buffalo, Erie Co.
Davenport & Ridley, 1128 Seneca st	Buffalo, Erie Co.
G. Elias & Bro., Inc	Buffalo, Erie Co.
Ford Motor Car Co., 2495 Main st	Buffalo, Erie Co.
Graves, Manbert & Geroge, Inc	Buffalo, Erie Co.
Greenwood Chair Co., 70 Oneida st	Buffalo, Erie Co.
Hersey & Co	Buffalo, Erie Co.
E. & B. Holmes Machinery Co	Buffalo, Erie Co.
The Jewett Refrigerator Co	Buffalo, Erie Co.
Kittinger Co., Inc., 1893 Elmwood av	Buffalo, Erie Co.
MacLean Box Factory, 160–170 Elk st	Buffalo, Erie Co.
Meyer Wagon Works	Buffalo, Erie Co.
Montgomery Bros. Co., Court & Wilkinson sts.	Buffalo, Erie Co.
Niagara Box Co	Buffalo, Erie Co.
Niagara Machine & Tool Works, 683 Northland av.	Buffalo, Erie Co.
Otis Elevator Co	Buffalo, Erie Co.
Pierce-Arrow Motor Car Co., 1695 Elmwood av.	Buffalo, Erie Co.

H. E. Holbrook Co	Caledonia, Livingston Co.
W. F. Babcock	Camden, Oneida Co.
F. H. Conants Sons, Inc	Camden, Oneida Co.
George W. Dana	Camden, Oneida Co.
F. P. Linderman & Son	Cameron, Steuben Co.
Lisk Mfg. Co	Canandaigua, Ontario Co.
Lenox Shops, Inc	Canastota, Madison Co.
J. E. Talley	Canastota, Madison Co.
Booth Fisheries Co	Cape Vincent, Jefferson Co.
H. W. Field	Cassadaga, Chautauqua Co.
Climax Mfg. Co	Castorland, Lewis Co.
Oakes & Burger Co	Cattaraugus, Cattaraugus Co.
Judd & Leland Mfg. Co	Clifton Springs, Ontario Co.
M. Breault Co	Cohoes, Albany Co.
J. C. Fish	Corbettsville, Broome Co.
Brockway Motor Truck Co	Cortland, Cortland Co.
Champion Milk Cooler Co	Cortland, Cortland Co.
Edlund Machinery Co., Inc	Cortland, Cortland Co.
H. W. Newton	Cortland, Cortland Co.
Wickwire Bros.	Cortland, Cortland Co.
American Valve Co	Coxsackie, Greene Co.
American Assembling Mch. Co	Croton Falls, Westchester Co.
American Locomotive Co	Dunkirk, Chautauqua Co.
Atlas Crucible Steel Co	Dunkirk, Chautauqua Co.
Continental Heater Co	Dunkirk, Chautauqua Co.
Empire Axle Co	Dunkirk, Chautauqua Co.
Essex Glass Co	Dunkirk, Chautauqua Co.
George H. Graf Co	Dunkirk, Chautauqua Co.
Hanford Bros	East Meredith, Delaware Co.
Pierce, Butler & Pierce	Eastwood, Onondaga Co.
Stickley Mfg. Co	Eastwood, Onondaga Co.
A. D. Morton	Eaton, Madison Co.
Dwight, Devine & Sons	Ellenville, Ulster Co.
F. M. Howell & Co	Elmira, Chemung, Co.
I. T. R. Co	Endicott, Broome Co.
Supreme Furniture Co	Falconer, Chautauqua Co.
Muller & Buckley	Far Rockaway, Queens Co.
J. & J. G. Stickley, Inc	Fayetteville, Onondaga Co.
Tindale Cabinet Co	Flushing, Queens Co.
The Bailey Knitting Mills	Fort Plain, Montgomery Co.
Fort Plain Knitting Co	Fort Plain, Montgomery Co.
Alphonso Walrath Co	Fort Plain, Montgomery Co.
Franklinville Canning Co	Franklinville, Cattaraugus Co.
Silts Machine Shop	Fulton, Oswego Co.
J. A. Cross Mfg. Co	Fultonville, Montgomery Co.
Doubleday Page & Co	Garden City, Nassau Co.
Burr Lumber Co	Gloversville, Fulton Co.
Lyon Iron Works	Greene, Chenango Co.
Wood & Chute	Greenport, Suffolk Co.
W. Eddy Plow Co	Greenwich, Washington Co.
American Road Machinery Co	Groton, Tompkins Co.
Groton Electrical Devices, Inc	Groton, Tompkins Co.

Hammondsport Box Factory	Hammondsport, Steuben Co.
Horrocks Desk Co	Herkimer, Herkimer Co.
H. M. Quackenbush	Herkimer, Herkimer Co.
Wagner Furniture Co	Herkimer, Herkimer Co.
Noble & Wood Machinery Co	Hoosick Falls, Rensselaer Co.
J. M. Deutsch Co	Hornell, Steuben Co.
Nestles Food Co	Horseheads, Chemung Co.
Library Bureau	Ilion, Herkimer Co.
A. N. Russell & Sons Co	Ilion, Herkimer Co.
Advance Furniture Co., Inc	Jamestown, Chautauqua Co.
Art Metal Construction Co	Jamestown, Chautauqua Co.
Elite Furniture Co	Jamestown, Chautauqua Co.
Empire Case Goods Co	Jamestown, Chautauqua Co.
International Casement Co., Inc	Jamestown, Chautauqua Co.
Jamestown Chair Co	Jamestown, Chautauqua Co.
Jamestown Period Furniture Co	Jamestown, Chautauqua Co.
Monarch Furniture Co	Jamestown, Chautauqua Co.
The A. C. Norquist Co	Jamestown, Chautauqua Co.
Seaburg Mfg. Co	Jamestown, Chautauqua Co.
The Star Furniture Co., Inc	Jamestown, Chautauqua Co.
Superior Furniture Co	Jamestown, Chautauqua Co.
Weborg Bros. Spring Bed Co	Jamestown, Chautauqua Co.
Lestershire Lumber & Box Co	Johnson City, Broome Co.
C. L. Meech	Jordan, Onondaga Co.
Ausable–Essex Horse Nail Co	Keesville, Essex Co.
Oneida Community, Ltd	Kenwood, Madison Co.
Herbert Brush Mfg. Co	Kingston, Ulster Co.
Adam Walburger	Lafayette, Onondaga Co.
Industrial Glass Co	Lancaster, Erie Co.
Lancaster Machine & Knife Works	Lancaster, Erie Co.
National Enamel & Stamping Co	Laurel Hill, Suffolk Co.
American Laundry Machine Co	Lincoln Park, Monroe Co.
Frank Bowman	Little Falls, Herkimer Co.
D. H. Burrell & Co., Inc	Little Falls, Herkimer Co.
C. J. Lindstrom Mfg. Co	Little Falls, Herkimer Co.
H. P. Snyder Mfg. Co	Little Falls, Herkimer Co.
Murphy Bros	Livonia, Livingston Co.
Cochran Box & Mfg. Co., Inc	Lockport, Niagara Co.
Evans & Co	Lockport, Niagara Co.
Merritt Mfg. Co	Lockport, Niagara Co.
Richmond Mfg. Co	Lockport, Niagara Co.
Trevor Mfg. Co	Lockport, Niagara Co.
Joseph Turner	Lockport, Niagara Co.
Klein Bros	Long Island City, Queens Co.
Central Paper Box Co	McGraw, Cortland Co.
The Courbot Co., Inc	Mallory, Oswego Co.
S. Cheney & Son	Manlius, Onondaga Co.
Frank Morrison	Marion, Wayne Co.
George C. Topping	Marion, Wayne Co.
The Blaisdell Mfg. Co	Martville, Cayuga Co.

New York Rubber Co	Matteawan, Dutchess Co.
Medina Wood Working & Fur. Co., Inc	Medina, Orleans Co.
Ideal Wrapping Machine Co	Middletown, Orange Co.
Morgans & Wilcox Mfg. Co	Middletown, Orange Co.
Cronk & Carrier Mfg. Co	Montour Falls, Schuyler Co.
Shepard Elec. Crane & Hoist Co	Montour Falls, Schuyler Co.
Empire Machine Works	Mount Morris, Livingston Co.
Grubb & Kosegarten Bros	Nassau, Rensselaer Co.
American Can Co., 120 Broadway	New York, New York Co.
American Hard Rubber Co., 11 Mercer st	New York, New York Co.
Artists Packing & Shipping Co., 139 W. 54th st	New York, New York Co.
Semon Bache & Co., 636 Greenwich st	New York, New York Co.
L. Baldasky & Co., Inc., 537 E. 15th st	New York, New York Co.
John A. Bank & Bro., 510 E. 72d st	New York, New York Co.
Fred Bieg Box Co., Inc., 40–42 Gold st	New York, New York Co.
Estate of Frederick Buse, 1110 First av	New York, New York Co.
Carolina Box & Lumber Co., 38 Commerce st	New York, New York Co.
Carroll Box & Lumber Co., 627 E. 18th st.	New York, New York Co.
City Packing Box Co., 624 E. 19th st	New York, New York Co.
Consolidated Packing Box & Lumber Co., Inc., 568–572 Washington st	New York, New York Co.
De La Vergne Machine Co., Foot of E. 138th st	New York, New York Co.
Downtown Packing Box Co., 79–81 Cliff st.	New York, New York Co.
Dunbar Box & Lumber Co., 551 W. 28th st.	New York, New York Co.
Eagle Box & Lumber Co., 128 Greene st	New York, New York Co.
Epstein & Vollweiler, 814 E. 5th st	New York, New York Co.
James Fagan & Sons, 202 West Houston st.	New York, New York Co.
Faultless Box & Lumber Co., 301 E. 21st st.	New York, New York Co.
Finkelstein Packing Box Co., 131 W. 3d st.	New York, New York Co.
J. H. Fitzgerald, Inc., 532 W. 20th st	New York, New York Co.
Forest Box & Lumber Co., 149 Mercer st	New York, New York Co.
E. Gerow, 450 Eleventh av	New York, New York Co.
M. Gerow & Sons, 450 Eleventh av	New York, New York Co.
M. Gershowitz, 128 Greene st	New York, New York Co.
J. A. Gilmour, 23 Bond st	New York, New York Co.
M. Gottlieb & Sons, 20 Clarke st	New York, New York Co.
Harlem Storage Warehouse Co., 211–213 E. 100th st	New York, New York Co.
Charles Korn, 8 Bond st	New York, New York Co.
The Laffargue Co., 134th st. & S. Boulevard	New York, New York Co.
The Manhattan Box Co., 410 E. 32d st	New York, New York Co.
Manhattan Show Case Co., 359 Canal st	New York, New York Co.
D. Milch, 131 W. 41st st	New York, New York Co.
Terence Montagu, 10 York st	New York, New York Co.
John E. Moore, 588 Greenwich st	New York, New York Co.
T. G. Patterson Lumber Co., 637 W. 55th st	New York, New York Co.
Rosenthal & Cohen, 53 Great Jones st	New York, New York Co.
P. Ryan, 556 Washington st	New York, New York Co.
Shwab Bros. Co., 311 E. 9th st	New York, New York Co.
Star Box & Lumber Co., 81 Tompkins st	New York, New York Co.
Stulman Box & Lumber Co., 20 Wooster st.	New York, New York Co.
Tifft Bros., 2 Broadway	New York, New York Co.

Valance & Grosjean, 299 Broadway	New York, New York Co.
Van Kannel Revolving Door Co., 716 Whitlock av	New York, New York Co.
F. Vogel & Co., 222 East 37th st	New York, New York Co.
United Forestry Co., Inc	Niverville, Columbia Co.
Alliger Box & Lumber Co	No. Tonawanda, Niagara Co.
Batt Bros. Lumber Co	No. Tonawanda, Niagara Co.
Dock & Mill Co	No. Tonawanda, Niagara Co.
Dodge & Bliss Co	No. Tonawanda, Niagara Co.
Allen Herschell Co	No. Tonawanda, Niagara Co.
The R. T. Jones Lumber Co	No. Tonawanda, Niagara Co.
North Tonawanda Musical Instruments	No. Tonawanda, Niagara Co.
W. G. Palmer, Inc	No. Tonawanda, Niagara Co.
The Rand Co	No. Tonawanda, Niagara Co.
Richardson Boat Co	No. Tonawanda, Niagara Co.
White-Gratwick-Mitchell	No. Tonawanda, Niagara Co.
Rudolph Wurlitzer Mfg. Co	No. Tonawanda, Niagara Co.
Foot Mfg. Co	No. Tonawanda, Niagara Co.
Acme Glass Co	Olean, Cattaraugus Co.
Hathaway & Reynolds	Oriskany Falls, Oneida Co.
Ames Iron Works	Oswego, Oswego Co.
National Starch Co	Oswego, Oswego Co.
Oswego Shade Cloth Co	Oswego, Oswego Co.
Standard Oil Co., of New York	Oswego, Oswego Co.
Painted Post Development Co	Painted Post, Steuben Co.
The Garlock Packing Co	Palmyra, Wayne Co.
C. F. Powers & Son	Palmyra, Wayne Co.
Cortland Hat Co., Inc	Peekskill, Westchester Co.
Sinclair Chair Co	Phoenix, Oswego Co.
Century Steel Co. of America	Poughkeepsie, Dutchess Co.
Moline Plow Co	Poughkeepsie, Dutchess Co.
Pouvailsmith Corp.	Poughkeepsie, Dutchess Co.
Pierce & Coryell	Plattsburg, Clinton Co.
Salmon River Table Co	Pulaski, Oswego Co.
William Wilder	Pulaski, Oswego Co.
Seneca Furniture Corp	Randolph, Cattaraugus Co.
W. Yates Lansing	Rensselaer, Rensselaer Co.
The American Laundry Machine Co	Rochester, Monroe Co.
Archer Mfg. Co., 187 N. Water st	Rochester, Monroe Co.
Barnard & Simonds Co	Rochester, Monroe Co.
Chase Bros. Co	Rochester, Monroe Co.
Cooperative Foundry Co	Rochester, Monroe Co.
D. E. Cross, 49 South av	Rochester, Monroe Co.
Eastman Kodak Co	Rochester, Monroe Co.
General Railway Signal Co	Rochester, Monroe Co.
Langslow-Fowler Co	Rochester, Monroe Co.
George J. Michelsen Furniture Co	Rochester, Monroe Co.
The Pfaudler Co	Rochester, Monroe Co.
The Ricker Mfg. Co	Rochester, Monroe Co.
Rochester Barrel Mch. Works	Rochester, Monroe Co.
Rochester Show Case Works, 404 Platt st.	Rochester, Monroe Co.
Rochester Box & Lbr. Co., Culver rd	Rochester, Monroe Co.

Traders Box & Lbr. Co., 1040 Jay st......	Rochester, Monroe Co.
Yawman & Erbe Mfg. Co................	Rochester, Monroe Co.
Rome Box & Lbr. Co....................	Rome, Oneida Co.
Joseph Fahys & Co......................	Sag Harbor, Suffolk Co.
Fancher Furniture Co..................	Salamanca, Cattaraugus Co.
Sterling Furniture Co..................	Salamanca, Cattaraugus Co.
American Locomotive Works	Schenectady, Schenectady Co.
General Electric Co......................	Schenectady, Schenectady Co.
W. Cady Smith..........................	Schenectady, Schenectady Co.
F. A. Guernsey & Co...................	Schoharie, Schoharie Co.
Fulton Furniture Co., Inc................	Shandaken, Ulster Co.
G. A. Clark Co..........................	Sidney, Delaware Co.
Huntley Mfg. Co........................	Silver Creek, Chautauque Co.
Invincible Grain Cleaner Co..............	Silver Creek, Chautauqua Co.
H. J. Montgomery Mfg. Co..............	Silver Creek, Chautauqua Co.
Hooker & Higgs.........................	Sinclairville, Chautauqua Co.
The Schoeck Mfg. Co....................	Skaneateles, Onondaga Co.
R. M. Brower...........................	Sodus Center, Wayne Co.
B. F. Gladding & Co., Inc...............	South Otselic, Chenango Co.
Elwood Barringer	Springwater, Livingston Co.
Frank H. Stuart.........................	Springwater, Livingston Co.
Overton Mfg. Co........................	Staatsburg, Dutchess Co.
Staatsburg Ice Tool Works.............	Staatsburg, Dutchess Co.
Leslie E. Youngs........................	Stanley, Ontario Co.
C. C. Bradley & Son....................	Syracuse, Onondaga Co.
Continental Can Co., Inc................	Syracuse, Onondaga Co.
The Cook Box & Lumber Co., 2613 Lodi st.	Syracuse, Onondaga Co.
The O. M. Edwards Co., Inc.............	Syracuse, Onondaga Co.
Engelberg Huller Co....................	Syracuse, Onondaga Co.
Halcomb Steel Co., Geddes st............	Syracuse, Onondaga Co.
John H. Lyons, Inc., 542 Canal st.........	Syracuse, Onondaga Co.
Market Mfg. Co., 618 E. Water st........	Syracuse, Onondaga Co.
H. A. Moyer, 241 Wolf st...............	Syracuse, Onondaga Co.
Onondaga Steel Co., Inc.................	Syracuse, Onondaga Co.
Quaint Art Furniture Co................	Syracuse, Onondaga Co.
F. H. Schneider, 631 Belden av...........	Syracuse, Onondaga Co.
Uhle-Kramer Box Co., 408–12 Canal st....	Syracuse, Onondaga Co.
Chevrolet Motor Car Co.................	Tarrytown, Westchester Co.
Wilson Lumber & Box Co................	Tonawanda, Erie Co.
Bascom Pattern Works..................	Troy, Rensselaer Co.
Cluett, Peabody & Co., Inc..............	Troy, Rensselaer Co.
W. & L. E. Gurley......................	Troy, Rensselaer Co.
Hall Hartwell & Co.....................	Troy, Rensselaer Co.
Century Cabinet Co.....................	Utica, Oneida Co.
Jacob Fassler	Utica, Oneida Co.
Utica Knitting Co......................	Utica, Oneida Co.
Uebler Mfg. Co.........................	Vernon, Oneida Co.
Rider-Ericson Engine Co.................	Walden, Orange Co.
Garner Print Works & Bleachery.........	Wappinger Falls, Dutchess Co.

