GENERAL PROPOGATION OF PLANTS

BY

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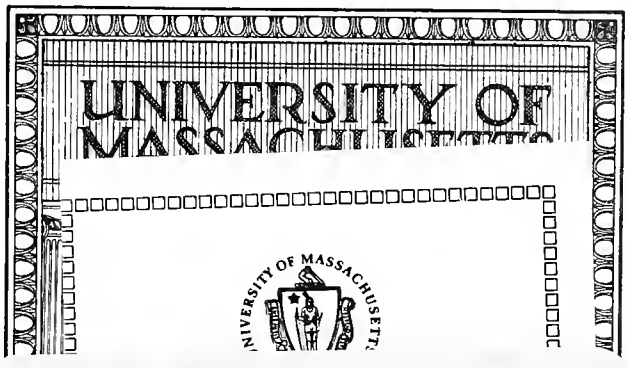

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The following is a portion of a bulletin which was published by A. D. Taylor, in connection with work done in the graduate school on the subject of general propogation of trees and shrubs.

The material is not complete and I am having it bound simply for use as reference.

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(I)

The foremost object of the experimental work has been to determine the medium--including both sand and temperature conditions--in which the different types of cuttings succeed to best advantage. Other factors which have beenconsidered secondarily are :

1. The relative ability of cuttings, from the different species and varieties, to strike roots.

2. Advantages of large and small cuttings, and the best type for commercial propagators.

3. Effect of frost upon the ability of the cuttings to strike roots.

Considering first the medium in which cuttings do best, we will at once see that for each and every type of cutting there is no one condition of temperature and moisture conditions, which is most favorable to all. From lack of more extensive experiments and the ability to dofinitely control the degree of top and bottom heat the conclusions in this respect can be but general in their scope. However by an examination of Tables 1 and 2 it will be seen that for a small cutting of this type the higher degrees of temperature, the finer sand and shorter callusing period are best adapted to root growth ; in Tables 3 and 9 it will be seen that the

(2.)

higher temperature, coarser sand and longer callusing period are best adapted to the root growth in such cuttings. The number of cuttings used in Table 9 was very limited, hence the results are simply relative in value. The figures in Tables 4, 5, 8 and 10 show that, subjecting to low temperature conditions for too long a period, as well as watering to excess, are factors which greatly retard the growth of the cutting. The lower the temperature of the propagating house, within certain limits--the more capable are cuttings to resist adverse conditions ; but they will not strike roots unless given a higher temperature which is more favorable to growth. After the necessary period required for callusing is over greater care should then be exercised to obtain the best results. The photographs including Plates
show for themselves the effects of temperature, sand and moisture conditions upon rooting power of various cuttings.

1. Relative Ability of various cuttings so strike roots

By examining the tables and the photographs it is easily seen that there exists a wide variation in the ability of cuttings from different genera, species and even varieties in their power of striking roots. It seems strange that there should be such a difference in this respect, as is often manifested in many varieties of the same species. The juvenile and mature forms as pointed out under the chapter on Cuttings, vary greatly in this phase; this is illustrated by comparing Plates ((and ((. From the legend accompanying these

plates it will be seen that the root development attained by the former, is far greater than that seen in the case of the mature forms of the same species.

No genus can be said to be more difficult to root, under favorable conditions, than another. There are, however, certain species, which show a marked difference in this respect ; and as a result of my experience with their propagation, I have placed them in the following order, commencing with the most easily rooted and ending with those which are the most difficult to root or callus.

Very Easily Rooted

Thuya Occidentalis var. Hoveyii

Thuya Occidentalis var. Siberica

Thuya Globosa

Thuya Orientalis var. Pyramidalis

Cupressus Lawsoniana

Chamaecyparis Pisifera

Juniperus Communis var. Prostrata

Chamaecyparis Squarrosa

Medium Easily Rooted

Chamaecyparis Pisifera var. Plumosa

Juniperus Communis var. Hibernica

Juniperus Communis Aurea

Taxus Rapundra

Difficult to Root

Thuya Occidentelis var. Warriana

Juniperus Virginiana

Biota Orientalis

Chamaecyparis Obtusa

Juniperus Sabina (mature form)

Taxus Cuspidata

Taxus Baccata

The foregoing list includes only a few of the more common species and varieties which showed marked differences in this respect.

2. Advantages of Large and small cuttings

As seen in the plates, the root system formed by the larger types of cuttings which are included in the first part of the list is almost as great as that formed by the smaller types. With cuttings which naturally root very easily it is by far better to reproduce, if possible from the larger types of cuttings ; while with the other classes which do not root as readily, those of the Mechan type are the most economical to make, from a commercial standpoint. However, as seen with J. Virginiana, in Plate ( ) the size of the cutting makes little difference in the progress of the callus during the first year. With plants which grow as slowly as do Conifers during the early part of their life, it is readily seen that, if cuttings are abundant, the larger the cutting which can be made and well rooted during the first season, the greater the

time saved in the development of the plant. The smaller cuttings in some cases, as seen in Plats ( ) ( ) do not root as readily as the larger ones. Cuttings of the green wood, as shown by Tables 2 and 5 callus with difficulty and root very slowly. Those taken from the leading branchlets, of a very vigorous growth, as seen in Plates ( ) ( ) root much more slowly than those taken from the lateral branchlets, and of not so vigorous a growth. The practice of trimming a portion of the leaf surface from the cuttings as seen in the Moon type, is not to be encouraged. Unlike hardwood and herbaceous cuttings, this operation seems to be of no practical value in the reproduction of conifers, and on the other hand as seen in the plates it seems detrimental to the best results in the development of the cuttings after rooted.

3. Effect of frost upon ability of the cutting to strike roots.

This is a point much discussed among different nurserymen, and one which ultimately would depend upon the nature and history of the species, to determine accurately. If a species is naturally a northern one and adapted to adverse conditions of climatic influences, it could better undergo freezing effects than one which was of a less hardy nature. With my limited experiments in this line I have failed to see that having been subjected to conditions of freezing, has exerted any influence upon the ability of the cutting to strike roots. Cuttings taken in early October and those taken in December show very little difference in the root development, other than

that naturally expected from the increased start of those placed in the cutting bed at the earlier date.

The tabular results and the photographs herein included need very little explanation other than that already given. I have inserted very few tables bearing upon the investigational work ; because in the case of such work being conducted with the practical end wholly in view, and the lack of a properly equipped propagating house, the would be no more than a compilation of useless data meaning nothing to the reader.

HISTORY OF PROPAGATION

The first and most primitive method whereby plants were propagated, was without doubt that of seed, which is the most natural and seen to the greatest degree in nature. Among the few writers who have touched upon this subject, there does to be no strong and well defined idea as to the origin of this art.

It is seen from the history of Solomon, King of the Jews, that he was well acquainted with the nature of plants ; hence it is inferred that in the extensive gardens and pleasure grounds of this wealthy sovereign, there had been no little attention paid to the rearing of trees both for ornamental and useful purposes.[1] These were in all probability mostly grown from seed ; however we have no knowledge of other methods being in practice at that time. The art of grafting, says A. Thonin[2]; "is an art, the discovery of which is of the highest antiquity ; its inventor is unknown." Whether it was suggested by the adhesions of the parts of two plants in nature is still a mystery.

The Phoenecians transmitted it to the Carthaginians and

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1. The Forester, by James Brown
2. 1827

the Greeks and from the latter it was carried to the Romans. Theophrastus and other Greek authors mention the graft, and more than twenty modifications of the general method have been given by the Roman Varro. From the Romans the knowledge of grafting spread to Europe where it has gradually developed to the stage in which we see it today. The principal treatise which first gave in a clear manner the Theory of Grafting was that by De Candolle entitled, "Physiologie Vegetale." Another principal author upon the subject is M. Thouin, of Paris, who described and figured more than 100 kinds of grafts.

About 1676 Millington and Grew establish the fact that different sexes existed in various plants. Malphighi and others laid claim to the priority in the discovery of this fact ; but it was Dr. Lindley who said, "I see nothing so precise in their works as is found in the declaration of Grew, that the stamens do serve as male for the germination of the seed." Work along this line was taken up by Bradley in 1717, who first produced hybrids artificially ; and also by Linnaeus in 1744.

The application of the mode of propagation, known as grafting, to members of the coniferous group was first made by the Baron Tschondy, upon Pinus Laricio, probably about the end of the eighteenth century ; and the method was thereafter practiced upon his estate at Colombey, near Metz. The method is described quite fully in the "Traite Pratique" of Delmarre, the substance of which is as follows :

"The method was called by him, herbaceous grafting, and was performed in the cleft manner. The time of performing the operation was when the leading shoot of the stock had attained a length of eight to twelve inches, and was quite brittle. The time during which the shoot is in this condition is usually not more than fifteen days ; the graft is always inserted in the leading shoot, the side shoots being removed or shortenened, and the young shoots produced from the stock during that season are pinched off at about half their length. In performing the operation the first step is to reduce the leading shoot to four or six inches ; the leaves are then removed from the remaining portion, with the exception of about an inch at the top ; these being left to draw up the sap. Scions should be deprived of leaves and cut in the form of a thin wedge. After being grafted, cover the graft with a cornet of paper tied slightly to the stock, so as to admit air but exclude sun. This may be removed in ten to fifteen days after grafting, and in six to eight weeks the upper portion of the stock with the leaves on, may be trimmed off upon both sides of the scion, and all shoots produced upon the lower part of the stock removed in order to throw sap into the scion. Most suitable stocks are plants sown where they are finally to stand, and of four to six years growth ; the object being to make the graft from 3three to four feet above the ground in order to avoid stooping on the part of the operator."

The first real mention of the fact in American literature, namely, that propagators began to realize that ornamental trees and shrubs could be propagated from cuttings was in 1847.[1] In 1845, through an accident, James Barnes found that cuttings left from pruning some shrubbery, had taken root in a kiln which had been used for converting such refuse into useful manure, by jeans of charring. This hint was turned to useful account, and perhaps led to the idea of bottom heat and the fundamental principles of treating cuttings. About 1860 John Watson of Rochester, N.Y., published his ideas and discoveries upon the growing of plants from cuttings. His summaries were as follows : "common sharp sand, dried until it has in it no excessive moisture is best ; the receptacle, any rough wooden box, is filled with sand and cuttings in alternate layers, and the whole buried out of sight under a greenhouse bench or similar place, where the underground temperature will be comparatively steady and not too warm. The temperature which cuttings will bear is the greatest amount without endangering the bursting of the buds. After this callousing process is completed, the cuttings may be then placed in a propagating house."

The progress in the methods of propagation as applied to different plants has been very gradual and slow, many of the best methods having been stumbled upon and thus making for the propagator a work full of pleasure instead of one of hardship

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1. Downing's Horticulturist ; Vol. II ; 1847

and uncertainty. As examples, I may cite one or two typical instances ; the propagation of Cydonia Japonica was at one time considered the most difficult and uncertain in results ; today it is one of the easiest shrubs to propagate. The discovery being made through the fact that a propagator discarded a lot of root prunings, and a short time afterwards saw that the greater number of them had taken root. It was not generally known prior to 1880 that Hydrangea could be readily propagated from cuttings, and this fact was discovered by a man who stuck some small stakes, made from its wood, into the ground ; later finding them well rooted. Thus one instance after another might be cited. Suffice to say that at the present time the methods of propagation employed by nurserymen of this country are as welllperfected as those of any other country ; the one great drawback being, that because of the cheapness of foreign labor it still becomes necessary to import each year, thousands of seedling plants which could be produced just as well in this country, did economic conditions permit.

PROPAGATION

For the reproduction of plants nature has adopted various methods, among which are those of seedage, suckers, and natural cuttings. The first two of these methods are quite common ; but with cuttings, there is only one instance in which nature propagates by this method unaided. This is seen in many of the willows which grow in moist places near streams. Many plants not only produce alarge quantities of seed ; but nature has found in addition these other methods above mentioned, by which a species may be perpetuated.

These, however, were found not to be adapted in all cases to the requirements of horticulturists. Hence we have many artificial methods, among the most important of which are cuttings, Budding, Grafting and Layerage. With these and these of nature combined, man has obtained a variety by which plants can be propagated with ease and facility ; each method having its peculiarities and adaptations. The most widely used of these methods as applied to the reproduction of conifers are Seeds, Cuttings and Grafts.

A short discussion of these three methods with the advantages and disadvantages of each, may show their relative value and position in this field.