Brown Knitting Co	Warsaw, Wyoming Co.
Warsaw Paper Box Co	Warsaw, Wyoming Co.
H. H. Babcock Co	Watertown, Jefferson Co.
Knowlton Bros.	Watertown, Jefferson Co.
The New York Air Brake Co	Watertown, Jefferson Co.
Plail Bros.	Wayland, Steuben Co.
J. D. Nivison	Webster, Monroe Co.
George Boardway	West Bangor, Franklin Co.
George J. J. Druschel	West Walworth, Wayne Co.
Quigley Furniture Co	Whitesboro, Oneida Co.
W. B. Allen	Whitney Point, Broome Co.
Otis Elevator Co	Yonkers, Westchester Co.

Brushes and Brooms

Williams & Hurd	Arlington, R. F. D. No. 1, Bennington Co., Vt.
L. Noellers Sons, 43–47 Locust st	Buffalo, Erie Co.
Brannan Mfg. Co	Carthage, Jefferson Co.
H. A. Williams	Hancock, Delaware Co.
Herbert Brush Mfg. Co	Kingston, Ulster Co.
Henry Peak	Long Eddy, Sullivan Co.
A. L. Sonn Brush Co	North Troy, Rensselaer Co.
A. Mason & Sons	Peru, Clinton Co.
United States Brush Co	Potsdam, St. Lawrence Co.
Nicholas J. Karl, 168 N. Water st	Rochester, Monroe Co.
Alpha Brush Co	Troy, Rensselaer Co.
Diack Bros	Troy, Rensselaer Co.
Flynn Bros	Troy, Rensselaer Co.
Fred'k M. Hoyt & Bro	Troy, Rensselaer Co.
Henry I. Hughes Co	Troy, Rensselaer Co.
Reliable Brush Co	Troy, Rensselaer Co.
Rensselaer Brush Co	Troy, Rensselaer Co.
Unity Brush Co	Troy, Rensselaer Co.

Car Construction

Pittsburg, Shawmut & Northern R. R. Co	Angelica, Allegany Co.
Mortonsen Wood Working Co., Inc., 554 Hamilton av	Brooklyn, Kings Co.
Pennsylvania R. R. Co	Buffalo, Erie Co.
Pullman Co., 1770 Broadway	Buffalo, Erie Co.
American Locomotive Co	Dunkirk, Chautauqua Co.
N. Y., Ontario & W. R. R. Co	Middletown, Orange Co.

New York Central R. R.	New York, New York Co.
Long Island Railroad	Richmond Hill, Queens Co.
American Locomotive Works	Schenectady, Schenectady Co.
Lehigh & Hudson River R. R.	Warwick, Orange Co.
D. & H. R. R. Co. "Colonie"	Watervliet, Albany Co.

Caskets and Coffins

Morgan Casket Co., 572–590 Park av.	Brooklyn, Kings Co.
N. Y. & Brooklyn Casket Co., 703 Bedford av.	Brooklyn, Kings Co.
Central Casket Co., 45 Niagara st	Buffalo, Erie Co.
A. W. Hawley	Colton, St. Lawrence Co.
H. R. Taylor Corp.	Cornwall, Orange Co.
Younglove Casket Co	Johnstown, Fulton Co.
H. W. Palen's Sons	Kingston, Ulster Co.
National Casket Co	Long Island City, Queens Co.
Asbestos Burial Casket Co	Lowville, Lewis Co.
Hornthal & Co., 597 Lexington av	New York, New York Co.
J. P. Linahan, 100 E. 138th st	New York, New York Co.
J. & J. W. Stolts, 440 E. 106th st	New York, New York Co.
H. E. Taylor & Co., 154 E. 23d st	New York, New York Co.
Norwood Casket Co	Norwood, St. Lawrence Co.
Nunda Casket Co., Inc	Nunda, Livingston Co.
National Casket Co	Oneida, Madison Co.
National Casket Co	Rochester, Monroe Co.
John Marsellus Casket Co	Syracuse, Onondaga Co.
Monroe Mfg. Co	Webster, Monroe Co.
O'Dell Bros	Webster, Monroe Co.
Wellsville Burial Case Co	Wellsville, Allegany Co.

Chairs and Chair Stock

F. W. Elant	Arkville, Delaware Co.
C. J. Harrison Mfg. Co	Arkville, Delaware Co.
Binghamton Chair Co	Binghamton, Broome Co.
N. M. Sargent's Sons	Boonville, Oneida Co.
P. C. Prevett	Broadalbin, Fulton Co.
C. H. Trevett	Broadalbin, Fulton Co.
Sikes Chair Co., 500 Clinton st	Buffalo, Erie Co.

F. H. Conant's Sons, Inc	Camden, Oneida Co.
J. M. Young & Sons	Camden, Oneida Co.
Lee Chair Co	Canastota, Madison Co.
C. J. Armstrong & Sons	Cherry Valley, Otsego Co.
Wm. Schwarzwaelder & Co., Inc	Chichester, Ulster Co.
Jamestown Chair Co	Jamestown, Chautauqua Co.
Superior Furniture Co	Jamestown, Chautauqua Co.
Frank D. Harden Co	McConnellsville, Oneida Co.
Empire Couch Co	Medina, Orleans Co.
Charles J. Armstrong & Sons	Milford, Otsego Co.
The Mottville Chair Works	Mottville, Onondaga Co.
Sinclair Allen Mfg. Co	Mottville, Onondaga Co.
Herbert G. Pratt	Newburgh, Orange Co.
George Hunzinger & Son, 325 W. 16th st.	New York, New York Co.
Marks Invalid Supply Co., 212 E. 41st st.	New York, New York Co.
John Miller & Co., 518 E. 17th st	New York, New York Co.
N. Y. Chair Co., 164 Mulberry st	New York, New York Co.
Schilling Bros. Table Co., 631 E. 16th st.	New York, New York Co.
Sinclair Chair Co	Phoenix, Oswego Co.
Poughkeepsie Chair Co	Poughkeepsie, Dutchess Co.
Archer Mfg. Co	Rochester, Monroe Co.
Barnard & Simonds Co	Rochester, Monroe Co.
Hubbard, Eldredge & Miller	Rochester, Monroe Co.
C. M. Lenhard	Rochester, Monroe Co.
The Shreve Chair Co	Sherman, Chautauqua Co.
H. J. Montgomery Mfg. Co	Silver Creek, Chautauqua Co.
W. H. Gunlock Chair Co	Wayland Steuben Co.
W. E. Sprague	Westdale, Oneida Co.

Clocks

Ansonia Clock Co., Seventh av. & 12th st.	Brooklyn Kings Co.
John A. Bank & Bro., 510 E. 72d st	New York, New York Co.
Henry Salzler	Springville, Erie Co.

Cigar Boxes

J. Berleant, 603 Clinton st	Buffalo, Erie Co.
Louis Doebert	Buffalo, Erie Co.
F. M. Howell & Co	Elmira, Chemung Co.
Philip Fehl	Hudson, Columbia Co.
Lyons Mfg. Co	Lyons, Wayne Co.

Nic. Althaus Co., 637–641 E. 17th st......	New York, New York Co.
S. Elkeles Cigar Box Co., 535 E. 79th st..	New York, New York Co.
Schwarzkopf & Ruckert, 413–415–417 E. 36th st..............................	New York, New York Co.
S. Sladkus & Son, 392 Madison st........	New York, New York Co.
Charles Stutz Co., 283–289 Monroe st.....	New York, New York Co.
J. C. Van Brunt & Son, 291 Monroe st....	New York, New York Co.
Louis Walter, Inc., 132d st. & Lincoln av..	New York, New York Co.
L. F. Schlecht, 316–318 E. Water st......	Syracuse, Onondaga Co.

Dairymen's, Poulterers', and Apiarists' Supplies

Gilbert Gale	Barnerville, Schoharie Co.
Charles Quackenbush	Barnerville, Schoharie Co.
A. A. French............................	Black River, Jefferson Co.
D. Karlen	Boonville, Oneida Co.
E. W. Coon..............................	Cape Vincent, Jefferson Co.
Oakes & Burger Co.......................	Cattaraugus, Cattaraugus Co.
C. L. Sancomb...........................	Chateaugay, Franklin Co.
W. F. Stetson Co........................	Cherry Creek, Chautauqua Co.
Meldrim Bros	Cincinnatus, Cortland Co.
C. H. Payne.............................	Cold Brook, Herkimer Co.
The Steam Mill Co.......................	Constableville, Lewis Co.
C. V. Peck..............................	Cortland, Cortland Co.
Joseph Steiner	Croghan, Lewis Co.
Stanley C. Swift Mfg. Co................	Cuba, Allegany Co.
Sternberg Bros	Depauville, Jefferson Co.
American Mfg. Concern...................	Falconer, Chautauqua Co.
Hollenbeck & Son........................	Ft. Jackson, St. Lawrence Co.
Edward W. Gossett.......................	Frewsburg, Chautauqua Co.
Fred Sauer & Sons.......................	Glenmore, Oneida Co.
E. C. Lawton............................	Gouverneur, St. Lawrence Co.
Block Bros	Great Valley, Cattaraugus Co.
G. B. Gerard Mills......................	Holland Patent, Oneida Co.
Edward L. Gossett	Jamestown, Chautauqua Co.
W. S. Sammons	Johnstown, Chautauqua Co.
C. Hargrave.............................	Laurens, Otsego Co.
F. C. Rogers............................	Le Roy, Genesee Co.
Hall Mammoth Incubator Co...............	Little Falls, Herkimer Co.
The Courbot Co..........................	Mallory, Oswego Co.
D. S. Mawson & Sons.....................	Manlius, Onondaga Co.
G. H. Whittaker.........................	Marcy, Oneida Co.
R. R. Ripley............................	Morris, Otsego Co.
W. N. Cardner...........................	New Woodstock, Madison Co.
Charles E. Gue	North Western, Oneida Co.

Fred Babcock	Orwell, Oswego Co.
W. S. Brooks	Philadelphia, Jefferson Co
Morrison, Blair, & Co	Rensselaer Falls, St. Lawrence Co.
Charles Mills	Richfield Sprgs., Otsego Co.
John G. Elbs, 397 Main st	Rochester, Monroe Co.
L. C. McElheny	Rushford, Allegany Co.
D. S. Tilyon	Vanhornesville, Herkimer Co.
W. L. Spink	Varysburg, Wyoming Co.
Charles H. Hess	Vernon Center, Oneida Co.
H. R. Myers	Waterville, Oneida Co.
Wellsville Custom Co	Wellsville, Allegany Co.
C. C. & F. R. Wellington	West Stockholm, St. Lawrence Co.
F. A. Capron	West Valley, Cattaraugus Co.
A. C. Hackley	West Winfield, Herkimer Co.
C. T. Dickinson	Whitney Point, Broome Co.
G. S. Van Buskirk	Wiscoy, Allegany Co.

Dowels & Skewers

Horton Lumber Co	Altmar, Oswego Co.
W. J. Cowee	Berlin, Rensselaer Co.
Setter Bros. Co	Cattaraugus, Cattaraugus Co.
Acme Reed Co	Woodside, Queens Co.

Electrical Machinery and Apparatus

Gould Coupler Co	Depew, Erie Co.
Gen. Railway Signal Co	Rochester, Monroe Co.
Beach Lumber Co	Rome, Oneida Co.
General Electric Co	Schenectady, Schenectady Co.

Elevators

Otis Elevator Co	Buffalo, Erie Co.
Smith Elevator Co., Inc., 301 Liberty bldg.	Buffalo, Erie Co.
Acme Road Machinery Co	Frankfort, Herkimer Co.
Anton Larsen & Sons, Brook av. & 134th st.	New York, New York Co.
Republic Elevator & Machine Co	Rochester, Monroe Co.
Warsaw Elevator Co	Warsaw, Wyoming Co.
Otis Elevator Co	Yonkers, Westchester Co.

Excelsior

Big Indian Wood Products Co	Big Indian, Ulster Co.
Chateaugay Excelsior Co	Chateaugay, Franklin Co.
New York Excelsior Co	East Branch, Delaware Co.
F. M. Blystone, Inc	Elmira, Chemung Co.
Chas. M. Allen, Inc	Fulton, Oswego Co.
David & Mason	Fulton, Oswego Co.
National Desk Co	Herkimer, Herkimer Co.
Fenton & Dence, Inc	Lowville, Lewis Co.
Port Leyden Excelsior Co	Lowville, Lewis Co.
Chas. Harden Estate	McConnellsville, Oneida Co.
F. E. Sheffield	Mooers, Clinton Co.
H. J. Weiden	Narrowsburg, Sullivan Co.
Boston Excelsior Co., Eleventh av. & 29th st.	New York, New York Co.
North River Mfg. Co	North Creek, Warren Co.
J. H. Wilder	Petries Corners, Lewis Co.
Gromley Bros.	Phoenicia, Ulster Co.
Harry Cunningham	Warrensburg, Warren Co.

Firearms

The Hunter Arms Co., Inc	Fulton, Oswego Co.
The Remington Arms Union Metallic Cartridge Co	Ilion, Herkimer Co.
Ithaca Gun Co	Ithaca, Tompkins Co.
Savage Arms Corp	Utica, Oneida Co.

Fixtures

E. B. & H. J. Koon	Auburn, Cayuga Co.
American Show Case Co., 289 Greenport av.	Brooklyn, Kings Co.
Columbia Mantel Co., 274 Leonard st	Brooklyn, Kings Co.
Eagle Show Case Co., 899 Myrtle av	Brooklyn, Kings Co.
Eastern Show Case Co., 470 Park pl	Brooklyn, Kings Co.
Eichman Co., 7 McKibben	Brooklyn, Kings Co.
Frederick Elflein & Sons, Inc, 216–226 Seigel st	Brooklyn, Kings Co.
E. Hamburger & Co., 139 Emerson pl	Brooklyn, Kings Co.
Interstate Parlor Frame Co., 280 Leonard st.	Brooklyn, Kings Co.
Manhattan Show Case Co., 265 Calyer st	Brooklyn, Kings Co.

Schwartz & Co., 87–105 Richardson st....	Brooklyn, Kings Co.
Toyeson Partition Co., 291 Adams st....	Brooklyn, Kings Co.
M. J. Bernhard Co., Inc., 712–720 Jefferson st.	Buffalo, Erie Co.
A. Dutch & Co., 148 Seneca st.	Buffalo, Erie Co.
A. F. Meyer & Sons Co., 408 Broadway....	Buffalo, Erie Co.
Queen City Store Fixture Co., 431 William st.	Buffalo, Erie Co.
George W. Dana	Camden, Oneida Co.
William Schwarzwaelder & Co., Inc.	Chichester, Ulster Co.
M. Jergin & Son	Hempstead, Nassau Co.
A. N. Russell & Sons Co	Ilion, Herkimer Co.
Acme Wood Working Co., Inc., 514–516 W. 46th st.	New York, New York Co.
Ammann Mfg. & Const. Co., 155–163 Av D.	New York, New York Co.
C. W. Anderson, 449–451 W. 41st st	New York, New York Co.
Becker & Korb, 553 W. 35th st	New York, New York Co.
Bubeck & Guerin, Inc., 161–163 W. 18th st.	New York, New York Co.
Drosin Bros., 2076 Second av	New York, New York Co.
Louis R. Fisher, 227 Mercer st	New York, New York Co.
P. H. Gellman & Co., Wooster bet. Canal & Grand st	New York, New York Co.
Homckman Bros. & Co., 820 E. 5th st....	New York, New York Co.
Wm. Kleeman & Co., Inc., 101 Park av....	New York, New York Co.
Manhattan Office Partition Co., 143 Front st.	New York, New York Co.
Manhattan Show Case Co., 359 Canal st..	New York, New York Co.
Mount & Robertson, 41 Beaver st	New York, New York Co.
N. Y. Store Fixture Co., 9–11 E. 137th st..	New York, New York Co.
N. Y. Wood Working Corp., 506 E. 19th st.	New York, New York Co.
H. Pearlman, 858 Eighth av	New York, New York Co.
Queensboro Cabinet Co., 1110 First av....	New York, New York Co.
Ely J. Riesser & Co., Inc., 28th st. & First av.	New York, New York Co.
Charles R. Ross & Son, 12 Cedar st	New York, New York Co.
Wm. B. Rummler, 367–369 W. 11th st....	New York, New York Co.
Benj. Rybakoff, 229 E. 22d st	New York, New York Co.
Robert Wick Lumber Co., 556 W. 52d st..	New York, New York Co.
J. G. Wilson Corp	New York, New York Co.
Walker Bin Co	Penn Yan, Yates Co.
American Drafting Furniture Co	Rochester, Monroe Co.
Rochester Cabinet Co.. Inc	Rochester, Monroe Co.
Rochester Show Case Works, 404 Platt st..	Rochester, Monroe Co.
Stromberg–Carlson Tel. Mfg. Co	Rochester, Monroe Co.
J. W. Storanit Mfg. Co	Rochester, Monroe Co.
E. M. Allewelt, 416 S. Salina st	Syracuse, Onondaga, Co.
Syracuse Show Case Works, 109 Decker st.	Syracuse, Onondaga Co.