In propagating trees from seed we at once see that there are certain difficulties presented. By this method, only the species in the abstract is propagated, while by means of the other methods the species is perpetuated with all the habits of the individual parent, especially is this true within the province of grafting. In the case of dioecious trees some other method must be adopted ; because unless both types exist in the vicinity fertile seed will not be produced. It is often the situation that the seed trees may be of a quality from which it is not desirable to propagate ; in such an instance it may be better to propagate from other trees which do not bear seed. The seeds even when produced may be of such a character that they are undesirable for propagating purposes. With some of the conifers one must wait years for the tree to mature, and here too it is far better if, by another method, the species may be perpetuated and increased before the parent plant comes to the stage of maturity. The difficulty of gathering seed in many localities, and the wide variation in the percentage of germination makes this method of propagating, an expensive operation. The great diversity of color and habit which many seedling plants assume, is quite marked. This is seen most strongly in Lawson's Cypress ; but Firs, Spruces and Sequoias show the variation to a less marked degree. Young trees of Abies Nobilis are very apt to produce; at first, a larger number of cones than of male catkins ; hence it has been necessary, in order to obtain seed, to collect

pollen from other trees and use artificial fecundation that fertile seeds may be produced.

After these statements one must not consider that growing from seeds is not a valuable method. Oftentimes the great abundance of seeds, their cheapness, and the ease of gathering make it most valuable to the propagator. In general it requires less trouble and expense to grow from seed, and in the greater number of instances more vigorous and healthy plants are produced. Meehan of Germantown, Pa., grows every tree from seed, which produces seed of the proper quality as a commercial proposition it is by far the best to adopt and encourage.

The great majority of the conifers in the opposite leaved group are grown from cuttings, in this country. The care of cuttings is exacting, and although the greater percentage of them strike root ; yet whenever possible the common types of the genera should be grown from seed. For the perpetuation of varieties with all their peculiarities, the methods of growing from Cuttings and Grafts is unsurpassed. Thus a shoot taken from a weeping spruce and grafted upon the common Norway Spruce, will in general produce a weeping plant. Many of the most beautiful forms of Taxus, Firs, Cypresses and Thuyas have been originally either natural variations selected from the seed bed, or sports perpetuated by grafting the variegated branches upon a plant of the green or normal form of the species. The advantages of growing from these two

last named methods go hand in hand. They may be used to reproduce plants which do not bear seed, those which mature late in life, and those which produce imperfect seed. By cuttings, in rare cases, one may render a monoecious plant dioecious.

The main objects of grafting as applied to the ornamental trees are :

1. The propagation of a variety or species not freely grown by other methods.
2. The increasing of the vigor of delicate species by grafting upon robust, vigorous stocks.
3. Preserving of varieties from degeneration.
4. Adapting trees to different soils by placing upon roots adapted to the soil.
5. Introducting of more than one variety upon the same tree.
6. Rendering dioecious trees monoecious.
7. Making many trees assume very picturesque forms.
8. The exciting of the development of branches, flowers or fruit on parts of a tree where they are deficient.

It is easily seen that the value of all of these methods together is immeasurable. Though no one of them is best adapted to all cases of a particular genus or species ; yet by proper selection of the method, the grower is able to mold the nature of the plant almost at will.

Botanists for their specimensplants with great differences of variety characters, propagate quite extensively by grafting;

while nurserymen use this method only in rare cases where no other exists. Grafted specimens as in cuttings, are often apt not to throw a leader and hence the greater care which they require for proper development.

The methods of propagation as adopted in our commercial propagating establishments differ somewhat from those adopted by botanists ; the former produce plants upon an economical basis and the latter upon an "aesthetic" basis. To the nurserymen the main object is to produce the best specimens possible at a minimum of cost in the expense of production and in the shortest time possible ; the quality of the specimen being often sacrificed to the consideration of cost. The botanist, on the other hand, propagates regardless of cost, by the method, not that will be the least expensive, but which will produce the best specimen of a plant. The differences between the methods adopted by botanists and those adopted by commercial growe may be seen in the table beginning upon page

Some of the important nurseries which propagate conifers to a greater or less extent are as follows :

Andorra Nurseries	Chestnut Hill, Philadelphia
Bloodgood Nurseries	Flushing, L. I.
Flemer and Felmy	Springfield, N. J.
Elizabeth Nursery Co.	Elizabeth, N. Y.
D. Hill, Dundee, Ill.	
Hoopes Bros. and Thomas	West Chester, Pa.
Waukegan Nurseries	Waukegan, Ill.
Thos. Meehan and Sons	Germantown, Pa.
Morrisville Nursery	Morrisiville, Pa.

C U T T I N G S

This method of propagation is the one generally adopted among nurserymen for producing new plants of the species included in the following genera of the Conifers : Cupressus, Chamaecyparis, Juniperus, Libocedrus, Thuyopsis, Thuya and Taxus. It is used quite extensively as a means of producing a large number of the deciduous trees and shrubs, and especially for varieties and rarer forms.

Cuttings of deciduous trees and those of coniferous trees differ strongly as to time of taking, method of making and the subsequent care of the cutting. Those of deciduous trees may be taken,--as green wood cuttings,--in late spring and summer; or as hardwood cuttings at any time during the fall previous to the coming of severe frosts. Those of conifers may be taken, preferably as cuttings of the mature wood, at any time between the months of September and January ; it is seldom the practice to take these cuttings during the spring or early summer.

The method of making the cuttings may be divided as follows :

A. Hardwood Cuttings

Mature wood

1. Cuttings may be made with or without a heel;

generally without, and below a joint.

2. Cuttings eight to ten inches long, wholly bare of leaves.

Green wood

1. Cuttings with or without leaves and leaves trimmed when left upon cutting.

B. Soft Wood Cuttings

Mostly mature wood

1. Cuttings with a heel.
2. Cuttings four to six inches long and leaf surface not taken off.

Cuttings of the hardwood trees are subjected to a callusing process ~~of~~ by burying in sand, which is moist, and keeping in a cool place during the winter months ; those of soft wood trees are kept in a cool house for a few weeks then the temperature is raised as described later in this chapter.

There are two classes of evergreen cuttings : (1) those which are made from the green wood, varying in size from two to four inches long, and (2) those taken from the mature wood, and varying in size from four to eight inches long.

Under these two classes there are various types of cuttings differing mostly in size and the method of treating the top. Cuttings of class (1) rarely have any of the leaf surface removed ; those of class (2) may be divided into two types,-- those with a portion of the leaf surface removed, and those with none removed. There is a wide diversity of opinion among the different propagators as to the relative merits of the

different types and the conditions best adapted to each. Samuel C. Moon of Morrisville, Pa., adheres to a type of cutting, ranging in size from four to five inches long with a portion of the leaf surface removed ; Thomas Meehan of Germantown, Pa., adheres to a type from the mature wood, size four to five inches long and no leaf surface removed ; Wm. Harper of Chesnut Hill, Pa., adheres to a small type of mature or green wood cutting with no leaf surface removed ; Ellwanger and Barry of Rochester, N.Y., adhere to the largest type of cutting, from the mature wood with no leaf surface removed. A discussion of the relative merits of these different types is given later in the chapter under the head of investigational results.

The various methods of making evergreen cuttings as well as those of the hardwood trees are shown in the different plates and described in the legend upon the opposite page. The descriptions of the different kinds of cuttings are readily found in Bailey's "Nursery Book."

It is often the case with many of the Conifers, which are propagated from cuttings, that the cuttings as they develop show a branchlike character and a strong tendency not to form a leader. The following are a few rules which might well be observed in making a selection of the branchlets from which to take cuttings, in general.

1. Cuttings should be taken only from the healthy plants of vigorous growth.

2. Shoots with flower buds should be avoided, if possible, for cuttings. If flower buds are taken they should be carefully removed before the cuttings are planted, because the development of flowers deprives the cuttings of the food material which should go into the formation of new roots.
3. Strong side shoots, with healthy leaves from the best cuttings ; but such as are of the more luxuriant growth should be avoided.
4. In slow growing evergreens choose rather woody side shoots of the mature wood.
5. Select branches, which have been well exposed to the light and air, from which to take cuttings ; interior shoots are very apt to damp off.

The branchlets with the long needle shaped leaves, or the juvenile-form of foliage strike root more easily than those portions with the mature form of leaves. Shoots of Juniperus Chinensis with the long leaves, taken from the lower part of the plant strike root more readily than those cuttings taken from the upper part of the plant.

The time for taking evergreen cuttings varies from the latter part of September to January. They may be taken either before having been frozen or after ; the relative ability to strike roots, of those which have not been subjected to freezing and those which have, is practically the same. Cuttings, however, should never be made when in a frozen condition ;

they should be kept in a warm, moist place for a short time, until they have become thoroughly thawed out, before being prepared for the cutting bed. In preparing for the cutting bed, a sharp knife is one of the first essentials ; and if there is any great number of cuttings to be made, it is best that a pan of water be close by, into which each cutting, as it is made, may be put. Exposure of the clean cut base of the cutting to dry air for even a short time will invariably injure the striking quality severely. If the cuttings after having been made, become for any reason exposed to the dry air for a length of time it is best, before placing in the cutting bed, to drop them into a pail containing luke warm water and allow to remain for a few minutes. They should always, for the best results, be made with a slight heel.[1]

The medium used, in which to strike cuttings is a very clean sand ; however, various propagators advocate brick dust, charcoal and even clay ; in Holland sphagnum moss is used very frequently. The sand used by Moon, the most successful propagator of these trees, is a coarse pit sand which is obtained as clean as possible. For the larger types of cuttings this is best ; but for those of a smaller type the fine sand is more preferable. The depth to which cuttings should be inserted in the sand varies with the size of the cutting ; in general terms the best rule to follow is that of having one-third of the length in the sand and two-thirds out. Cuttings

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1. Bailey's "Nursery Book" (Heel Cuttings)

may be grown in pots, flats or benches. For large nursery lots the shallow flats are much more preferable ; the reasons being as follows : it does not become necessary in the spring to transfer from benches to flats and disturb the roots and also it is much easier to control cutting bed fungous diseases when cuttings are grown in flats. For small quantities, benches are quite satisfactory. The rows should be from four to seven inches apart and the cuttings should be two to four inches apart the distances varying with the size of the cuttings. In some cases borders, out of doors, are used ; but where any degree of success is expected it is necessary to have the conditions of temperature and moisture as much within the control of the propagator as possible.

The success attained with cuttings from these trees depends largely upon the degree of care given them in supplying proper conditions. The ideal conditions for success require that, during the first five or six weeks after the cuttings are placed in the sand the top temperature shall not be so great as to stimulate vegetative growth in the least. During this time a bottom temperature of from 40 to 45 degrees should be maintained and a top temperature ranging from 40 to 60 degrees ; this of course is impossible if the cuttings are taken before the general outside temperature averages close to or below these figures. After this time the condition of the surface of the base of the cutting should be such as to allow a higher temperature. The bottom heat may be raised to about

60 degrees, and the top heat regulated so as to run from 60 degrees at night to even 80 degrees during mid-day when the sun is shining brightly.

We know that cuttings in general die from two causes ; dmying up or rotting before the roots are produced. The whole object of the propagator is to hasten the production of roots and also to arrest the evaporation or decay until the roots are formed. One of the fundamental causes of the rotting of cuttings arises from ruptured cells, and excessive top growth before the base of the cutting has callused sufficiently. The idea of keeping the comparatively low temperature for the first few weeks is to hasten the callusing process, which is the means taken by the cutting to heal over the wounded surface.

After this the roots are emitted readily with the majority of cuttings ; and the cutting can obtain its food from the medium in which it is kept. During this period the cutting bench should be shaded, especially is this necessary during the heat of mid-day. Shading is produced by putting a thin coat of whitewash over the outer surface of the glass immediately over the cuttings. The beds should be watered, until thoroughly soaked, once each week if the weather is bright ; and less often during cloudy spells. In addition to this it is necessary, for the best results, to syringe once during the heat of the day, when the sun gets stronger in the spring ; this should be very light and just sufficient to moisten the surface of the leaves, and hence prevent excessive evaporation

which is detrimental to the formation of roots.

By examining almost any of the plates containing photographs of rooted cuttings, it may be seen that the roots very rarely originate from the callus, as supposed by many. The roots come from the stem just above the callus and hence the natural conclusion is, as stated previously, that this process is simply a healing process. And it is during the formation of this callus that we have the critical point in the life of the cutting. It is then necessary that until this is formed and the roots emitted that the greatest care should be given to the cuttings.