Furniture

Auburn Prison	Auburn, Cayuga Co.
Kroehler Mfg. Co., Inc..................	Binghamton, Broome Co.
Brooklyn Parlor Frame Co., Inc., 189–191 Wallabout st........................	Brooklyn, Kings Co.
Colonial Mantel & Refrigerator Co., 494 Dumont av..........................	Brooklyn, Kings Co.
Glasau–Thompson Co., 16 Ashland pl......	Brooklyn, Kings Co.
Gluck Bros., 38 Maujer st................	Brooklyn, Kings Co.
Manhattan Mantel Co., 55 Humboldt st..	Brooklyn, Kings Co.
National Parlor Suit Co., 71 Raymond st..	Brooklyn, Kings Co.
Romer Mfg. Co., Inc., 205–209 Deamond st.	Brooklyn, Kings Co.
Royal Table Co., 24 Boerum st..........	Brooklyn, Kings Co.
Schneider & Sons, 156 19th st............	Brooklyn, Kings Co.
Schwartz & Co., 87–105 Richardson st....	Brooklyn, Kings Co.
Weber & Co., 5 LaGrange st.............	Brooklyn, Kings Co.
Barcalo Mfg. Co., 225 Louisiana st.......	Buffalo, Erie Co.
Board of Education	Buffalo, Erie Co.
C. M. Bott Furn. Co., 170 Leslie st.......	Buffalo, Erie Co.
Buffalo Bed Spring Co..................	Buffalo, Erie Co.
Buffalo Lounge Co.....................	Buffalo, Erie Co.
Cutler Desk Co., 20 Church st...........	Buffalo, Erie Co.
Doll, Brown Co., Inc...................	Buffalo, Erie Co.
Hersey & Co., 303 Ellicott st...........	Buffalo, Erie Co.
Kittinger Co., Inc., 1893 Elmwood av.....	Buffalo, Erie Co.
Pezold Furniture Co., 19 B st...........	Buffalo, Erie Co.
Steul & Thuman Co....................	Buffalo, Erie Co.
Frank S. Harden Co....................	Camden, Oneida Co.
Louis Perin & Sons.....................	Camden, Oneida Co.
Lee Chair Co..........................	Canastota, Madison Co.
Lenox Shops, Inc......................	Canastota, Madison Co.
Oriental Furniture Co..................	Canisteo, Steuben Co.
A. M. Zodansky	Cedarhurst, L. I., Nassau Co.
W. Hoffer Furniture Co., 180–182 Lancaster st............................	Cohoes, Albany Co.
A. W. Hawley	Colton, St. Lawrence Co.
Cortland Cabinet Co...................	Cortland, Cortland Co.
Cornell Table Co., Inc..................	Earlville, Madison Co.
The Roycrofters	E. Aurora, Erie Co.
Stickley Mfg. Co......................	Eastwood, Onondaga Co.
A. D. Morton	Eaton, Madison Co.
Elbridge Chair Co.....................	Elbridge, Onondaga Co.
Public Schools	Elmira, Chemung Co.
American Mfg. Concern.................	Falconer, Chautauqua Co.
C. W. Herrick Mfg. Co.................	Falconer, Chautauqua Co.
Supreme Furniture Co..................	Falconer, Chautauqua Co.
L. & J. G. Stickley, Inc.................	Fayetteville, Onondaga Co.
A. & C. A. Hix........................	Fort Plain, Montgomery Co.

Doubleday, Page & Co	Garden City, Nassau Co.
Greene Mfg. Co	Greene, Chenango Co.
Koons Bros	Grooville, Sullivan Co.
Corona Typewriter Co	Groton, Tompkins Co.
F. E. Hale Mfg. Co	Herkimer, Herkimer Co.
Horrocks Desk Co	Herkimer, Herkimer Co.
National Desk Co	Herkimer, Herkimer Co.
Standard Furniture Co	Herkimer, Herkimer Co.
Wagner Furniture Co	Herkimer, Herkimer Co.
J. M. Deutsch Co	Hornell, Steuben Co.
F. L. Casper	Howe Cave, Schoharie Co.
Metropolitan Furniture House	Hudson, Columbia Co.
Traver & Cibulas	Hudson, Columbia Co.
Library Bureau	Ilion, Herkimer Co.
A. N. Russell & Sons Co	Ilion, Herkimer Co.
H. J. Bool Co	Ithaca, Tompkins Co.
Active Furniture Co	Jamestown, Chautauqua Co.
Advance Furniture Co	Jamestown, Chautauqua Co.
Alliance Furniture Co	Jamestown, Chautauqua Co.
Allied Furniture Co	Jamestown, Chautauqua Co.
The Anchor Furniture Co	Jamestown, Chautauqua Co.
Atlas Furniture Co	Jamestown, Chautauqua Co.
Bailey Table Co	Jamestown, Chautauqua Co.
C. W. Berrick Mfg. Co	Jamestown, Chautauqua Co.
Diamond Furniture Co	Jamestown, Chautauqua Co.
Elite Furniture Co	Jamestown, Chautauqua Co.
Empire Case Goods Co	Jamestown, Chautauqua Co.
Himebaugh Bros	Jamestown, Chautauqua Co.
Jamestown Lounge Co	Jamestown, Chautauqua Co.
Jamestown Period Furniture Co	Jamestown, Chautauqua Co.
Jamestown Table Co	Jamestown, Chautauqua Co.
Marvel Furniture Co	Jamestown, Chautauqua Co.
Monarch Furniture Co	Jamestown, Chautauqua Co.
Monitor Furniture Co	Jamestown, Chautauqua Co.
The A. C. Norquist Co	Jamestown, Chautauqua Co.
Paterniti Table Co	Jamestown, Chautauqua Co.
H. P. Robertson Co	Jamestown, Chautauqua Co.
Schulze & Van Stee Mfg. Co	Jamestown, Chautauqua Co.
Seaburg Mfg. Co	Jamestown, Chautauqua Co.
Shearman Bros. Co	Jamestown, Chautauqua Co.
Standard Table Co	Jamestown, Chautauqua Co.
The Star Furniture Co	Jamestown, Chautauqua Co.
Watson Mfg. Co	Jamestown, Chautauqua Co.
R. B. Prescott & Son, Inc	Keeseville, Essex Co.
Oneida Community, Ltd	Kenwood, Madison Co.
C. J. Lindstrom Mfg. Co	Little Falls, Herkimer Co.
Peter Duerr & Bros	Liverpool, Onondaga Co.
Charles Raupach	Liverpool, Onondaga Co.
Klein Bros	Long Is. City, Queens Co.
J. E. Haberer Furniture Co	Lowville, Lewis Co.

H. S. Wright	Madrid, St. Lawrence Co.
S. A. Cook & Co	Medina, Orleans Co.
Maher Bros. Co	Medina, Orleans Co.
Medina Wood Working & Furn. Co., Inc.	Medina, Orleans Co.
Niagara Furniture Co	Middleport, Niagara Co.
Giles & Giles Co	Middletown, Orange Co.
Charles J. Armstrong & Sons	Milford, Otsego Co.
W. S. Stevens	Moravia, Cayuga Co.
Hallagan–Thompson Co	Newark, Wayne Co.
American Parlor Frame Co., 499 Staff st.	New York, New York Co.
Wm. Baumgarten Co., 715 5th av	New York, New York Co.
Aug. Casiraghi, 725 First av	New York, New York Co.
Ernest Distelhorst, 522–524 E. 81st st	New York, New York Co.
Dubois Refrigerator Co., 107–111 W. 18th st.	New York, New York Co.
E. Eckenroth & Son, 921 E. 5th st	New York, New York Co.
Henry Fuldner & Sons, 404 E. 14th st	New York, New York Co.
John Helmsky, Inc., 637 W. 55th st	New York, New York Co.
Hofstatter's Sons, Inc., 362–372 Second av.	New York, New York Co.
H. F. Huber & Co., 627 E. 18th st	New York, New York Co.
L. H. Mace & Co., Inc., 55 E. 150th st	New York, New York Co.
Manhattan Table Mfg. Corp., 34–47 Broome st.	New York, New York Co.
W. F. Metz, 152 Av. D	New York, New York Co.
The Nahon Co., 53d st. & E. River	New York, New York Co.
National Parlor Frame Co	New York, New York Co.
New York Couch Frame Co., 652 E. 12th st	New York, New York Co.
Palmer & Embury Mfg. Co., 9 Gouverneur Slip	New York, New York Co.
M. Reischmann & Sons, 135th st. & Willow av.	New York, New York Co.
M. Reischmann & Sons, Inc., 138 Willow av.	New York, New York Co.
Richter Furniture Co., 521 E. 72d st	New York, New York Co.
Theodore Sauer Co., 417 E. 47th st	New York, New York Co.
Schilling Bros. Table Co., Inc., 631 E. 16th st	New York, New York Co.
Schloss Bros. Inc., 637 W. 55th st	New York, New York Co.
Schmeig & Co., 521 E. 72d st	New York, New York Co.
Skrivanek & Tannhauser, 1110 First av.	New York, New York Co.
Philip Strobel & Sons, Inc., 53 Elizabeth st.	New York, New York Co.
F. Vogel & Co., 222 E. 37th st	New York, New York Co.
S. W. Johnson & Son	Nichols, Tioga Co.
Indian River Mfg. Co	Philadelphia, Jefferson Co.
Salmon River Table Co	Pulaski, Oswego Co.
Seneca Furniture Corp	Randolph, Cattaraugus Co.
Curtiss Bros	Richland, Oswego Co.
American Drafting Furniture Co	Rochester, Monroe Co.
The Hayden Co	Rochester, Monroe Co.
Langslow–Fowler Co	Rochester, Monroe Co.
C. M. Lenhard, 21 Weicher st	Rochester, Monroe Co.
George J. Michelson Furn. Co	Rochester, Monroe Co.
Miller Cabinet Co	Rochester, Monroe Co.
H. P. Sickles Co., 840 University av	Rochester, Monroe Co.
Yawman & Erbe Mfg. Co	Rochester, Monroe Co.
Roscoe Ten Pin Co	Roscoe, Sullivan Co.

Fancher Furniture Co	Salamanca, Cattaraugus Co.
Sterling Furniture Co	Salamanca, Cattaraugus Co.
Schenectady Public Schools	Schenectady, Schenectady Co.
Fulton Furniture Co., Inc	Shandaken, Ulster Co.
H. J. Montgomery Mfg. Co	Silver Creek, Chautauqua Co.
The Schoeck Mfg. Co	Skaneateles, Onondaga Co.
Norton & Mitchell	Sodus, Wayne Co.
Henry Salzler Co	Springville, Erie Co.
Erskine-Danforth Corp	(Stamford, Fairfield Co., Conn.)
Butler Mfg. Co	Syracuse, Onondaga Co.
H. Doetsch, 708 Hickory st	Syracuse, Onondaga Co.
Kronen & Beehner, 101 E. Willow st	Syracuse, Onondaga Co.
Quaint Art Furniture Co	Syracuse, Onondaga Co.
Elgin A. Simonds Co., 717 Clinton st	Syracuse, Onondaga Co.
Bryant Furniture Co	Truxton, Cortland Co.
T. D. Wadelton	Tuckahoe, Westchester Co.
Board of Education	Utica, Oneida Co.
Hall & Lyon Furniture Co	Waverly, Tioga Co.
Plail Bros	Wayland, Steuben Co.
Telescope Cot & Novelty Works	West Pike, Potter Co., Pa.
Quigley Furniture Co	Whitesboro, Oneida Co.
W. S. Allen	Whitney Point, Broome Co.

Handles

The J. S. Harrison Co	Addison, Steuben Co.
Gardner Brown Co	Amsterdam, Montgomery Co.
Pioneer Broom Co., Inc	Amsterdam, Montgomery Co.
Sacandaga River Land & Lumber Co	Amsterdam, Montgomery Co.
Cady Mfg. Co	Auburn, Cayuga Co.
Henry V. Watkins	Bellport, Suffolk Co.
P. E. Kennehan Son & Co	Brasher Falls, St. Lawrence Co.
Cadosia Mfg. Co	Cadosia, Delaware Co.
E. Q. Dutton & Co	Cato, Cayuga Co.
S. Roberts	Chester, Orange Co.
Dwight, Divine & Sons	Ellenville, Ulster Co.
Union Fork & Hoe Co	Frankfort, Herkimer Co.
Ellis & Smith	Gloversville, Fulton Co.
H. A. Williams	Hancock, Delaware Co.
Herbert Brush Mfg. Co	Kingston, Ulster Co.
H. Cheney Hammer Corp	Little Falls, Herkimer Co.
Henry Peak	Long Eddy, Sullivan Co.

H. R. Greenman	McGraw, Cortland Co.
Margaretville Handle Co	Margaretville, Delaware Co.
New York Knife Co., 225 Fifth av	New York, New York Co.
North Creek Mfg. Co., Inc	North Creek, Warren Co.
Woodworth Knife Works	Nunda, Livingston Co.
The Jennings & Griffin Mfg. Co	Port Jervis, Orange Co.
Edgar W. Cornius	Redfield, Oswego Co.
Mack & Co	Rochester, Monroe Co.
W. D. Blasier	Rome, Oneida Co.
Salem Mfg. Co	Salem, Washington Co.
Lehentaler Bros	Saratoga Springs, Saratoga Co.
E. J. Tuthill	Stokes, Oneida Co.
C. C. Bradley & Son	Syracuse, Onondaga Co.
Tie Co	Unadilla, Otsego Co.

Laundry Appliances

Blackstone Mfg. Co	Jamestown, Chautauqua Co.
Lestershire Lumber & Box Co	Johnson City, Broome Co.
General Railway Signal Co	Rochester, Monroe Co.
Syracuse Washer Corp	Syracuse, Onondaga Co.
Cluett, Peabody & Co., Inc	Troy, Rensselaer Co.

Machine Construction

John McCarthy	Albion, Orleans Co.
Isham Mfg. Co	Avon, Livingston Co.
W. G. Case & Co	Black River, Jefferson Co.
McDonell & Brennen	Bolivar, Allegany Co.
Union Loom Works, Inc	Booneville, Oneida Co.
Buffalo Pitts Co., 27 Carolina st	Buffalo, Erie Co.
Alphonso Walrath Co	Fort Plain, Montgomery Co.
Acme Road Machinery Co	Frankfort, Herkimer Co.
American Road Machinery Co	Groton, Tompkins Co.
Hillsdale Plow Co	Hillsdale, Columbia Co.
Noble & Wood Machinery Co	Hoosick Falls, Rensselaer Co.
Gifford Wood Co	Hudson, Columbia Co.
Williams Bros	Ithaca, Tompkins Co.
Universal Road Machinery Co	Kingston, Ulster Co.

Hall Iron Works........................ Lockport, Niagara Co.
William C. Aul .... Lyons, Wayne Co.

American Road Machinery Co............. Marathon, Cortland Co.
Bradney Machine Co..................... Middletown, Orange Co.
Shepard Electric Crane & Hoist Co...... Montour Falls, Schuyler Co.
Linn Mfg. Corp......................... Morris, Otsego Co.

Ireland Machine & Foundry Co........... Norwich, Chenango Co.

American Laundry Machine Co............ Rochester, Monroe Co.

Huntley Mfg. Co........................ Silver Creek, Chautauqua Co.
Invincible Grain Cleaner Co............ Silver Creek, Chautauqua Co.
Staats Ice Tool Works.................. Staatsburg, Dutchess Co.
Boomer & Boschert Press Co., 329 Water st. Syracuse, Onondaga Co.
Engelberg Huller Co.................... Syracuse, Onondaga Co.

Walton Foundry Co...................... Walton, Delaware Co.

Matches

Northern Match Splint Co., Inc......... Constantia, Oswego Co.

The Diamond Match Co................... Oswego, Oswego Co.
Northern Match Splint Co., Inc......... Oswego, Oswego Co.

Motor Vehicles

Wm. L. Schupp & Sons................... Albany, Albany Co.
Seim & Reissig......................... Albany, Albany Co.
Horton Lumber Co....................... Altmar, Oswego Co.
Geo. C. Broadbooks Co., Inc............ Attica, Wyoming Co.
Eagle Wagon Works...................... Auburn, Cayuga Co.

Henry D. Jackson....................... Beacon, Dutchess Co.
Peattie Bros........................... Beacon, Dutchess Co.
Larrabee-Deyo Motor Truck Co., Inc..... Binghamton, Broome Co.
Borden's Farm Products Co., Inc., 992 Gates av............................ Brooklyn, Kings Co.
A. Kreinbrink & Co., 46 Bergen st...... Brooklyn, Kings Co.
Thos. Rockford, 1066 Bedford av........ Brooklyn, Kings Co.
Shadbolt Mfg. Co., 68-78 Flushing av.... Brooklyn, Kings Co.
J. A. Shephard & Son, Atlantic & Fountain av............................... Brooklyn, Kings Co.
American Body Co., 1200 Niagara st...... Buffalo, Erie Co.
Atterbury Motor Corp, Elmwood & Hertel av............................... Buffalo, Erie Co.
Buffalo Body Corp, 838 Seneca st........ Buffalo, Erie Co.
Buffalo Wagon Works, 111-115 Carroll st. Buffalo, Erie Co.
J. Christensen, 635 Genesee st.......... Buffalo, Erie Co.
E. A. Cook Wagon Co..................... Buffalo, Erie Co.
The Thomas Derry Co., Inc., 466 Vermont st............................... Buffalo, Erie Co.
Harvey Top & Body Co., 918 Main st...... Buffalo, Erie Co.
Hill Mfg. Co., 27 Fuller st............. Buffalo, Erie Co.

Henry Landsheft, 1202 Jefferson st.	Buffalo, Erie Co.
Meyer Wagon Works, 216 Elm st.	Buffalo, Erie Co.
Pierce-Arrow Motor Car Co., 1695 Elmwood av.	Buffalo, Erie Co.
Watkins Commercial Body Corp, 666-668 Genesee st	Buffalo, Erie Co.
Wurster Wagon Works, 314 Seneca st.	Buffalo, Erie Co.
The Brewer-Titchener Corp.	Cortland, Cortland Co.
Brockway Motor Truck Co.	Cortland, Cortland Co.
James B. Hunt	Cortland, Cortland Co.
W. F. Smith	Dansville, Livingston Co.
Mulholland Co.	Dunkirk, Chautauqua Co.
H. L. Post	Farmingdale, Nassau Co.
Geneva Wagon Co.	Geneva, Ontario Co.
B. Braun	Hempstead, Nassau Co.
D. H. Starr	Highland, Ulster Co.
J. T. Cantrell & Co.	Huntington, Suffolk Co.
Brewster & Co.	Long Island City, Queens Co.
Washington Taylor	Mt. Vernon, Westchester Co.
Wayne Wheel Co.	Newark, Wayne Co.
Arthur Colvill	Newburgh, Orange Co.
Demarest & Co., Inc., 521 E. 72d st.	New York, New York Co.
Earnest Distethorst & Co., 522-524 E. 81st st	New York, New York Co.
Healey & Co., 1622 Broadway	New York, New York Co.
S. Katsur Co., 1161 First av.	New York, New York Co.
Wm. Koenig, 24 St. Lawrence st.	New York, New York Co.
J. Kramer & Sons Mfg. Co., 673-679 Water st.	New York, New York Co.
Liberty Wagon Works, 540 W. 40th st.	New York, New York Co.
Chas. Scheidler Est., 352 W. 53d st.	New York, New York Co.
Sebastian Wagon Co., 422 E. 54th st.	New York, New York Co.
J. A. Shephard & Son, Atlantic & Fountain av	New York, New York Co.
John Theurer Wagon Works, 609-615 W. 56th st.	New York, New York Co.
Niagara Motor Boat Co.	No. Tonawanda, Niagara Co.
August Schubert Wagon Co.	Oneida, Madison Co.
Champion Wagon Works	Owego, Tioga Co.
A. L. Cole	Owego, Tioga Co.
Pouvailsmith Corp.	Poughkeepsie, Dutchess Co.
W. H. & J. T. Callister	Queens, Queens Co.
Caley & Nash, Inc., 1828 East av.	Rochester, Monroe Co.
James Cunningham Son & Co., 13 Canal st.	Rochester, Monroe Co.
Dousing & Zieres	Rochester, Monroe Co.
Rochester Carriage Co., 1701 East av.	Rochester, Monroe Co.

W. H. Rowedink, 80 North st............ Rochester, Monroe Co.
Seldon Motor Vehicle Co................ Rochester, Monroe Co.
A. F. Stewart.......................... Rochester, Monroe Co.

Cortland Cart & Carriage Co............ Sidney, Delaware Co.
W. H. Webier........................... Sodus Center, Wayne Co.
H. H. Franklin Mfg. Co................. Syracuse, Onondaga Co.
L. Vaeth Sons, 332 S. West st.......... Syracuse, Onondaga Co.

National Body Corp..................... Tarrytown, Westchester Co.
Jos. J. LeCompte....................... Troy, Rensselaer Co.
Chas. J. Vannier....................... Troy, Rensselaer Co.

Bailey & Bowie......................... Utica, Oneida Co.
Willoughby Co.......................... Utica, Oneida Co.

Waterloo Wagon Co...................... Waterloo, Seneca Co.
H. H. Babcock Co....................... Watertown, Jefferson Co.
Chas. G. Richenecker................... Watervliet, Albany Co.

Musical Instruments

Sohmer & Co., Jamaica av. & Boulevard.. Astoria, L. I., Queens Co.

French Cabinet Corp., Metropolitan av... Brooklyn, Kings Co.
Jordan Cabinet Wks., Inc., 129 Degraw st. Brooklyn, Kings Co.
Reuben Midmer & Son, Inc., 375 Fulton st. Brooklyn, Kings Co.
Otto Wissner, Inc., 1072–1108 Atlantic av. Brooklyn, Kings Co.
C. Kurtzmann Co., 526 Niagara st........ Buffalo, Erie Co.
Viner & Son, 1375 Niagara st............ Buffalo, Erie Co.

George Lahm .... Callicoon, Sullivan Co.
A. C. Cheney Piano Action Co............ Castleton, Rensselaer Co.
N. T. Manufacturing Co.................. Cohoes, Albany Co.

J. Breckwoldt & Co...................... Dolgeville, Herkimer Co.
George Loucks .... Dolgeville, Herkimer Co.

Foster–Armstrong Co..................... East Rochester, Monroe Co.

Jamestown Mantel Co..................... Falconer, Chautauqua Co.
Merriam Cabinet Co., Inc................ Falconer, Chautauqua Co.

Auto Phone Co........................... Ithaca, Tompkins Co.

Ahlstrom Piano Co....................... Jamestown, Chautauqua Co.
Level Furniture Co...................... Jamestown, Chautauqua Co.

C. J. Lindstrom Mfg. Co................. Little Falls, Herkimer Co.
Jos. N. Courtade & Sons, Inc., Webster & 8th av.................. Long Island City, Queens Co.
Steinway & Sons, Riker av. & Blackwell st. Long Island City, Queens Co.

Reuben Midmer & Son, Inc................ Merrick, Nassau Co.
Mount Kisco Woodworking Co.............. Mount Kisco, Westchester Co.

Grubb & Kosegarten Bros	Nassau, Rensselaer Co.
Aimone Mfg. Co., 430 E. 23d st	New York, New York Co.
Autotone Co., 433 5th av	New York, New York Co.
Biddle Piano Co., 107 E. 128th st	New York, New York Co.
Christman Piano Co., 597 E. 137th st	New York, New York Co.
Jacob Doll & Sons, 100 Southern blvd	New York, New York Co.
Esty Piano Co., 112 Lincoln av	New York, New York Co.
Hardman, Peck & Co., 433 5th av	New York, New York Co.
E. G. Harrington Co., 433 5th av	New York, New York Co.
Kindler & Collins, 520 W. 48th st	New York, New York Co.
Kohler Industries, 601 W. 50th st	New York, New York Co.
Krakauer Bros., 191 Cypress av	New York, New York Co.
Kranich & Bach, 235 E. 23d st	New York, New York Co.
The Laffargue Co., 134th st. & S. blvd	New York, New York Co.
Ludwig & Co., 748 E. 136th st	New York, New York Co.
Paul G. Mehlin & Sons, 27 Union Square	New York, New York Co.
J. H. & C. S. O'Dell Co., 407 W. 42d st	New York, New York Co.
Ricca & Son, 99 Southern blvd	New York, New York Co.
The Schubert Piano Co., 1 W. 139th st	New York, New York Co.
The Staib-Abendschein Co., 500 E. 134th st.	New York, New York Co.
Standard Pneumatic Action Co., 638 W. 52d st	New York, New York Co.
Strauch Bros., Inc., 30 W. 10th av	New York, New York Co.
Stultz & Bauer, 338–340 E. 31st st	New York, New York Co.
Wessel, Nickel & Gross, 457 W. 45th st	New York, New York Co.
North Tonawanda Musical Instrument Works	N. Tonawanda, Niagara Co.
The Rudolph Wurlitzer Mfg. Co	N. Tonawanda, Niagara Co.
Ben Ferrara	Oneida, Madison Co.
Charmaphone Co.	Pulaski, Oswego Co.
Fred Englehardt Piano Co	St. Johnsville, Montgomery Co.
The Amphion Co., 618 N. Clinton st	Syracuse, Onondaga Co.
Pullman Bros.	Thendara, Herkimer Co.
Century Cabinet Co	Utica, Oneida Co.
C. E. Morey	Utica, Oneida Co.
Marr & Colton Co	Warsaw, Wyoming Co.

Patterns and Flasks

Westinghouse Elec. Mfg. Co	Attica, Wyoming Co.
Morris Machine Works	Baldwinsville, Onondaga Co.
Dutchess Tool Co	Beacon, Dutchess Co.
Foster Pump Works, 36 Bridge st	Brooklyn, Kings Co.
American Radiator Co	Buffalo, Erie Co.
Bingham Taylor	Buffalo, Erie Co.
Board of Education	Buffalo, Erie Co.
Buffalo Pattern Works, Inc., 830 Hertel av.	Buffalo, Erie Co.

Buffalo Pitts Co., 27 Carolina st.	Buffalo, Erie Co.
W. A. Case & Son Mfg. Co., 174 Kensington av.	Buffalo, Erie Co.
F. A. Colson Pattern Works, 89 Main st.	Buffalo, Erie Co.
Otis Elevator Co.	Buffalo, Erie Co.
Peerless Pattern Works, 1139 Main st.	Buffalo, Erie Co.
Pierce Arrow Motor Car Co., 1695 Elmwood av.	Buffalo, Erie Co.
American Locomotive Co.	Dunkirk, Chautauqua Co.
Atlas Crucible Steel Co.	Dunkirk, Chautauqua Co.
Continental Heater Co.	Dunkirk, Chautauqua Co.
Pierce Butler & Pierce	Eastwood, Onondaga Co.
Public Schools	Elmira, Chemung Co.
Silts Machine Shop	Fulton, Oswego Co.
J. H. Newbury & Son	Goshen, Orange Co.
Gowanda Agr. Works	Gowanda, Cattaraugus Co.
American Road Machinery Co.	Groton, Tompkins Co.
Groton Bridge Co.	Groton, Tompkins Co.
Guilderland Foundry Co.	Guilderland, Albany Co.
Hilsdale Plow Co.	Hillsdale, Columbia Co.
Gifford Wood Co.	Hudson, Columbia Co.
Lackawanna Steel Co.	Lackawanna, Erie Co.
American Malleable Co.	Lancaster, Erie Co.
Lock City Pattern & Mach. Co.	Lockport, Niagara Co.
Trevor Mfg. Co.	Lockport, Niagara Co.
S. Cheney & Sons	Manlius, Onondaga Co.
N. Y. C. & W. R. R. Co.	Middletown, Orange Co.
Shepard Electric Crane & Hoist Co.	Montour Falls, Schuyler Co.
R. J. & T. H. Stuart	New Hamburg, Dutchess Co.
De La Vergne Machine Co., ft. of 1. 138th st.	New York, New York Co.
Ames Iron Works	Oswego, Oswego Co.
Corning Foundry, Inc.	Painted Post, Steuben Co.
Painted Post Development Co.	Painted Post, Steuben Co.
The Garlock Packing Co.	Palmyra, Wayne Co.
Bayles Shipyard, Inc.	Port Jefferson, Suffolk Co.
American Laundry Machine Co.	Rochester, Monroe Co.
Co-operative Foundry Co.	Rochester, Monroe Co.
Gen. Railway Signal Co.	Rochester, Monroe Co.
National Car Wheel Co.	Rochester, Monroe Co.
The T. H. Symington Co.	Rochester, Monroe Co.
American Locomotive Works	Schenectady, Schenectady Co.
Gen. Electric Co.	Schenectady, Schenectady Co.

Huntley Mfg. Co	Silver Creek, Chautauqua Co.
Halcomb Steel Co., Geddes st	Syracuse, Onondaga Co.
Engeiberg Huller Co	Syracuse, Onondaga Co.
Syracuse Pattern Works, Inc., 107 N. Franklin st.	Syracuse, Onondaga Co.
The Straight Line Engine Co	Syracuse, Onondaga Co.
Bascom Pattern Works	Troy, Rensselaer Co.
Cluett, Peabody & Co., Inc	Troy, Rensselaer Co.
Ross Pattern Works	Troy, Rensselaer Co.
Board of Education, Manual Training	Utica, Oneida Co.
Rider-Ericsson Engine Co	Walden, Orange Co.
George B. Mentz Co	Wallkill, Ulster Co.
Otis Elevator Co	Yonkers, Westchester Co.
Saunders Trades School	Yonkers, Westchester Co.

Picture Frames and Moldings

Empire Moulding Co., 391 Leonard st	Brooklyn, Kings Co.
Gottl-Weber Co., 5 La Grange st	Brooklyn, Kings Co.
Greenpoint Moulding Co., Cuyler, Newell & Diamond sts	Brooklyn, Kings Co.
Greenpoint Picture Frame Works, 106 Franklin st.	Brooklyn, Kings Co.
National Mldg. Co., 39th st. & 2d av	Brooklyn, Kings Co.
C. H. Pearson, Co., 34 Lorimer St	Brooklyn, Kings Co.
Union Mill Co., 2d av., Cor. 8th st	Brooklyn, Kings Co.
Mullin, Wagner & Co	Coney Island, Kings Co.
Oliver Jackson	Greenwood, Steuben Co.
J. Borowsky, Inc., 146 Ave. D	New York, New York Co.
E. A. Gillespie, Ozone Park	New York, New York Co.
Lippi & Co., 328 E. 26th st	New York, New York Co.
D. Milch, 131 W. 41st st	New York, New York Co.
N. Y. Carved Mldg. Co., 139th st. & 3d av.	New York, New York Co.
F. J. Newcomb Mfg. Co., 44 W. 13th st	New York, New York Co.
Nonnenback & Co., 102 Mulberry st	New York, New York Co.
S. & R. Frame Co., 213 4th av	New York, New York Co.
Ullman Mfg. Co., 338 E. 59th st	New York, New York Co.
Unionport Woodworking Co., Westchester av. & White Plassis rd	New York, New York Co.
Zubrinsky Mldg. Mfg. Co., 1 E. Bway	New York, New York Co.
J. W. Gillis Co	Rochester, Monroe Co.
N. L. Lockhart Co., 100 S. Fitzhugh st	Rochester, Monroe Co.
Rochester Moulding Wks., Inc	Rochester, Monroe Co.
E. M. Klock & Sons, 1962 W. Fayette st	Syracuse, Onondaga Co.
P. B. & H. Moulding Co	Syracuse, Onondaga Co.

Planing Mill Products

F. E. Wright & Co	Adams, Putnam Co.
William Smith	Addison, Steuben Co.
Albany Lumber & Planing Mill Co., Inc.	Albany, Albany Co.
Carl W. Savage	Alden, Erie Co.
Hutchinson Bros.	Alexandria Bay, Jefferson Co.
E. F. Smith	Allegany, Cattaraugus Co.
Fred E. Purdy	Altona, Clinton Co.
Milford H. Ketcham	Amityville, Suffolk Co.
Andover Heading Co	Andover, Allegany Co.
J. E. Baker	Angola, Erie Co.
Geo. D. Bethel	Antwerp, Jefferson Co.
Frank Palmer & Sons	Apalachin, Tioga Co.
Elmer E. Spencer	Arcade, Wyoming Co.
Green Bros.	Ashville, Chautauqua Co.
Wesley Ranger	Attica, Wyoming Co.
John L. Alnutt	Auburn, Cayuga Co.
W. R. Prouty	Bainbridge, Chenango Co.
Charles Baker	Bakers Mills, Warren Co.
L. C. Lum	Barker, Niagara Co.
Charles P. Emerson	Bath, Steuben Co.
A. B. Wier	Belfast, Allegany Co.
Armstrong & Piermann	Bellport, L. I., Suffolk Co.
Bartlett & Co	Binghamton, Broome Co.
John L. Lewis	Binghamton, Broome Co.
Ed. & Wm. Van Antwerp	Binghamton, Broome Co.
Russell L. Merwin	Blue Mt. Lake, Hamilton Co.
F. M. Hoy	Brainardsville, Franklin Co.
Charles Vail	Broadalbin, Fulton Co.
Louis Bossert & Sons, Inc., 1335 Grand st.	Brooklyn, Kings Co.
Cross, Austin & Ireland, 1246 Grand st.	Brooklyn, Kings Co.
H. F. Gumninau, 118 Montauk av	Brooklyn, Kings Co.
Johnson Bros., 45 Classon av	Brooklyn, Kings Co.
Jacob Morganthaler & Son. 663 Sackett st.	Brooklyn, Kings Co.
E. C. Smith, 420 Oakland st	Brooklyn, Kings Co.
Herman Vossnack, Jr., Inc., 128 Fulton st.	Brooklyn, Kings Co.
Greene's Planing Mill	Brushton, Franklin Co.
Behringer Bros., Inc., 167 Imson st	Buffalo, Erie Co.
Charles Boller & Sons Co	Buffalo, Erie Co.
G. Elias & Bro., Inc	Buffalo, Erie Co.
Christian Flierl Co., Inc., 1352 Genesee st.	Buffalo, Erie Co.
E. M. Hager & Sons Co., 141 Elm st	Buffalo, Erie Co.
Hurd Bros., 719 Bailey av	Buffalo, Erie Co.
John Hutzler Lbr. Co., Inc., 1670–1682 Genesee st.	Buffalo, Erie Co.
McNeil Lumber Corp., 1767 Fillmore av.	Buffalo, Erie Co.
Montgomery Bros. Co., Court & Wilkinson sts.	Buffalo, Erie Co.
William Neubecker, 243 French st	Buffalo, Erie Co.
Stokes Bros., 50 Brayton st	Buffalo, Erie Co.
L. N. Whissel Lumber Corp., 577–615 Cambridge st.	Buffalo, Erie Co.
Irving Dunham	Burdett, Schuyler Co.