"Callusing is but an evidence that the vital principle of the cutting is healthy and active ; rather than that roots are to be emitted, and it is very probable that the effort made to callus, is to a certain degree, exhaustive, and demanding far more care from the propagator from that time until roots appear, than at any other period of the cutting state."

If made in December or January the cuttings will be well rooted by the first of May ; at which time they may be placed in cold frames out of doors to harden off. Cuttings grown in benches may be transplanted into boxes containing a light sandy loam and kept with the others in the frames during the summer. Before the flats are placed in the frame, it should be partially filled with ashes so that the tops of the cuttings will not be more than six inches from the glass. The frame should be covered with sash during the cooler days of spring and on many

nights, and should also be shaded on very hot days. Many propagators transplant their cuttings into a light soil as soon as they are well rooted, leaving the unrooted ones in the cutting bed until the following year if necessary.

The flats containing the rooted cuttings are left in the frames during the greater part of the summer ; in early fall they are placed in a shed built for the purpose of hardening off evergreen cuttings. This is constructed of 2x3 inch pieces[1] and so built that it supplies the cuttings with sufficient shade, and protection from the winter, to have them ready in the following spring to be transplanted to the baby garden ; this is a plot of ground generally more or less sheltered and in the close vicinity of the propagating house. In order to be perfectly certain that the rooted cuttings will pass through the winter safely it is best to mulch the flats late in the fall with litter, which is removed early in the spring.

Young plants which on farther development show a branch-like character may be benefited by cutting back very strongly, thereby inducing a new leader to form.

The foregoing is a detailed description of the general method of propagating evergreens from cuttings. The propagation of hardwood trees from cuttings varies in many of the minor details, and will be treated under a separate heading.

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1. Chapter on Shading (shed screens)

S E E D S

Collecting and Storing

The method of propagating conifers from seed is in general the most widely adopted method whereby the greatest number of these trees are reproduced, both in this and in foreign countries. The seed may be collected in large quantities from the mountainous regions of the West or from the scattered trees of the East. The time for collecting the seed of both the conifers and the hardwood trees varies widely. Those conifers whose cones open very tardily, an example of which is the Pitch Pine, may have their seed collected during later winter ; while others as Spruces and Firs, need to be collected in the fall as soon as the cones are ripe. The following is a partial list of the conifers giving the time at which their seed should be colledted.

Pinus Strobus	August and September
Paris	September
Picea	September and October
Abies	September and October
Libocedrus	September and October
Thuya	September and October
Juniperus	September and November
Cupresses	September and October

In collecting care should be exercised that the seed are not taken before they are fully ripened. With the conifers the seeds are generally ripe from a week to a month before the cones appear brown, and mature. If there exists doubt in a person's mind as to the ripeness of the seed, from the external appearance, then the most certain method of determining definitely is to cut the cones through at various angles with a knife. The seeds, if ripe, will present a very whitish appearance and their coverings will have a brownish appearance.

The following is an experiment conducted by Nobbe showing the effect upon germinating qualities from the use of unripe seeds.

Spruce seed gathered July 15 gave 5% 0%germination
Spruce seed gathered August 1 gave 40.8% germination
Spruce seed gathered August 15 gave 61.2% germination
Spruce seed gathered September 1 gave 75.3% germination
Spruce seed gathered September 15 gave81.6% germination
Spruce seed gathered October 1 gave 84.5% germination
Spruce seed gathered November 1 gave 88.2% germination

A discussion of this question of the use of unripe seed is given by J. C. Arthur in the "American Naturalist." He says, "That immature seed will grow us by no means a recent discovery; it was known to Theophrastus as early as the third century before Christ. The fact was well established by experiments in 1760, using Ash and Walnut, in 1822 an investigator and propagator despairing of every obtaining ripe seed

from which to propagate a certain Japanese species, took a branch bearing green fruit, not two-thirds grown, hung it up till dry, then planted the seed in a cold frame at the proper time ; from these he obtained a quantity of healthy plants which developed very beautifully. In growing green seed it is a case in which an attempt is made to give the plantlet the conditionssfor continued development without its passing through the full protective tstage. There seems nothing in the nature of things, except lack of skill and care, to prevent the embryo plantlet from being removed from the parent plant at any point in its early development, even before its organs can be detected, and by supplying it with the necessary nutriment,--heat and moisture--and protecting it against the inroads of destructive organisms, securing to it by these artificial means the conditions for uninterrupted growth, with entire omission of the resting period.

With this view it is easy to see why green seed generally give fewer germinations as a rule than mature seed ; the more exacting conditions for its growth are not well met.

In some cases we may get seeds which are over-mature as well as those which are immature. The main points against the use of immature or unripe seeds are :

1. Loss of vigor and thrift in the young plants ; these dying before maturity;
2. Full vigor of plants is never recovered.
3. Reproductive parts are increased at the expense of the vegetative organs.

As regards the age of trees from which seed may best be collected, Mr. J. Alexander in 1870 carried on the following experiment : He collected twenty cones from each of ten different trees whose ages were known ; the cones were carefully opened and all of the seeds of the ten different sorts were sown in different beds,--the results of which were as follows :

300 years old	produced	10 plants
250 years old	produced	13 plants
200 years old	produced	50 plants
150 years old	produced	74 plants
125 years old	produced	106 plants
100 years old	produced	196 plants
50 years old	produced	104 plants
15 years old	produced	46 plants
10 years old	produced	40 plants

It can thus be seen that seed gathered from trees between the ages of 50 and 125 years produce the greatest number of plants.

Among conifers, the scattered trees and those in an open forest are generally more productive of seed than trees which are closely crowded by others. Such trees as Arborvitaes, Larches, Firs and Spruces which have conical tops bear a large quantity of seed at the top, and are hence often quite productive even in dense stands. Cones may best be gathered by picking from the tree before they open ; because at that time

the seeds are quite apt to be lost by the wind. Leaders of such trees as Spruces and Firs should never be sacrificed for the sake of the cones they bear. In such trees permanent injury is very apt to result from decay being admitted at the point of removal, and moreover the leader removed is not always replaced by a lateral top branch turning and growing upwards. The cones may be quite easily collected by a man with a long pole terminated with a hook, with which to pull in the branches. The cones are picked in this way and placed in a canvas bag carried by the collector.

After the cones are collected it then becomes necessary to obtain the seed from them. With the larger number of conifers the cones may be readily opened by spreading them upon a clean, tight floor or in shallow trays arranged one above the other in racks. This drying is usually done in the sun, out of doors, in which case, with such seed as those of Spruce, Fir, Larch, Hemlock, and Thuya, care should be taken to protect from the wind as they are easily blown away by the slightest breeze. When the cones are thoroughly dry the scales will open and the seed be emitted ; sometimes cones are collected and spread upon the floor of a dry, warm room ; here they are turned occasionally for a few weeks, after which time they may be threshed and removed, leaving the seed. It has been the practice to obtain seed from the cones which held them tightly, by the use of cone kilns, which consisted of a wire cloth upon which the cones were spread and a gentle fire

built beneath it ; the cloth being raised about twelve feet above the fire. The cones were stirred frequently during the drying process, until they began to open ; after which they were removed and the seeds gathered up. Cones treated thus are those of the Scotch Pine, larch and some spruces; the heat should never rise above 100 to 120 degrees F. Fleshy seeds, as those of Taxus and Juniper, may be treated as outlined under the heading of Juniperus. If kept until the following spring they should be stratified in medium, moist and fine sand.

There are many seeds which ripen so late in the season that it becomes necessary to store them during the winter months. The seed must be kept in such a condition that their germinating power will be impaired as little as possible. Early maturing seeds which mature before late summer are by far better if sowed immediately than to attempt carying over. These are confined almost entirely to the hardwood group ; the conifers as a rule mature late and must be stored. All conifer seed should be stored by placing in sacks and hanging up in a cold, dry cellar or other building. Such seed should be examined from time to time during the winter to see that they are keeping properly.

Conifer seed vary greatly in size as seen by the table giving the approximate number in a pound ; an idea of the amount of seed produced by different species may be obtained from the following figures taken from the Trans. of High. and

Agr'l Society of Scotland.

Larix	20 bushels of cones produce 112 lb. of seed
Pinus Sylvestris	90 bushels of cones produce 112 lb. of seed
Pinus Excelsa	68 bushels of cones produce 112 lb. of seed
Abies Pectinata	44 bushesl of cones produce 112 lb. of seed

The question of vitality in seeds is an important one in the storage work. There are some seeds which naturally have a more lasting vitality than do others, this is especially true in the case of the hardwood trees and far more pronounced than in the conifers. The seeds of Juniper, Pine and Spruce retain their vitality about the same length of time and naturally are as prolonged as any of the conifer seed. Some of the pine seed kept in their closed cones have been known to give a small percentage of germination when seven to nine years old.[1]

Propagating from Seed

Considering the propagation of trees from the broad standpoint, there is very little difference, in the soil and care necessary, that does not apply equally well to garden seed. If given a medium rich, sandy soil of a moist nature, and within certain limits of temperature, almost any tree seed may be germinated and made to live for a longer or shorter time. There are minor details which do not apply to both ; and which for the best results in the raising of seedling trees are necessary.

The first consideration is that of the seed bed ; this

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1. Bull. 29. U.S. Dept. o Agr.

should be located upon ground which is somewhat higher than adjacent land, and affords good surface drainage, with as little liability to washing as possible. The land best adapted is a well worked field or garden, in preference to new ground. The water supply, proximity to the nursery, and the home, are factors which should be considered before choosing the site for seed beds, and more so if they are to be conducted upon an extensive scale.

The soil preferable for the seed bed should be a sandy loam of a medium degree of richness. A deep, loose, gravelly soil willbe favorable if the finer soil cannot be had ; in case the soil is naturally very poor it may be enriched by adding well rotted manure or leaf mould. The only preparation necessary, if the ground has been under cultivation is a deep spading and a thorough raking. If pasture land is used it will bring better results, to spade or plow the seed bed site during the preceeding fall, to a depth of ten to twelve inches, and if possible spading in a liberal amount of rotted manure. Early the next spring the ground should be again plowed, thoroughly pulverized and raked off level. Too good a preparation cannot be given a seed bed for the best results. The size of the seed bed is of course dependent upon the amount of seed to be sown ; the width should best be four feet. Stakes twelve to fourteen inches above ground are driven in on the upper side of the bed two inches higher than those upon the lower side. Upon the upper part of these stakes are

nailed strips of boards two inches wide and one inch thick. Meehan, one of the most extensive propagators of trees in general, from seed, does not make a frame around the seed beds. The beds are made of varying lengths, four feet wide and stakes are driven upon which to support the shades. This method is simple and answers well for the more hardy seed ; b but in order to guard against the different external influences the method of enclosing the seed bed, for the more delicate seeds is best. For the rarer nand tender species the practice of growing the seedlings in flats, indoors, is common ; by so doing the root system is much strengthened and the young plants withstand transplanting much better.

In the sowing of seed there are two general methods with their variations ; these are known as broadcast and drills. The department of forestry at Washington advocate four methods of seeding, namely : (1) broadcasting over the whole area of the bed, (2) broadcasting in strips six to eight inches wide, (3) sowing in single drills, and (4) sowing in doubc drills. The chief advantages of the broadcast method are that a larger number of seedlings can be grown upon a given area than by any other method ; and it is often the case, especially with broad leaf trees, that such a stand of seedlings may be secured as will choke out the greater number of the weeds which come up. It is, however, seen that the failure of certain seeds to germinate will cause bare spaces in the bed, upon which weeds will grow. The second method named is, for the most part,

but a compromise between the drill and the broadcast theory, and combines to a greater or less extent the individual merits of each. Where the method of broadcasting in strips is adopted, a space of six inches is usually left between the seeded strips to allow cultivation with a narrow rake. The advantages of the drill method of sowing seed are : that the seeds in drills produce plants of greater vigor and more uniform size throughout the bed ; and also facilitate weeding and allow of more easy cultivation which is often very beneficial to the young plants by preventing a rapid evaporation from the soil. The single drills and the couplets of double drills are six inches apart, while the individual rows of the couplets are three inches apart. We may readily see that with the more common seeds which are produced abundantly and possess a good percentage of germination, that upon general principles and from an economical standpoint, it is fully as advisable to adopt the first general method as the second. If the seed possess a high rate of germination it is always better to sow thin and in all cases the expensive conifer seeds should be sown with great care and with economy. Light seeds, such as those of Arborvitaes, Libocedrus, Cypress, and the smaller Pine, Spruce, Hemlock, Fir and Larch seed are very difficult to sow in such a manner that they will not require thinning.