Henderson Lumber Co	Caledonia, Livingston Co.
Charles A. McGhee	Cambridge, Washington Co.
George W. Dana	Camden, Oneida Co.
J. A. Scobell Estate	Cape Vincent, Jefferson Co.
Grant Brown	Carlisle, Schoharie Co.
Elitsac Mfg. Co	Castile, Wyoming Co.
C. L. Sancomb	Chateaugay, Franklin Co.
Clymer Lumber Co	Clymer, Chautauqua Co.
State Shop	Cohoes, Albany Co.
Kraemer Bros. Co	College Pt., L. I., Suffolk Co.
Johengen, Johnson & Schmitz	Collins Center, Erie Co.
White & Vogel	Comstock, Washington Co.
Emporium Forestry Co	Conifer, St. Lawrence Co.
The Steam Mill Co	Constableville, Lewis Co.
Joseph P. Brady	Cooperstown, Otsego Co.
H. R. Taylor Corp	Cornwall, Orange Co.
Croghan Flooring & Mfg. Co., Inc	Croghan, Lewis Co.
Benj F. Zehr	Croghan, Lewis Co.
Geo. Jungst & Son	Croton Falls, Westchester Co.
J. W. Phillips	Crown Point, Essex Co.
J. E. Pond & Son	Crown Point, Essex Co.
Phelps & Sibley	Cuba, Allegany Co.
John G. Fontaine	Dansville, Livingston Co.
Deposit Lumber Co	Deposit, Broome Co.
Atlas Crucible Steel Co	Dunkirk, Chautauqua Co.
Dunkirk Lumber & Coal Co	Dunkirk, Chautauqua Co.
Madigan Lumber Co	Dunkirk, Chautauqua Co.
Zine Lumber Co	East Aurora, Erie Co.
A. A. Stewart	East Randolph, Cattaraugus Co.
H. T. Gumtow	Eden, Erie Co.
Rust & Olin	Ellicottville, Cattaraugus Co.
The Doane & Jones Lumber Co	Elmira, Chemung Co.
William Schonckle	Far Rockaway, Queens Co.
Crosby Kelly	Fleischmanns, Delaware Co.
H. V. Berry	Fort Plain, Montgomery Co.
Empire Mfg. Co	Franklinville, Cattaraugus Co.
Luke & Bouquin	Fredonia, Chautauqua Co.
R. J. Rogers Lumber Co	Geneva, Ontario Co.
Rivenburg Bros	Germantown, Columbia Co.
C. F. Bushnell	Gilbertsville, Otsego Co.
W. G. Riffanacht	Glenfield, Lewis Co.
Finch Pruyn & Co	Glens Falls, Warren Co.
Burr Lumber Co	Gloversville, Fulton Co.
Holden Lumber Co	Gloversville, Fulton Co.
Forbush Planing Mills Co	Gowanda, Cattaraugus Co.
Fred Potter	Granville, Washington Co.
Lyon Iron Works	Greene, Chenango Co.
Hamburg Planing Mill Co	Hamburg, Erie Co.
R. A. Kilbourne & Son	Harrisville, Lewis Co.

C. R. Snell & Sons	Herkimer, Herkimer Co.
West Canada Lumber Co	Herkimer, Herkimer Co.
Griffin Lumber Co	Hudson Falls, Washington Co.
Kenyon Lumber Co	Hudson Falls, Washington Co.
Conrad Clipper	Ilion, Herkimer Co.
Oneida Community, Ltd	Kenwood, Madison Co.
The Blount Lumber Co	Lacona, Oswego Co.
George R. Russell	Lake George, Warren Co.
A. E. Paye	Lake Kushaqua, Franklin Co.
Lake Placid Co	Lake Placid Club, Essex Co.
R. C. Rogers	Le Roy, Genesee Co.
A. Little & Son	Little Falls, Herkimer Co.
Livingston Manor Lumber Co	Livingston Manor, Sullivan Co.
The Couroot Co., Inc	Mallory, Oswego Co.
Charles Boadway	Malone, Franklin Co.
John Kelley	Malone, Franklin Co.
Malone Knitting Co	Malone, Franklin Co.
Malone Lumber Co	Malone, Franklin Co.
Charles Garsch Sons	Margaretville, Delaware Co.
Margaretville Planing Mill Co	Margaretville, Delaware Co.
W. L. Pratt	Massena, St. Lawrence Co.
Mrs. J. K. Ames	Mexico, Oswego Co.
Thomas Rush	Middleburg, Schoharie Co.
H. F. Vogel	Middle Granville, Washington Co.
Giles & Giles Co	Middletown, Orange Co.
Tyrell & Kinner	Middletown, Orange Co.
Charles J. Armstrong & Sons	Milford, Otsego Co.
Witherbee, Sherman & Co., Inc	Mineville, Essex Co.
Isaac Smith	Monticello, Sullivan Co.
Stephen Trowbridge	Monticello, Sullivan Co.
Harry Washington	Monticello, Sullivan Co.
Mt. Kisco Bldg. Supply Co	Mount Kisco, Westchester Co.
The Wilson & Adams Co	Mount Vernon, Westchester Co.
E. H. Pierce	Naples, Ontario Co.
Manning Reddant	Naples, Ontario Co.
J. M. Slayton	Naples, Ontario Co.
John S. Ness & Son	Narrowsburg, Sullivan Co.
Newfane Lumber & Mfg. Co	Newfane, Niagara Co.
Dunbar Box & Lumber Co., 282 Eleventh av.	New York, New York Co.
East Side Planing Mill, 514 First av	New York, New York Co.
F. Eckenroth & Son, 921 E. 5th st	New York, New York Co.
Jacob Gangnagel, 801 Mutual Life Bldg.	New York, New York Co.
Church E. Gates & Co., 152d & East River	New York, New York Co.
Hasbrouck Flg. Co., 501–509 East 70th st.	New York, New York Co.
G. W. Koch & Son, 9 E. 40th st	New York, New York Co.
James McBride Flg. Co., 169 Lincoln av	New York, New York Co.
Charles A. Pope, 320 E. 95th st	New York, New York Co.
J. M. Saulpaugh Sons, 705 E. 11th st	New York, New York Co.
Gorham F. Smith, 301 Eleventh av	New York, New York Co.

Wright Lumber Co., Inc., 148 W. 38th st..	New York, New York Co.
Wm. P. Youngs & Bro., 735 E. 9th st.....	New York, New York Co.
Allen Smith Co........................	Niagara Falls, Niagara Co.
S. W. Johnson & Son....................	Nichols, Tioga Co.
W. H. Plumb & Son......................	North Bangor, Franklin Co.
C. P. Falk............................	North Collins, Erie Co.
The R. T. Jones Lumber Co.............	No. Tonawanda, Niagara Co.
King Construction Co..................	No. Tonawanda, Niagara Co.
George C. Meyers......................	No. Tonawanda, Niagara Co.
Northern Lumber Co....................	No. Tonawanda, Niagara Co.
W. G. Palmer, Inc.....................	No. Tonawanda, Niagara Co.
Thompson–Hubman–Fisher	No. Tonawanda, Niagara Co.
J. E. Wallace	No. Tonawanda, Niagara Co.
White–Gratwick–Mitchell	No. Tonawanda, Niagara Co.
The Sacandaga River Land & Lumber Co.	Northville, Fulton Co.
Charles Winters	North White Lake, Sullivan Co.
E. J. Elliott..........................	Norwich, Chenango Co.
N. F. Dewitt..........................	Odessa, Schuyler Co.
Proctor Manufacturing Co...............	Ogdensburg, St. Lawrence Co.
Skillings, Whitneys & Barnes Lbr. Co., Inc.	Ogdensburg, St. Lawrence Co.
W. D. Butler	Oneonta, Otsego Co.
McFee & Borst.........................	Oneonta, Otsego Co.
A. E. Norton	Oriskany Falls, Oneida Co.
J. E. Jones............................	Owego, Tioga Co.
A. Paine & Son.........................	Owego, Tioga Co.
Post & Henderson......................	Owego, Tioga Co.
L. B. Truman..........................	Owego, Tioga Co.
Frank C. Miller.......................	Parish, Oswego Co.
Plattsburg Lumber Co..................	Plattsburg, Clinton Co.
Port Chester Lumber Co................	Port Chester, Westchester Co.
The A. Sherman Lumber Co.............	Potsdam, St. Lawrence Co.
Charles Garrison	Ripley, Chautauqua Co.
William G. Bell, 962 Main st. E..........	Rochester, Monroe Co.
Rochester Parquet Floor Co..............	Rochester, Monroe Co.
Peter Zielinski	Rochester, Monroe Co.
S. N. Skinner	Rockdale, Chenango Co.
William Cooper & Son..................	Rushford, Allegany Co.
George H. Cleveland....................	Sag Harbor, Suffolk Co.
Clark H. Burkdorf......................	St. Johnsville, Montgomery Co.
John H. Kneeskern & Sons..............	St. Johnsville, Montgomery Co.
A. Sponable	St. Johnsville, Montgomery Co.
G. F. Miller & Son.....................	Salamanca, Cattaraugus Co.
Branch Gallahan	Saranac Lake, Franklin Co.
Seymour Ruggles	Saratoga Spgs., Saratoga Co.
J. B. Pierce...........................	Schenectady, Schenectady Co.
Funston Bros...........................	Schuylerville, Saratoga Co.
Thomas Nevins	Schuylerville, Saratoga Co.
The Lyon Washington Lumber Co........	Sherman, Chautauqua Co.
Hooker & Higgs........................	Sinclairville, Chautauqua Co.
L. C. Bowen	Skerry, Franklin Co.
Charles Coonley	Slingerlands, Albany Co.

Lyons Mills .... Solsville, Madison Co.
Fred A. Olmstead .... So. Fallsburgh, Sullivan Co.
Frank H. Stuart .... Springwater, Livingston Co.
H. S. Farrell .... Staten Island, Richmond Co.
Harding Morse .... Steamburg, Cattaraugus Co.
D. T. Bayles & Son .... Stony Brook, Suffolk Co.
J. J. Conrad .... Strykersville, Wyoming Co.
Wm. S. Kirsch .... Strykersville, Wyoming Co.
Wicker Lumber Co .... Suspension Bridge, Niag. Co.
Arthur Deuse .... Swartwood, Chemung Co.
Chapman Lumber Co., Carbon st .... Syracuse, Onondaga Co.
J. K. McDowell, 211 Wilkinson st .... Syracuse, Onondaga Co.
J. E. Mulherub, 331 N. Salina st .... Syracuse, Onondaga Co.

George Heller & Son .... Theresa, Jefferson Co.
Eastern Lumber Co .... Tonawanda, Niagara Co.
Charles Collins & Son .... Troy, Rensselaer Co.
W. E. Martin .... Troy, Rensselaer Co.
The Santa Clara Lumber Co .... Tupper Lake, Franklin Co.

Nellie Amos & Swift .... Utica, Oneida Co.

The N. A. Tyler Lumber Co .... Vernon, Oneida Co.
Charles H. Hess .... Vernon Center, Oneida Co.

Warrensburg Planing Mill Co .... Warrensburg, Warren Co.
Welch Bros. .... Warwick, Orange Co.
Charles W. Sloan & Son .... Watertown, Jefferson Co.
G. W. White & Son .... Watertown, Jefferson Co.
W. H. Marsh & Co .... Watervliet, Albany Co.
A. L. Smith & Co .... Watkins, Schuyler Co.
Wolff Lumber Co .... Wayland, Steuben Co.
Hanks & Vickland .... Wellsville, Allegany Co.
Westfield Lumber & Coal Co .... Westfield, Chautauqua Co.
William S. Van Clief .... West New Brighton, Richmond Co.
E. F. Gerwitz .... West Valley, Cattaraugus Co.
Wevertown Saw Mill .... Wevertown, Warren Co.
F. H. Lyman .... Whippleville, Franklin Co.
A. H. Smith .... White Plains, Westchester Co.
Denton & Waterbury .... Whitesbore, Oneida Co.
Knox Rieman Co .... Williamsville, Erie Co.
H. A. Beede .... Willsboro, Essex Co.
H. H. Giles .... Wilson, Niagara Co.
G. S. Van Buskirk .... Wiscoy, Allegany Co.
B. T. Clark .... Woodbourne, Sullivan Co.

Yerks & Co .... Yonkers, Westchester Co.

Plumbers' Woodwork

Coyne & Delaney Co., 832 Kent av .... Brooklyn, Kings Co.

A. Wyckoff & Son Co .... Elmira, Chemung Co.

M. P. Berglas Mfg. Co., 10 Fulton st ...... New York, New York Co.
Shwab Bros. Co., 811 E. 9th st .... New York, New York Co.

Printing Materials

American Wood Type Co., 302 McDougal st. Brooklyn, Kings Co.
A. R. Kohler, 567 Washington st.......... Buffalo, Erie Co.

Setter Bros. Co.......................... Cattaraugus, Cattaragus Co.

Morgans & Wilcox Mfg. Co.............. Middletown, Orange Co.

Frend Ungford Chambers Co., Inc........ New York, New York Co.

Roscoe Ten Pin Co...................... Roscoe, Sullivan Co.

Professional and Scientific Instruments

Ansco Co.–Camera Works................ Binghamton, Broome Co.
Eberhard Faber, 37 Greenpoint av........ Brooklyn, Kings Co.

Up–To–Date Advertising Co.............. Canisteo, Steuben Co.

I. T. R. Co............................. Endicott, Broome Co.

American Mfg. Concern.................. Falconer, Chautauqua Co.

N. Y. Mallet & Handle Works............ New York, New York Co.

Charles Tallners .... Pulaski, Oswego Co.

Bausch & Lomb Optical Works........... Rochester, Monroe Co.
Eastman Kodak Co...................... Rochester, Monroe Co.
Seneca Camera Mfg. Co.................. Rochester, Monroe Co.
Taylor Instrument Co., 95 Ames st....... Rochester, Monroe Co.

Lucus Tuttle Mfg. Co.................... Silver Springs, Wyoming Co.

W. & L. E. Gurley .... Troy, Rensselaer Co.

Pulleys and Conveyors

Excelsior Pulley Co..................... Cuba, Allegany Co.

Western Block Co....................... Lockport, Niagara Co.

Oneida Wood Pulley Co., Inc............. Oneida, Madison Co.

John M. Tousten Co., 110 Mill st......... Rochester, Monroe Co.

Pumps and Piping

A. Wyckoff & Son Co.................... Elmira, Chemung Co.

Robert Hoes .... Malden Bridge, Columbia Co.

American District Steam Co............. No. Tonawanda, Niagara Co.

A. A. Babcock Pump Co.................. Ogdensburg, St. Lawrence Co.

Lymen Curren .... Springlake, Cayuga Co.

A. W. Winters, Jr........................ Unionville, Orange Co.

Refrigerators and Kitchen Cabinets

Colonial Mantel & Refrigerator Co., 494 Dumont av	Brooklyn, Kings Co.
McKee Refrigerator Co	Brooklyn, Kings Co.
Heinz & Munshauer	Buffalo, Erie Co.
Jewett Refrigerator Co	Buffalo, Erie Co.
A. F. Meyer & Sons Co., 408 Broadway	Buffalo, Erie Co.
Fayetteville Mfg. Co	Fayetteville, Onondaga Co.
Garland Refrigerator Co., Beech st	Mt. Vernon, Westchester Co.
Dubois Refrigerator Co., Inc., 107–111 W. 18th st	New York, New York Co.
Anton Larsen & Sons, Brook av. & 134th st.	New York, New York Co.
Lorillard Refrigerator Co., Madison av. at 48th st	New York, New York Co.
James McLean, Inc., 537 W. 53d st	New York, New York Co.
L. H. Mace & Co., Inc., 55 150th st	New York, New York Co.
J. M. Saulpaugh Sons, 705 E. 11th st	New York, New York Co.
William Williams Co., 312 E. 95th st	New York, New York Co.
Trotter Refrigerator Co	Rochester, Monroe Co.

Sash, Doors, Blinds, and General Millwork

O. D. Greene	Adams, Putnam Co.
Park, Winton & True Co	Addison, Steuben Co.
Blakeslee Lumber Co	Albany, Albany Co.
Cameron & Hawn	Albany, Albany Co.
Ransdill & Co	Albany, Albany Co.
C. M. Mallory	Albion, Orleans Co.
F. D. Blowstein	Amenia, Dutchess Co.
Kelly–Green Co	Amsterdam, Montgomery Co.
J. D. Lasher	Amsterdam, Montgomery Co.
McNeil Mfg. Co	Amsterdam, Montgomery Co.
George D. Bethel	Antwerp, Jefferson Co.
Elmer E. Spencer	Arcade, Wyoming Co.
H. V. Mix	Argyle, Washington Co.
Weesburg–Baer Co	Astoria, Queens Co.
Wesley Ranger	Attica, Wyoming Co.
Clark Lumber Co	Auburn, Cayuga Co.
Luke B. Williams	Auburn, Cayuga Co.
E. W. Featherston	Au Sable Forks, Essex Co.
Streever Lumber Co	Ballston Spa., Saratoga Co.
L. W. Keeler & Son	Bangor, Franklin Co.
The Batavia & New York Wood Working Co	Batavia, Genesee Co.
Batavia Lumber & Coal Co	Batavia, Genesee Co.
Jones Bros. & Parker	Bath, Steuben Co.
Charles E. Kirkup	Bay Shore, Suffolk Co.
Bartlett & Co	Binghamton, Broome Co.
Junius I. Bishop	Binghamton, Broome Co.
John L. Lewis	Binghamton, Broome Co.

James O'Neil	Binghamton, Broome Co.
Ed. & Wm. Van Antwerp	Binghamton, Broome Co.
Barber & Robinson	Bolton Landing, Warren Co
W. M. Hubbard	Brewerton, Onondaga Co.
John D. Morehouse	Brewster, Putnam Co.
East Hampton Lumber & Coal Co	Bridgehampton, Suffolk Co.
Charles Vail	Broadalbin, Fulton Co.
Alpert Woodworking Corp, 410 Snediker av	Brooklyn, Queens Co.
Louis Bossert & Sons, Inc., 1335 Grand st.	Brooklyn, Queens Co.
M. J. Britt, E. 17th st. & Emmers Lane	Brooklyn, Queens Co.
Louis Brook, Inc., 148 India st	Brooklyn, Queens Co.
Brooklyn Fireproof Sash & Door Co., 87–105 Richardson st	Brooklyn, Queens Co.
Cross, Austin & Ireland, 1246 Grand st	Brooklyn, Queens Co.
S. Davis, 222 Newell st	Brooklyn, Queens Co.
Eastern Fireproof Sash & Door Co., 826 Flushing av	Brooklyn, Queens Co.
Eastern Woodworking Co., 820 Stone av	Brooklyn, Queens Co.
East N. Y. Sash Door & Trim Co., 245 Belmont av	Brooklyn, Queens Co.
Eichmann Co., 7 McKibben st	Brooklyn, Queens Co.
A. Entenman, Inc., 669 73d st	Brooklyn, Queens Co.
Samuel Feldman, 511 Flushing av	Brooklyn, Queens Co.
I. Feldman & Son, 98 Engert av	Brooklyn, Queens Co.
Fisher & Voorhies, Av. S. & W. 10th st	Brooklyn, Queens Co.
Haugard Bros., 1429 Metropolitan av	Brooklyn, Queens Co.
Benj. G. Hitchings, 999 E. 34th st	Brooklyn, Queens Co.
Frank Hockin, 107 Pine st	Brooklyn, Queens Co.
Interboro Sash & Door Co., 352 Junius st	Brooklyn, Queens Co.
S. Jacobs & Sons, 1365 Flushing av	Brooklyn, Queens Co.
C. R. Macaulay Co., 18th st. & Fifth av	Brooklyn, Queens Co.
John P. Milliken Co., 560 Willoughby av	Brooklyn, Queens Co.
Jacob Morganthaler & Son, 663 Sackett st.	Brooklyn, Queens Co.
The Mortonsen Wood Working Co., Inc., 554 Hamilton av	Brooklyn, Queens Co.
National Sash & Door Co., 137 Bayard st	Brooklyn, Queens Co.
J. P. Oates, Provost & Greenpoint av	Brooklyn, Queens Co.
Prims & Klein, 158–160 Walworth st	Brooklyn, Queens Co.
Reliance Fireproof Door Co., 78 West st	Brooklyn, Queens Co.
Robins Dry Dock & Repairs Co., Foot Beard st	Brooklyn, Queens Co.
J. Sklar Wood Work Co., Inc., 672 Hopkinson av	Brooklyn, Queens Co.
E. C. Smith, 420 Oakland st	Brooklyn, Queens Co.
Star Wood Turning Co., 276 Newport av	Brooklyn, Queens Co.
Estate of S. Weinstein, 95 Frost st	Brooklyn, Queens Co.
Behringer Bros., Inc., 167 Imson st	Buffalo, Erie Co.
Charles Boller & Sons Co	Buffalo, Erie Co.
Buffalo Grille Co	Buffalo, Erie Co.
Dohn, Fischer & Beyer, Inc., 1340 Niagara st	Buffalo, Erie Co.
G. Elias & Bro., Inc	Buffalo, Erie Co.
John Feist & Sons Co., 111 Ash st	Buffalo, Erie Co.
Christian Flierl Co., Inc., 1352 Genesee st.	Buffalo, Erie Co.
John E. Grenzebach, 2745 Seneca st	Buffalo, Erie Co.

E. M. Hager & Sons Co., 141 Elm st......	Buffalo, Erie Co.
William Hendrich's Sons Co..............	Buffalo, Erie Co.
Huntington & Finke Co., 625 Tonawanda st	Buffalo, Erie Co.
International Cabinet Co., 39 Henry st....	Buffalo, Erie Co.
Morse Sash & Door Co., 340 W. Main st...	Buffalo, Erie Co.
Mosier & Summers, 1266 Seneca st.......	Buffalo, Erie Co.
Smith Elevator Co., Inc., 301 Liberty Bldg.	Buffalo, Erie Co.
L. N. Whissel Lumber Corp., 577–615 Cambridge st...........................	Buffalo, Erie Co.
H. E. Holbrook Co......................	Caledonia, Livingston Co.
Martin Hermann	Callicoon, Sullivan Co.
George W. Dana.........................	Camden, Oneida Co.
George T. Thompson	Canandaigua, Ontario Co.
Louis Tobin	Canandaigua, Ontario Co.
Alfred E. Dew & Son....................	Canastota, Madison Co.
John Coakley	Canton, St. Lawrence Co.
J. W. Rushton..........................	Canton, St. Lawrence Co.
H. I. Starkweather.....................	Carthage, Jefferson Co.
Charles Beardsley	Catskill, Greene Co.
Catskill Supply Co.....................	Catskill, Greene Co.
William Bihl	Central Islip, Suffolk Co.
John Earl	Champlain, Clinton Co.
The Otis Brooks Lumber Co..............	Clayton, Jefferson Co.
A. Van Auken	Cobleskill, Schoharie Co.
G. H. Crandall Co......................	Cohoes, Albany Co.
Kraemer Bros Co........................	College Pt., L. I., Suffolk Co.
Joseph P. Brady........................	Cooperstown, Otsego Co.
Corning Building Co....................	Corning, Steuben Co.
H. R. Taylor Corp......................	Cornwall, Orange Co.
Mead & Taft Co.........................	Cornwall Landing, Orange Co.
Johnson & Bernston.....................	Corona, Steuben Co.
H. F. Benton Lumber Co.................	Cortland, Cortland Co.
H. W. Newton	Cortland, Cortland Co.
C. V. Peck.............................	Cortland, Cortland Co.
Phelps & Sibley........................	Cuba, Allegany Co.
Rowley Bros	Cuba, Allegany Co.
Gould Coupler Co.......................	Depew, Erie Co.
Dexter Woodworking & Bldrs. Sup Co....	Dexter, Jefferson Co.
J. E. Harnahan.........................	Dobbs Ferry, Westchester Co.
Dunkirk Lumber & Coal Co...............	Dunkirk, Chautaqua Co.
Madigan Lumber Co......................	Dunkirk, Chautaqua Co.
J. A. Taylor	Dunkirk, Chautaqua Co.
Zink Lumber Co. Inc....................	East Aurora, Erie Co.
Henry W. Burt..........................	East Northport, Suffolk Co.
H. T. Gumtow...........................	Eden, Erie Co.
E. L. Ackerman	Edmeston, Otsego Co.
E. A. Aldous	Edwards, St. Lawrence Co.
Harris, McHenry & Baker Co.............	Elmira, Chemung Co.
Kertscher & Co.........................	Elmira, Chemung Co.
Public Schools	Elmira, Chemung Co.
H. C. Spaulding Co.....................	Elmira, Chemung Co.
J. N. Wood & Co., Inc..................	Elmira, Chemung Co.

Young Lumber Co	Elmira, Chemung Co.
Endicott Box & Lumber Co	Endicott, Broome Co.
Light-Unkefer Co	Endicott, Broome Co.
Fairport Lumber & Coal Co	Fairport, Monroe Co.
George Adams Lumber Co	Far Rockaway, Queens Co.
George Closs	Far Rockaway, Queens Co.
Hicks, Hicks & Hicks	Far Rockaway, Queens Co.
Keshin, Blistern & Co	Far Rockaway, Queens Co.
Muller & Buckley	Far Rockaway, Queens Co.
Ralph O'Rorke	Far Rockaway, Queens Co.
W. E. Durhams	Fayetteville, Onondaga Co.
Allegany Lumber Co	Fillmore, Allegany Co.
Copp & Stratton	Flushing, Queens Co.
Ahrens & Salhoff	Fredonia, Chautauqua Co.
Sackett Screen Co	Fredonia, Chautauqua Co.
Silts Machine Shop	Fulton, Oswego Co.
George Deis & Son Co	Fulton Chain, Herkimer Co.
H. A. Irmler	Gardenville, Erie Co.
J. G. Henry	Geneva, Ontario Co.
Roland E. Lasher	Germantown, Columbia Co.
Kendrick & Brown Co	Glens Falls, Warren Co.
Burr Lumber Co	Gloversville, Fulton Co.
Holden Lumber Co	Gloversville, Fulton Co.
F. W. Jacksons	Good Ground, Suffolk Co.
Samuel C. Warner	Good Ground, Suffolk Co.
C. A. Corwin & Son	Greenport, Suffolk Co.
Henry A. Hedges	Greenport, Suffolk Co.
Stewart Thomas	Greenport, Suffolk Co.
Harriman Industrial Corp	Harriman, Orange Co.
Clark & Bennett Lumber Co	Haverstraw, Rockland Co.
J. H. Haney	Hensonville, Greene Co.
C. R. Snell & Sons	Herkimer, Herkimer Co.
West Canada Lumber Co	Herkimer, Herkimer Co.
Estate of Charles H. Voigt	Hicksville, Nassau Co.
James Elgar, Inc	Hornell, Steuben Co.
Hornell Lumber Co	Hornell, Steuben Co.
Weaver Building & Supply Co., Inc	Hudson, Columbia Co.
Brookside Planing Mill	Huntington, Suffolk Co.
Huntington Sash & Door Co	Huntington, Suffolk Co.
Conrad Klipper	Ilion, Herkimer Co.
A. M. Hunter & Sons	Irvington, Westchester Co.
Lord & Burnham Co	Irvington, Westchester Co.
B. S. Raynor	Islip, Suffolk Co.
Cornell University Repair Dept	Ithaca, Tompkins Co.
N. Y. State Agricultural College at Cornell.	Ithaca, Tompkins Co.
Potter & Allen	Ithaca, Tompkins Co.
Robinson & Carpenter	Ithaca, Tompkins Co.
Edward Sprigg	Ithaca, Tompkins Co.
John R. Carpenter	Jamaica, Queens Co.
E. & J. Dorf Son Co	Jamaica, Queens Co.

Alex. Piercey	Jamaica, Queens Co.
James H. Stansbury	Jamaica, Queens Co.
Lindbeck Lumber & Mfg Co	Jamestown, Chautauqua Co.
Nelson Bros.	Jamestown, Chautauqua Co.
Watson Mfg. Co	Jamestown, Chautauqua Co.
Estate John T. Wilson	Jamestown, Chautauqua Co.
Lestershire Lumber & Box Co	Johnson City, Broome Co.
Snyder & Way	Johnstown, Fulton Co.
Levi Stephenson	Johnstown, Fulton Co.
Stephenson & Newnham	Johnstown, Fulton Co.
Oneida Community, Ltd	Kenwood, Madison Co.
J. A. Milhern	Kingston, Ulster Co.
H. W. Palen's Sons	Kingston, Ulster Co.
Theo. Weeks & Son	Kingston, Ulster Co.
F. A. Montanye	Lacona, Oswego Co.
Lake Hill Wood Products Co	Lake Hill, Ulster Co.
Lake Placid Co	Lake Placid Club, Essex Co.
John Knauber	Lancaster, Erie Co.
J. H. Smith & Co	Lawrence, Nassau Co.
John A. Wood & Son Co	Lawrence, Nassau Co.
John J. Wood & Co	Lawrence, Nassau Co.
Joseph Lapp	LeRoy, Genesee Co.
F. C. Rogers	LeRoy, Genesee Co.
A. Little & Son	Little Falls, Herkimer Co.
S. P. McCloy	Lockport, Niagara Co.
G. W. Pencille	Lockport, Niagara Co.
Joseph Whelan	Lockport, Niagara Co.
Almar Manufacturing Co	Long Isl. City, Queens Co.
William Couch	Long Isl. City, Queens Co.
Lagana & Co	Long Isl. City, Queens Co.
Charles B. Mayer Architectural Woodworking Co.	Long Isl. City, Queens Co.
J. Murname, 37 Beebe av	Long Isl. City, Queens Co.
Tisdale Lumber Co	Long Isl. City, Queens Co.
The Courbot Co., Inc	Mallory, Oswego Co.
C. H. Dupree, Agt	Malone, Franklin Co.
Mamaroneck Lbr. & Supply Co	Mamaroneck, Westchester Co.
Mamaroneck S. D. & Tr. Co	Mamaroneck, Westchester Co.
Wines & Homan	Mattituck, Suffolk Co.
William Barber	Mechanicsville, Saratoga Co.
Pruyn Lbr. & Supply Co	Mechanicsville, Saratoga Co.
Thos. Bush	Middleburg, Schoharie Co.
J. C. Warner	Middleburg, Schoharie Co.
Giles & Giles Co	Middletown, Orange Co.
Tyrell & Kinner	Middletown, Orange Co.
Swift Bros., Inc	Millbrook, Dutchess Co.
Frank Godsky & Co	Mineola, Nassau Co.
R. L. Teeter	Moravia, Cayuga Co.
E. N. Austin	Morristown, St. Lawrence Co.
D. F. Dakin Co	Mount Kisco, Westchester Co.
H. L. Crain	Mount Upton, Chenango Co.
George L. Thayer	Mount Upton, Chenango Co.

Bengston & Nordholm	Mt. Vernon, Westchester Co.
Burton & Fenton	Mt. Vernon, Westchester Co.
Kapp & Nordholm Co.	Mt. Vernon, Westchester Co.
L. Vinton & Sons	Mt. Vernon, Westchester Co.
Norman Weiss	Mt. Vernon, Westchester Co.
Wilson & Adams Co.	Mt. Vernon, Westchester Co.
S. N. Keener Co.	Newark, Wayne Co.
Newburg Plaining Mill Co.	Newburgh, Orange Co.
Newfane Lbr. & Mfg. Co.	Newfane, Niagara Co.
Hubbell Hardwood Door Co.	N. Rochelle, Westchester Co.
The J. A. Mahlstedt Lumber & Coal Co.	N. Rochelle, Westchester Co.
Ahneman & Younkheers, 3320 Bailey av.	New York, New York Co.
Bardsley Bros. Co., 147–151 Baxter st.	New York, New York Co.
Baumgarten & Co., 715 5th av.	New York, New York Co.
Charles F. Biele & Sons Co., 381 W. 12th st.	New York, New York Co.
Bronx Sash & Door Co., 180th st. & E. Tremont av.	New York, New York Co.
John H. Carl & Sons, Inc., 514 First av.	New York, New York Co.
A. C. Chesley Co., Inc., 277 Rider av.	New York, New York Co.
City Kalamein Co., Inc., 4485 3d av.	New York, New York Co.
Dunbar Box & Lumber Co., 282 11th av.	New York, New York Co.
F. Eckenroth & Son, 921 E. 5th st.	New York, New York Co.
Eureka Woodworking Co., 318 E. 75th st.	New York, New York Co.
Fischer Bros., 5th av. & 137th st.	New York, New York Co.
James C. Forbes, Beach av.	New York, New York Co.
Jacob Froehlich Cabinet Works, 1041 Leggett av.	New York, New York Co.
Frank G. Hall, 310 E. 75th st.	New York, New York Co.
Hogan & Di-Genno, 1616 Webster av.	New York, New York Co.
L. Kern, 422 E. 92d st.	New York, New York Co.
Kessler Bros., Inc., 312–316 E. 95th st.	New York, New York Co.
David Kramer, 43 Broad st.	New York, New York Co.
J. F. McLaughlin, 314 E. 75th st.	New York, New York Co.
Manhattan Woodworking Co., 281 Rider av.	New York, New York Co.
Matteawan Mfg. Co., 392 5th av.	New York, New York Co.
Henry H. Meise & Son, Inc., 192 Southern blvd.	New York, New York Co.
Mount & Robertson, Inc., 41 Beaver st.	New York, New York Co.
New York Woodworking Corp., 506 E. 19th st.	New York, New York Co.
H. Pearlman, 858 8th av.	New York, New York Co.
J. M. Prudvosky, 432 E. 10th st.	New York, New York Co.
Charles Read, 406 W. 30th st.	New York, New York Co.
J. & W. Robb, 245–247 W. 28th st.	New York, New York Co.
Salom & Wuthe Co., Inc., 521 E. 72d st.	New York, New York Co.
J. M. Saulpaugh Sons, 705 E. 11th st.	New York, New York Co.
F. Schaettler, 533–537 W. 34th st.	New York, New York Co.
Schoeller & Richter, Inc., 537 W. 53d st.	New York, New York Co.
Sherwin & Berman, Inc., 405 E. 4th st.	New York, New York Co.
Sol. S. Silver & Co. Inc., 101 Park av.	New York, New York Co.
Skirwanek & Taunhaeuser, 1110 First av.	New York, New York Co.
Sloane & Moller, Inc., 316 E. 65th st.	New York, New York Co.
Star Fire Proof Door & Sash Co., 2650–2652 Park av.	New York, New York Co.