Seed should be sown from early April to the middle of May. The time depends upon the region and climate ; in

general they may be sown in the spring as soon as the soil is dry enough to be easily worked, which time in our Northern states is from the first of April to the twentieth of May. They are best sown when the soil is moist ; never when it is wet, or entirely dry. Seeds which have been stored during the winter in a dry, cool place will do better if sown promptly after being taken from the storage.

The very small seeds should by no means be covered as deeply as the larger ones. The proper depth of covering, when sowed, is important. In general seeds which are sown broadcast are not covered as deeply as those sown in drills. If the covering is too shallow the seeds may be washed out, and if too deep they may rot before germinating, or the seed may not have sufficient energy to push through the heavy covering. Small seed should, as a rule, be covered from two to three times their diameter ; large seeds may be covered twice their depth. It is best after sowing the seed to firm the earth over the seed rows by light rolling, or pressing down with a board. Various kinds of mulching may be resorted to for protection against wind and sun ; the surface of the bed may be kept dampened by mulching with moss, sawdust, or litter from the surface of the ground in the woods. An even supply of moisture in the seed bed will give the highest rate of germination in the shortest time. The aim of the propagator should be to keep the soil just moist and apply water only when it becomes necessary.

The seed with proper care should germinate in from three to five weeks ; however such seeds as Juniper and others are often apt to lie in the seed bed during a year or more before germination takes place. A wide difference exists in the germination[1] of seeds from different localities. Norway Spruce ; White Spruce ; Scotch, Austrian and Mountain Pine ; Colorado Conifers, Picea Pungens and Picea Engelmanni, come up about the same time. Abies Magnifica and Abies Grandis come up at long intervals, the first seed to appear being in April and the last in late summer. Various kinds of Cypress are irregular, as are also Sciadopitys, and Libocedrus. Seed of the native White Pine are the most irregular in germination.

The necessity of an even supply of moisture to the seed bed before germination has been cited ; the same is also true after the seeds have germinated. Seedlings of conifers, as a rule, require less watering than do those of the broadleaf trees. If the natural agencies do not supply water enough, the beds should be artificially watered once or twice a week ; applying the water in quantities sufficient to saturate the soil to a depth of six to eight inches deep. Seedlings should not be allowed to dry out ; on the other hand, for best results, the bed should be closely watched and never allowed to dry enough to give the seedlings the least check. Seed beds should be kept free from weeds and if the drill method is used, the soil should be kept well cultivated between the rows.

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1. R. Douglas ; Garden 1897

The protection of the seedlings during the first winter, in the northern states, is quite essential. Where the seedlings are in rows the most effective protection is to bank on either side of the row with earth ; to protect those sown in the broadcast manner a covering consisting of a foot or more of straw spread over the tops and held down by means of pine boughs is quite sufficient. The methods of shading and transplanting are treated in following chapters.

S H A D I N G

For the best results in the growing of seedlings it is most necessary that the seed bed should be shaded in order to protect the soil from being subjected to too great evaporation, and the tender seedlings from exposure to the blazing sun of mid-day.

In addition to these methods used solely for shading there is another object of fully as great importance ; it is that of supplying protection against the birds. Just at the time when the tender seedlings are appearing above the surface and before they have shed the seed coat the birds have a strong tendency of picking these off and in so doing totally destroying the young plant. Whole beds have been destroyed in a few hours by birds, and hence it becomes necessary to use the screens at this state of development as a means of protection against birds as well as the rays of the sun.

There are various types of shading ; these differing with the facilities, the object sought, and the conditions under which the bed exists.

1. Lath screens. These are most universally used among propagators of both ornamental and forest trees. The screens are four feet square and made of common laths, laid at right angles in a double series. The interstices between the laths

are square and equal in width to a single lath. Such screens are laid horizontally over the beds ; each screen being supported at the corners by posts protruding from a few inches to four or five feet above the surface of the seed bed. Where extensive propagating is carried on, such screens form the most efficient method of protecting and shading the beds. They allow thorough ventilation and confine the shadows to no one portion of the surface ; these changing with the time of the day.

2. Brush screens. These are used quite extensively especially where one desires as little expense as possible and is in the close vicinity of such material. Sometimes the boughs or small branches are laid directly upon the surface of the bed ; but more often they are raised from three to four feet to allow weeding. When laid directly upon the surface of the bed the brush must be removed as soon as the young plants germinate in order to allow of weeding. This method of shading is not as effective as that of lath screens ; the intensity of the shade varying greatly and more or less decayed matter is apt to get upon the surface of the bed.

3. Litter. In places where litter, from the ground beneath forest trees, can be obtained, free from weed seed, etc., it is often used with excellent results. As soon as the seed are sown this litter is spread a few inches in depth over the entire surface of the seed bed, thus wholly protecting the surface against the drying effects of wind and sun.

Immediately after the seedlings begin to show on the surface of the bed this litter is carefully raked away and just a thin covering of clean, dry sand is put over the surface. This also protects the young roots, which are near the surface, from drying out. It often happens that after the litter has been removed, screens of lath or brush are placed over the bed andmany foresters practice the use of both at the same time.

4. Cloth screens. Where the seed are in frames a screen is often used, made of cheesecloth or muslin. A frame is made over the glass, supported by posts and over this is placed the covering of cloth above named. This method is adopted by nurserymen and commercial propagators for shading cutting beds out of doors.

5. Whitewash. The method of whitewashing is the most efficient method of shading cutting beds in a propagating house. When the sun begins to become stronger and the days are warmer, the glass directly over the cutting bed may be subjected to a coat of whitewash. This is sometimes necessary in mid-winter ; its adoption depending upon the hardiness of the cuttings grown, the moisture of the air in the house and the temperature prevailing.

6. There have been other methods more or less used, and mostly of little practical value ; among which are those of covering the surface of the seed bed with cocoanut fiber or moss, to keep the soil uniformly moist.