Superior Fire Proof Door & Sash Co., 1811 Carter av	New York, New York Co.
Tiger & Dreeben, 4 & 6 Tompkins st	New York, New York Co.
Unionport Woodworking Co., West Chester av. & White Plassis rd	New York, New York Co.
C. S. Utterson, Inc., 941 6th av	New York, New York Co.
Cheseboro Whilman, 1167 1st av	New York, New York Co.
Alfred Wick, 276 9th av	New York, New York Co.
Charles Wollersen, 514 W. 46th st	New York, New York Co.
Wm. P. Youngs & Bro., 1st av. & 35th st	New York, New York Co.
F. E. Zimmerman & Co., 13 Baxter st	New York, New York Co.
S. W. Johnson & Son	Nichols, Tioga Co.
Fred Lindow, Sr	North Collins, Erie Co.
Ray H. Bennett Lumber Co	No. Tonawanda, Niagara Co.
George C. Meyers	No. Tonawanda, Niagara Co.
W. G. Palmer, Inc	No. Tonawanda, Niagara Co.
E. J. Elliott	Norwich, Chenango Co.
Rollin D. Reed	Norwood, St. Lawrence Co.
W. J. Pooler	Ogdensburg, St. Lawrence Co.
Proctor Mfg. Co	Ogdensburg, St. Lawrence Co.
A. Weston Lumber Co	Olean, Cattaraugus Co.
Appleby & Deen	Ossining, Westchester Co.
M. J. Gallagher	Ossining, Westchester Co.
Isaac Terwilliger's Sons	Ossining, Westchester Co.
S. E. Fournier	Oswego, Oswego Co.
James C. Harding Son	Oswego, Oswego Co.
A. Paine & Son	Oswego, Oswego Co.
Post & Henderson	Oswego, Oswego Co.
C. H. Vrooman	Patchogue, Suffolk Co.
Pendleton & Townsend	Patterson, Putnam Co.
Paul Smiths Hotel Co	Paul Smiths, Franklin Co.
William Brotherton's Sons	Peekskill, Westchester Co.
David Andrus	Perry, Wyoming Co.
A. J. Schwind	Perry, Wyoming Co.
A. Mason & Sons	Peru, Clinton Co.
E. C. Vickery	Phoenix, Oswego Co.
La Croix Sash & Door Co	Plattsburg, Clinton Co.
Plattsburg Lumber Co	Plattsburg, Clinton Co.
Lester Tompkins	Poland, Herkimer Co.
George Mertz & Sons	Port Chester, Westchester Co.
Port Chester Lumber Co	Port Chester, Westchester Co.
Loper Bros.	Port Jefferson, Suffolk Co.
W. W. Hendrickson Co	Port Jervis, Orange Co.
Charles Lindquist	Port Richmond, Richmond Co.
Wm. S. Van Clief & Sons	Port Richmond, Richmond Co.
Grant Street Planing Mill	Potsdam, St. Lawrence Co.
Brooks & Co	Poughkeepsie, Dutchess Co.
Levi Lumb's Son	Poughkeepsie, Dutchess Co.
Charles Tallners	Pulaski, Oswego Co.
Cook & Smith	Redwood, Jefferson Co.
George Van Allen	Rensselaer, Rensselaer Co.
Zepf Bros.	Rensselaer, Rensselaer Co.

Charles Skidmore	Riverhead, Suffolk Co.
Bantleon Bros. Co., 97 Railroad st	Rochester, Monroe Co.
Bausch & Lomb Optical Co	Rochester, Monroe Co.
Department of Public Instruction	Rochester, Monroe Co.
Philipp Enders & Son, 52 Rustic st	Rochester, Monroe Co.
W. K. Goetzman, 204 Water st	Rochester, Monroe Co.
Hollister Lumber Co., 100 Anderson av	Rochester, Monroe Co.
Palmer-Marcy Co., 36 Harrison st	Rochester, Monroe Co.
John B. Pike	Rochester, Monroe Co.
F. H. Phelps Lumber Co	Rochester, Monroe Co.
J. H. Reinhard & Son, 17 Favor st	Rochester, Monroe Co.
H. P. Sickles Co., 840 University av	Rochester, Monroe Co.
Smith Sash & Door Co., 175 Exchange st	Rochester, Monroe Co.
Spencer Lumber Co	Rochester, Monroe Co.
Stoertz Bros., 18 Commercial st	Rochester, Monroe Co.
Vogel & Binder Co., 388 St. Paul st	Rochester, Monroe Co.
Beach Lumber Co	Rome, Oneida Co.
Edward Comstock Co	Rome, Oneida Co.
Conklin, Tribby & Conklin	Roslyn, Nassau Co.
Isaac Hicks	Roslyn, Nassau Co.
George H. Cleveland	Sag Harbor, Suffolk Co.
Branch & Calloran	Saranac Lake, Franklin Co.
Hoyle & Tagliabue	Saranac Lake, Franklin Co.
J. J. O'Connell	Saranac Lake, Franklin Co.
W. J. Case & Sons	Saratoga Spgs., Saratoga Co.
Carl J. Lundgren	Saratoga Spgs., Saratoga Co.
Peckham, Wolf & Co	Schenectady, Schenectady Co.
J. B. Pierce	Schenectady, Schenectady Co.
J. Young	Schenectady, Schenectady Co.
Alva Laucks	Schoharie, Schoharie Co.
Ansell Raynor	Seaford, Nassau Co.
B. Merenes	Seward, Schoharie Co.
Vosburgh & Stone	Shady, Ulster Co.
John J. Hixson	Shortsville, Ontario Co.
Arthur Stevens	Shortsville, Ontario Co.
G. A. Clark Co	Sidney, Delaware Co.
August Kofoed	Sliver Creek, Chautauqua Co.
C. E. Smith & Co	Skaneateles, Onondaga Co.
F. G. Booth	Smithtown Branch, Suffolk Co.
D. W. Smith	South Bethlehem, Albany Co.
E. O. Fordham	Speonk, L. I., Suffolk Co.
Henry Salzler Co	Springville, Erie Co.
Springville Planing Mills	Springville, Erie Co.
Fred Cook	Stamford, Delaware Co.
H. S. Farrell	Staten Island, Richmond Co.
Branch Bros	Suspension Bridge, Niag. Co.
Haeberle Lumber Co	Suspension Bridge, Niag. Co.
August Steinbremer	Suspension Bridge, Niag. Co.
Wicker Lumber Co	Suspension Bridge, Niag. Co.
Joseph Caldwell, 250 Tallman st	Syracuse, Onondaga Co.
Chapman Lumber Co., Carbon st	Syracuse, Onondaga Co.
Doxtader & Wilcoxen, 408 E. Canal st	Syracuse, Onondaga Co.
E. Hagedorn Mfg. Co., Oakwood st	Syracuse, Onondaga Co.

Michael Hemmer, 215 Sunset Av.......... Syracuse, Onondaga Co.
John H. Lyons, Inc., 542 Canal st........ Syracuse, Onondaga Co.
J. K. McDowell, 211 Wilkinson st......... Syracuse, Onondaga Co.
Mann & Hunter Lumber Co.............. Syracuse, Onondaga Co.
Market Mfg. Co., 618 E. Water st........ Syracuse, Onondaga Co.
J. E. Mulheim, 331 N. Salina st.......... Syracuse, Onondaga Co.
J. M. Scott, Director of Industrial Education.............................. Syracuse, Onondaga Co.
John J. Sherlock, 206 Canal st........... Syracuse, Onondaga Co.
Wilson & Greene Lumber Co............. Syracuse, Onondaga Co.

Geo. Heller & Son...................... Theresa, Jefferson Co.
Madden Lumber Co...................... Troy, Rensselaer Co.
T. D. Wadelton......................... Tuckahoe, Westchester Co.

Amos Nellis & Swift..................... Utica, Oneida Co.
Philip Thomas' Sons..................... Utica, Oneida Co.

James Horton .... Warwick, Orange Co.
Charles W. Sloat & Son.................. Watertown, Jefferson Co.
W. A. Sullivan Lumber Co., Inc.......... Watertown, Jefferson Co.
W. H. Marsh & Co...................... Watervliet, Albany Co.
Thomas F. Sheehan..................... Watervliet, Albany Co.
James T. Young........................ Watervliet, Albany Co.
Westfield Lumber & Coal Co............ Westfield, Chautauqua Co.
Frank McWilliams .... W. New Brighton, Richm'dCo.
Frank N. Goble........................ White Plains, Westchester Co.
Kelsey, Smith & Co., Inc................ White Plains, Westchester Co.
H. F. Giles .... Wilson, Niagara Co.
A. B. Brown Co........................ Woodside, Queens Co.
Handshur & Sindler.................... Woodside, Queens Co.
Norman–Seton, Inc..................... Woodside, Queens Co.
Hadsell Bros. Co., Inc.................. Worcester, Otsego Co.

F. B. Mee............................. Yonkers, Westchester Co.
S. F. Quick & Sons...................... Yonkers, Westchester Co.
Saunders' Trades School................ Yonkers, Westchester Co.
Yerks & Co............................ Yonkers, Westchester Co.
H. C. Shumaker .... Youngstown, Niagara Co.

Shade and Map Rollers

John Kroder & Henry Reubel Co., 109 Meeker av .... Brooklyn, Kings Co.

Brannan Mfg. Co....................... Carthage, Jefferson Co.

The Columbia Mills, 225 Fifth av......... New York, New York Co.

Standard Shade Roller Co................ Ogdensburg, St. Lawrence Co.

Ship and Boat Building

J. H. Brown............................ Alexandria Bay, Jefferson Co.
Charles J. Estes........................ Alexandria Bay, Jefferson Co.
J. B. & R. L. Reil...................... Alexandria Bay, Jefferson Co.
Thomas Thurston .... Alexandria Bay, Jefferson Co.

Ward & Co., 54 Fulton av	Astoria, L. I., Queens Co.
R. Lenahan	Athens, Greene Co.
Albert V. Rogers	Bayshore, Suffolk Co.
Henry V. Watkins	Bellport, Suffolk Co.
Wm. J. Ridgely	Boonville, Oneida Co.
T. M. Milton & Sons	Brewerton, Onondaga Co.
Brooklyn Spar Co., foot of Columbia st	Brooklyn, Kings Co.
Ira S. Bushey & Sons, Inc., 764 Court st	Brooklyn, Kings Co.
Theo. A. Crane's Sons Co., foot Columbia st	Brooklyn, Kings Co.
C. M. Englis, Inc., 245 Greenpoint av	Brooklyn, Kings Co.
Furman Dry Dock Co., foot of 20th st	Brooklyn, Kings Co.
Wm. J. Gokey & Co., Inc., Pier L, Erie Basin	Brooklyn, Kings Co.
Jakobson & Peterson, foot 24th st	Brooklyn, Kings Co.
Kells Mill & Lumber Co., Java & Provost sts	Brooklyn, Kings Co.
Thomas F. Meehan & Son, 43 Van Brunt	Brooklyn, Kings Co.
Morse Dry Dock & Repair Co., foot 56th st.	Brooklyn, Kings Co.
Robins Dry Dock & Repair Co., foot Beard st	Brooklyn, Kings Co.
Schuyler & Caddell, pier 2 Erie basin	Brooklyn, Kings Co.
James Shewan & Sons, Inc., foot of 27th st	Brooklyn, Kings Co.
Buffalo Dry Dock Co	Buffalo, Erie Co.
Cowles Shipyard Co	Buffalo, Erie Co.
Fix Bros, foot of Amherst st	Buffalo, Erie Co.
Great Lakes Dredge & Dock Co., 1100 Morgan bldg	Buffalo, Erie Co.
W. E. Dodge	Cape Vincent, Jefferson Co.
Bredenburg Bros	Champlain, Clinton Co.
Robert Jacob, City Island av	City Islnd, N. Y., N. Y. Co.
Kyle & Purdy, Inc	City Islnd, N. Y., N. Y. Co.
The Otis Brooks Lumber Co	Clayton, Jefferson Co.
Walter E. Abrams	Cold Spring Harbor, Suffolk Co.
College Point Boat Corp	College Point, L. I., Queens Co.
J. Newton Hand	East Moriches, Suffolk Co.
Charles M. Allen, Inc	Fulton, Oswego Co.
Fay & Bowen Eng. Co	Geneva, Ontario Co.
Fyfe's Shipyard	Glenwood Landing, Nassau Co.
Albertson Construction Co	Greenport, Suffolk Co.
Eastern Shipyard Co	Greenport, Suffolk Co.
Greenport Basin & Construction Co	Greenport, Suffolk Co.
Greenport Ship Co., Inc	Greenport, Suffolk Co.
J. W. Ketcham	Greenport, Suffolk Co.

Harriman Industrial Corp............... Harriman, Orange Co.
Richard B. Chute, Jr.................... Huntington, Suffolk Co.
Wheeler Shipbuilding Co., Inc........... Huntington, Suffolk Co.

Dennis Donovan .... Kingston, Ulster Co.
C. Hildebrant .... Kingston, Ulster Co.
Kingston Shipbuilding Corp............. Kingston, Ulster Co.
R. Lenahan Co........................... Kingston, Ulster Co.
Daniel Murphy .... Kingston, Ulster Co.
Jacob Rice & Co......................... Kingston, Ulster Co.
Schoonmaker & Connors .... Kingston, Ulster Co.
William J. Turk Co...................... Kingston, Ulster Co.
W. F. & R. Co........................... Kingston, Ulster Co.

George & Bliss .... Lake Placid, Essex Co.

Orienta Boat Yards...................... Mamaroneck, Westchester Co.
Sound Machine Shop...................... Mamaroneck, Westchester Co.
S. F. Bauna .... Mariners Harbor, Richmond Co.
William B. Hougheout.................... Mariners Harbor, Richmond Co.
Johnsons Shipyards Corp................ Mariners Harbor, Richmond Co.
Staten Island Shipbuilding Co........... Mariners Harbor, Richmond Co.
Consolidated Shipbuilding Corp.......... Morris Heights, N. Y., New York Co.
N. Y. Yacht, Launch & Eng. Co.......... Morris Heights, N. Y., New York Co.

National D. D. & Repair Co.............. New Brighton, Richmond Co.
O. Stoneburg............................ New Rochelle, Westchester Co.
American Balsa Co., 50 E. 42d st.......... New York, New York Co.
W. F. Ruddock Boat & Yacht Works, Inc., 214 st. & Harlem River............... New York, New York Co.
Henry Steers, 17 Battery pl.............. New York, New York Co.
James Tregarthen & Sons Co., Inc., ft. E. 7th st............................ New York, New York Co.
United States Navy Yard................ New York, New York Co.
Northport Shipbuilding Corp............ Northport, Suffolk Co.
Richardson Boat Co...................... No. Tonawanda, Niagara Co.
International Shipbuilding & Marine Engineering Corp......................... Nyack, Rockland Co.
Nyack Shipbuilding Corp................ Nyack, Rockland Co.
Julius Paterson .... Nyack, Rockland Co.

Leyare Boat Works....................... Ogdensburg, St. Lawrence Co.
St. Lawrence Marine Railway............ Ogdensburg, St. Lawrence Co.
Fulton Navigation Co.................... Old Forge, Herkimer Co.
Parsons Bros............................ Old Forge, Herkimer Co.

George D. Bishop........................ Patchogue, Suffolk Co.
DeWitt S. Conklin....................... Patchogue, Suffolk Co.

Yachting Dept., N. Y. A. C.	Pelham Manor, Westchester Co.
Bayles Shipyard, Inc.	Port Jefferson, Suffolk Co.
Alexander McDonald, Inc.	Port Richmond, Richmond Co.
O'Brien Bros	Port Richmond, Richmond Co.
Hopeman Bros. Mfg. Co, 569 Lyell av	Rochester, Monroe Co.
William V. Long, 323 Jefferson av	Rochester, Monroe Co.
Skaneateles Boat & Canoe Co.	Skaneateles, Onondaga Co.
Fred A. McMillin	Sodus Point, Wayne Co.
Dan M. Corwin	South Jamesport, Suffolk Co.
Johnson Shipyard Corp., Marine Harbor	Staten Island, Richmond Co.
A. C. Brown's Sons	Tottenville, Richmond Co.
Harry Cossey	Tottenville, Richmond Co.
John Matton	Waterford, Saratoga Co.
Albany Boat Corp	Watervliet, Albany Co.
P. Jesse Matton	Watervliet, Albany Co.
Downey Shipbuilding Corp.	West New Brighton, Richmond Co.
National Dry Dock & Repair Co.	West New Brighton, Richmond Co.
National Dry Dock Co.	West New Brighton, Richmond Co.
Frank McWilliams, Inc.	West New Brighton, Richmond Co.

Shuttles, Spools and Bobbins

Avoca Mfg. Co.	Avoca, Steuben Co.
Big Indian Wood Products Co.	Big Indian, Ulster Co.
Lestershire Spool Mfg. Co.	Johnson City, Broome Co.

Sporting and Athletic Goods

Wm. J. Ridgely	Boonville, Oneida Co.
Bredenburg Bros	Champlain, Clinton Co.
Livingston Manor Turning Works	Livingston Manor, Sullivan Co.
Reiper Mfg. Co., 149 Baxter st	New York, New York Co.
Sandford, Bell & Lahm, 61 4th av	New York, New York Co.
H. Wagner & Adler Co., 30 Union sq	New York, New York Co.
Frank Schwinkert & Son, 149 South av	Rochester, Monroe Co.
Roscoe Ten Pin Co.	Roscoe, Sullivan Co.

Tanks and Silos

Mayer Tank Mfg. Co., Inc., 212–220 Russell st	Brooklyn, Kings Co.
Peter Pfeil Cooperage Works, 223–233 Madison st	Buffalo, Erie Co.

Alfred E. Dew & Son.................... Canastota, Madison Co.

F. E. Hudson & Sons.................... Ellisburg, Jefferson Co.

Burr Lumber Co......................... Gloversville, Fulton Co.
Holden Lumber Co....................... Gloversville, Fulton Co.

Noble & Wood Machinery Co.............. Hoosick Falls, Rensselaer Co.

D. H. Burrell & Co., Inc............... Little Falls, Herkimer Co.
A. Little & Sons....................... Little Falls, Herkimer Co.

R. L. Teeter........................... Moravia, Cayuga Co.

Newfane Lumber & Mfg. Co............... Newfane, Niagara Co.
Anton Hoffman, 317 E. 91st st.......... New York, New York Co.
Isseks & Rosenwach, 94 Mangin st....... New York, New York Co.
National Cooperage Co., 501 Water st... New York, New York Co.
J. Rosenwach, 615-625 Grand st......... New York, New York Co.
Morris Sheres, 460 E. 10th st.......... New York, New York Co.
Enterprise Lumber & Silo Co............ North Tonawanda, Niag. Co.

Craine Silo Co., Inc................... Norwich, Chenango Co.

Carley Heater Co., Inc................. Olean, Cattaraugus Co.

T. J. Parry............................ Remsen, Oneida Co.

B. Merenes .... Seward, Schoharie Co.
Globe Silo Co.......................... Sidney, Delaware Co.
Lyons Mills .... Solsville, Madison Co.
Samuel Wandell, Wythe Av. & N. 15th st.. South Brooklyn, Kings Co.

Unadilla Silo Co....................... Unadilla, Otsego Co.

Toys

The J. S. Harrison Co.................. Addison, Steuben Co.
The Embossing Co., 20 Pruyn st......... Albany, Albany Co.

The Wilkinson Mfg. Co.................. Binghamton, Broome Co.
M. Gropper & Sons Bush Terminal........ Brooklyn, Kings Co.

Sherwood Bros. Mfg. Co................. Canastota, Madison Co.

American Mfg. Concern.................. Falconer, Chautauqua Co.

Vincent & McDonald..................... Gloversville, Fulton Co.

S. J. Bens Co.......................... Herkimer, Herkimer Co.

Medina Toy Co., Inc.................... Medina, Orleans Co.

Walton Toy Co.......................... Walton, Delaware Co.

Trunks and Suit Cases

Bingham Trunk Co.	Buffalo, Erie Co.
Buffalo Trunk Mfg. Co.	Buffalo, Erie Co.
Charap & Mark, 101 Green st.	New York, New York Co.
D. Diamond & Son, 315 E. 22d st.	New York, New York Co.
Innovation Trunk Co., 3 Canal pl.	New York, New York Co.
F. R. Merrall & Co., 505–507 E. 18th st.	New York, New York Co.
H. Likly & Co., 330 Lyell st.	Rochester, Monroe Co.
Syracuse Trunk Co., 444 S. Salina st.	Syracuse, Onondaga Co.
H. C. Faber & Son Co., 12 Meadow st.	Utica, Oneida Co.

Vehicles and Vehicle Parts

Knox & Schaible, 235–245 Spruce st.	Albany, Albany Co.
W. S. Clark	Andover, Allegany Co.
A. G. Crawford	Angola, Erie Co.
Eagle Wagon Works	Auburn, Cayuga Co.
Avoca Wheel Co.	Avoca, Steuben Co.
Horace J. Henty	Avon, Livingston Co.
George V. Fellows	Baldwinsville, Onondaga Co.
L. M. Tappan	Baldwinsville, Onondaga Co.
Barber & Robinson	Bolton Landing, Warren Co.
J. P. Badore	Bombay, Franklin Co.
Decker Mfg. Co.	Brockport, Monroe Co.
Borden's Farm Products Co., 992 Gates av.	Brooklyn, Kings Co.
Thos. Rockford, 1066 Bedford av.	Brooklyn, Kings Co.
J. A. Shephard & Son, Atlantic & Fountain avs	Brooklyn, Kings Co.
Brunn's Carriage Mfg. Co., 1140 Main st.	Buffalo, Erie Co.
J. Christensen, 635 Genesee st.	Buffalo, Erie Co.
George Clarke, 249 15th st.	Buffalo, Erie Co.
E. A. Cook Wagon Works	Buffalo, Erie Co.
John D. Davis Wagon Works, 172 Elk st.	Buffalo, Erie Co.
Fred L. Grampp, 206 Chicago st.	Buffalo, Erie Co.
Handel Wagon Works, 314 Seneca st.	Buffalo, Erie Co.
L. Noellers Sons, 43–47 Locust st.	Buffalo, Erie Co.
John F. Vogt, 268 Jefferson st.	Buffalo, Erie Co.
Wurster Wagon Works, 314 Seneca st.	Buffalo, Erie Co.
Wm. Garrett	Canadaigua, Ontario Co.
Charles L. Wheeler	Canaseraga, Allegany Co.
F. M. Yocum	Canaseraga, Allegany Co.
Watson Products Corp.	Canastota, Madison Co.
Alfred Slawson Est.	Canisteo, Steuben Co.
H. J. Ackerman	Cato, Cayuga Co.
Edward Kennedy	Cato, Cayuga Co.
C. L. Sancomb	Chateaugay, Franklin Co.
Wm. Nelson	Claverack, Columbia Co.
I. E. Davis	Clayville, Oneida Co.
Charles Myers	Clifton Springs, Ontario Co.
Buckley & Kernan	Cortland, Cortland Co.

J. H. Waterman	Deansboro, Oneida Co.
Huber Carriage Works	Delhi, Delaware Co.
E. J. Carpenter	Delphi Falls, Onondaga Co.
Neenan Bros.	East Bloomfield, Ontario Co.
E. D. Satterlee	East Otto, Cattaraugus Co.
F. W. Sykes	East Otto, Cattaraugus Co.
John Gibbon	Elton, Cattaraugus Co.
George Parsons	Forestport, Oneida Co.
Acme Road Machinery Co	Frankfort, Herkimer Co.
E. A. Breese	Freeville, Tompkins Co.
George S. Monroe	Freeville, Tompkins Co.
James Eaton	Georgetown, Madison Co.
H. M. Cronk	Grand Gorge, Delaware Co.
Jason Weeks	Greenwood, Steuben Co.
B. Braum	Hempstead, Nassau Co.
Davis B Todd	Hempstead, Nassau Co.
Eaton & Fisher	Holcomb, Ontario Co.
D. F. Tanner	Holland, Erie Co.
R. R. Durkee	Hume, Allegany Co.
James Rafferty	Kings Ferry, Cayuga Co.
John Mayer	Kingston, Ulster Co.
Adam Walburger	LaFayette, Onondaga Co.
Wm. Eitleman	Livingston, Columbia Co.
Philip Deuchler & Son	Lyons, Wayne Co.
D. D. Costello	Manlius, Onondaga Co.
Willis Kinyon	Marietta, R. D. No. 2, Onondaga Co.
Francis McGarry	Merrifield, Cayuga Co.
George S. Cady & Son	Moravia, Cayuga Co.
George FitzSimmons	Morrisville, Madison Co.
D. B. Jones	Morrisville, Madison Co.
F. R. Brady	Mt. Vernon, Westchester Co.
Roscoe Velie	Nassau, Rensselaer Co.
Everett Mfg. Co	Newark, Wayne Co.
Arthur Colvill	Newburgh, Orange Co.
George Anthon, 507 W. 54th st	New York, New York Co.
W. Babor, 417 E. 75th st	New York, New York Co.
Wm. Koenig, 24 Lawrence st	New York, New York Co.
J. Kramer & Sons Mfg. Co., 673–679 Water st.	New York, New York Co.
Liberty Wagon Works, 540 W. 40th st	New York, New York Co.
New York Wagon Works, 1924 1st av	New York, New York Co.
Peters & Heins, 503–505 E. 82d st	New York, New York Co.
Henry Reinmuller & Sons, 521 W. 47th st.	New York, New York Co.
M. Sahr, 1892, First av	New York, New York Co.
Yorkville Wagon & Auto Body Bldg Co., 336 E. 64th st	New York, New York Co.
The Buffalo Sled Co	North Tonawanda, Niagara Co.

James McCasland .... Ogdensburg, St. Lawrence Co.
Conklin Wagon Co........................ Olean, Cattaraugus Co.
G. W. Wayne............................. Otto, Cattaraugus Co.
Champion Wagon Works................ Owego, Tioga Co.

W. C. Woodford......................... Pompey, Onondaga Co.
Thos. McWhinnie .... Poughkeepsie, Dutchess Co.

T. J. Parry............................... Remsen, Oneida Co.
J. W. Reed................................ Remsen, Oneida Co.
E. C. Locke.............................. Richville, St. Lawrence Co.
Caley & Nash, Inc., 1828 E. av........... Rochester, Monroe Co.
Deusing & Zieres........................ Rochester, Monroe Co.
George A. Lane......................... Rochester, Monroe Co.
Fitch Gear Co........................... Rome, Oneida Co.
N. Forget .... Roslyn, Nassau Co.

R. Winkler & Son........................ Salisbury, Herkimer Co.
R. M. Whitney Co., Inc.................. Salisbury Center, Herkimer Co.

Adelbert Weller .... Salt Springville, Otsego Co.
Jay B. Baker............................. Sanitaria Springs, Broome Co.

Warners Repair Shop.................... Schoharie, Schoharie Co.
John A. Lehman .... Seward, Schoharie Co.
D. J. Van Vlack......................... Silver Creek, Chautauqua Co.
Lyons Mills .... Solsville, Madison Co.
S. J. King................................ Somerset, Niagara Co.
Zorn & Schrengauer .... Stapleton, Richmond Co.
H. A. Moyer, 241 Wolf st................ Syracuse, Onondaga Co.

Valentine Gaetz .... Troy, Rensselaer Co.

Wallings Carriage Works................ Utica, Oneida Co.

Charles G. Richenecker.................. Watervliet, Albany Co.
I. J. Misner.............................. Woodbourne, Sullivan Co.
Hadsell Bros. Co., Inc.................. Worcester, Otsego Co.

Veneer

Crandall Panel Co., Inc.................. Brocton, Chautauqua Co.
Standard Veneer Panel Co., 241 37th st.... Brooklyn, Kings Co.

American Panel Co....................... Cattaraugus, Cattaraugus Co.

Jamestown Panel Co., Inc................ Jamestown, Chautauqua Co.

Whips and Umbrella Sticks

Buffalo Whip Co., 335 Glenwood av...... Buffalo, Erie Co.

Ulster Wood Products Co................. Ellenville, Ulster Co.

Empire State Whip Co.................... Windsor, Broome Co.
Windsor Whip Co........................ Windsor, Broome Co.

Woodenware and Novelties

Spies Bros. & Gould, Inc.................	Adams, Jefferson Co.
C. M. Mallory	Albion, Orleans Co.
John McCarthy	Albion, Orleans Co.
W. W. Babcock Co.....................	Bath, Steuben Co.
Big Indian Wood Products Co............	Big Indian, Ulster Co.
Glidden, W. L., 1035 Atlantic av.........	Brooklyn, Kings Co.
Show Woodworking Co., 14 Dunham pl....	Brooklyn, Kings Co.
Standard Wood Turning Co, 661 Margan av.	Brooklyn, Kings Co.
L. A. Miller............................	Cairo, Greene Co.
B. W. Vaughn..........................	Cairo, Greene Co.
H. E. Holbrook Co.....................	Caledonia, Livingston Co.
Up-to-Date Advertising Co..............	Canisteo, Steuben Co.
Setter Bros	Cattaraugus, Cattaraugus Co.
W. B. Buell	Cold Brook, Herkimer Co.
F. W. Barker...........................	Coopers Plains, Steuben Co.
Ames Mfg. Concern.....................	Falsoner, Chautauqua Co.
Fayetteville Mfg. Co....................	Fayetteville, Onondaga Co.
Hollenbeck & Son......................	Fort Jackson, St. Lawrence Co.
Edgar Palmer	Freehold, Greene Co.
Bacon & Co............................	Gasport, Niagara Co.
L. Holden	Gilbertsville, Otsego Co.
John J. Finkle.........................	Gloversville, Fulton Co.
F. D. Peters & Co......................	Gloversville, Fulton Co.
Catskill Mt. Souvenir Co................	Hensonville, Greene Co.
S. J. Bens Co..........................	Herkimer, Herkimer Co.
H. M. Quackenbush	Herkimer, Herkimer Co.
Ralph Cooper	Holland, Erie Co.
Edward Hope	Hurleyville, Sullivan Co.
Edward L. Gossett	Jamestown, Chautauqua Co.
Adler Veneer Seat Co....................	Long Island City, Queens Co.
Klein Bros	Long Island City, Queens Co.
Charles J. Teape........................	Long Island City, Queens Co.
A. A. Clark & Sons......................	Marion, Wayne Co.
George C. Topping......................	Marion, Wayne Co.
Kalt Lumber Co., 320 E. 64th st..........	New York, New York Co.
Maron Woodworking Co., 519 W. 45th st..	New York, New York Co.
National Hanger and Fixture Mfg. Co., 496–498 E. 134th st..................	New York, New York Co.
N. Y. Ladder Co., Inc., 384 Hudson st....	New York, New York Co.
N. Y. Mallet and Handle Works, 743 E. 11th st..............................	New York, New York Co.
Schloss Bros., 637 W. 55th st............	New York, New York Co.
Cheseboro Whitman, 1167 First av........	New York, New York Co.
S. W. Johnson & Sons...................	Nichols, Tioga Co.

E. W. Baker & Sons.................... Orwell, Oswego Co.
W. H. Lattimer & Sons.................. Orwell, Oswego Co.

Charles E. Post........................... Palenville, Greene Co.

F. B. Pease Co........................... Rochester, Monroe Co.
H. P. Sickles Co., 840 University av...... Rochester, Monroe Co.

George W. Kidder........................ Staatsburg, Dutchess Co.
W. C. Cure.............................. Stamford, Delaware Co.
Schoeck Mfg. Co., Spencer st............ Syracuse, Onondaga Co.
E. C. Stearns & Co...................... Syracuse, Onondaga Co.

Burgess Howard .... Tannersville, Greene Co.
Oval Wood Dish Co...................... Tupper Lake, Franklin Co.

Garner Print Works and Bleachery....... Wappingers Falls, Dutchess Co.

Spies Bros. & Gould, Inc................ Watertown, Jefferson Co.
John S. Tilly Ladder Co................. Watervliet, Albany Co.
American Novelty Co.................... Wellsville, Allegany Co.
Frank Conklin .... Willowemoc, Sullivan Co.
Henry Becker .... Woodridge, Sullivan Co.

H. L. Clark............................ Vernon, Oneida Co.

Miscellaneous Industries

Artificial Limbs

George R. Fuller Co..................... Rochester, Monroe Co.

Bottle Stoppers

Independent Cork Co., Inc., 574 Hamilton av. .... Brooklyn, Kings Co.

Bungs

Stephan Kampf, 186 Jefferson st......... Albany, Albany Co.

Butchers' Supplies

A. B. Schreckinger, 809 First av.......... New York, New York Co.

Cores and Plugs

W. G. Case & Co......................... Black River, Jefferson Co.

Adirondack Core & Plug Co.............. Carthage, Jefferson Co.
Setter Bros. Co......................... Cattaraugus, Cattaraugus Co.

Florists' Sticks

W. J. Cowee............................ Berlin, Rensselaer Co.

W. F. Babcock.......................... Camden, Oneida Co.

A. W. Winters, Jr....................... Unionville, Orange Co.

Mop Wringers

White Mop Wringer Co.................. Fultonville, Montgomery Co.

Mouse Traps

Shann Manufacturing Co................. Middletown, Orange Co.

Playground Equipment

James F. Wilbur........................ Berkshire, Tioga Co.

Allen Herschell Co...................... North Tonawanda, Niagara Co.

Reels

M. E. Woodcock......................... Edwards, St. Lawrence Co.

National Conduit & Cable Co............. Hastings-on-Hudson, Westchester Co.

Signs and Supplies

Up-to-Date Advertising Co............... Canisteo, Steuben Co.

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