7. Shed screens. These are built of slats, usually

Immediately after the seedlings begin to show on the surface of the bed this litter is carefully raked away and just a covering of clean, dry sand is put over the surface. This also protects the young roots, which are near the surface, from drying out. It often happens that after the litter has been removed, screens of lath or brush are placed over the bed and many foresters practice the use of both at the same time.

4. Cloth screens. Where the seed bed is small a screen is often used, made of cheesecloth or muslin. A frame is made over the glass, supported by posts and over this is placed the covering of cloth above mentioned. This method is adopted by nurserymen and commercial propagators for shading cutting beds out of doors.

5. Whitewash. The method of whitewashing is the most efficient method of shading cutting beds in a propagating house. When the sun begins to become hot and the days are warmer, the glass directly over the cutting bed may be subjected to a coat of whitewash. This is commonly done in mid-winter; the shading depending upon the [illegible] of the cuttings grown, the amount of [illegible] in the house and the temperature prevailing.

6. There have been other methods mentioned, [illegible] are mostly of little practical value; among them [illegible], or covering the surface of the seed bed with [illegible], or moss, to keep the soil uniformly moist.

7. Slat screens. These are built of slats [illegible]

three inch stuff and vary in size, covering areas from a few square feet to an acre. The object of these is not primarily the same as that of the other methods named ; it is mostly a means by which the tender cuttings may be "hardened off" before being placed in the baby garden. The flats containing the rooted cuttings are set upon the ground under this structure or often on shelves and here they are left from the spring after being struck to the succeeding spring ; generally a period of one year.

These sheds are often very useful and convenient as a place in which to store the flats containing the slower germinating seeds of the more hardy species. This method is practiced quite extensively by Meehan of Philadelphia in hardening off cuttings of the conifers.

As regards the length of time which such shade should be applied to the seedlings, it is generally best to keep the seed beds, containing conifer seedlings, shaded from the time that the seeds are sown until the fall of the succeeding year ; removing the screens only upon cloudy days or during light showers. However, provided the soil in the seed bed is sufficiently moist at the time previous to a shower, the screens may be left on as a partial means of shedding some of the water. With most of the broad leaf seedlings the practice of continuous shading, as applied to the conifers, is not necessary. After the second leaves have appeared such seedlings

are little affected by the sun and may be left unprotected except during the middle of the warmest days.

Conifer seedlings grown in the shade of other trees require little or no artificial protection.

G R A F T I N G

Grafting as applied to conifers has been until recent years an art, the practice of which many of our best propagators avoided. It is, however, at the present time, quite extensively practiced and for many purposes serves better than some of the other methods. At first considered a most difficult feat, requiring skill and practice ; it is now known to be successful, and performed with decided ease and certainty, although it requires more time to complete the union of scion and graft in conifers than in hardwood trees. The treatment of the stocks and scions together with the methods of making the graft are somewhat different from those adopted in the producing of ornamental deciduous trees in the same manner. With the latter the methods vary greatly in different genera ; while the same methods apply generally to all conifers. Root grafting while rarely practiced with conifers, is seen many times in the reproduction of varieties of hardwood trees ; cleft grafting though common in the latter is practiced only rarely with conifers.

The great majority of the grafting performed in this country is that practiced among the nurserymen and botanists. The stocks upon which the grafting is done are mostly of foreign origin. They are imported to this country each year

from foreign countries such as France and Germany ; countries in which labor is cheap and natural conditions are adapted to the work. There is no doubt but that home grown stocks are fully as well adapted to the work ; but the cost of producing such, upon a commercial basis, is so much greater than the net cost of importation, that we see very few plants upon domestic roots.

Seedlings of the common type species are imported at the age of two to three years and immediately potted into four to six inch pots and sometimes larger, if the development of the root system requires. Home grown seedlings may be taken directly from the flats under the hardening off frame and potted in the same manner. The size of these plants, used for grafting purposes, should be such that the diameter of the main stem ranges from one-eighth to one-fourth inches. If the young plants are in a frame out of doors they should be potted during September or October and placed upon a bench in the propagating house, with the temperature ranging from 60 to 80 degrees. All such plants should always be potted long enough before grafting, so that the root system will have become thoroughly well established in the new situation.

The season for grafting conifers is during the time b between the middle of December and the first of March. Many do the grafting between early August and October and many also fail at this time. The cause of failure being due to changeable weather and difficulty of keeping a steady degree of temperature. After the middle of March the union of the stock

and scion is much more difficult to obtain , and it is necessary to take great precaution against external influences, which may lead to failure. Grafting should always be performed under glass for the best results. During the winter months the temperature and moisture conditions of the propagating house may be controlled and kept more constant than during the spring and fall months when it becomes very difficult to control.

The scions, if of the more common varieties, and from trees close at hand, may be gathered at any time during the winter previous to a few days before thetime of grafting and stored in a cool cellar in moss, the temperature being sufficiently low so that growth will not be excited, and still the scions will not be subjected to freezing effects. Scions if received in the fall, may be stored or if necessity urges, they may be at once grafted, great care being exercised with the plants from then on. Commercial propagators prefer, when possible, to gather the scions but a few days previous to the grafting, and, if frozen, see that they are well thawed out before using. The scions are taken from the last summer's growth ; generally being from two to three inches long.

The preparation of the stocks for the operation consists going over all of the plants about two weeks previous to this time and cleansing each plant thoroughly. At the same time any long straggling shoots may well be shortened. The plants may then be placed in the propagating frame, which is a section of a bench covered with sash ; here they are kept rather close

in order to encourage a brisk circulation of the sap. This is most advisable ; however it may be dispensed with, as a preparatory step, if the temperature and moisture conditions of the propagating house are well controlled.

At the time of grafting, the stocks should not be cut down at all, otherwise the flow of sap towards the mutilated portion will be so great as to kill the graft.

The methods[1] adapted to these trees are known as side, veneer and saddlegrafting ; cleft grafting is practiced more with the pines than with the other genera. Side or veneer grafting is best adapted and most universally practiced ; it has the strong advantage over cleftgrafting and saddle grafting, in that if the graft does not take at the first operation, the stock is not destroyed for the season. The operation in such case may be readily repeated upon another side of the stem or a little lower down. This is impossible in cleft grafting, in which case the stock is worthless until the following season. By means of the foregoing method, propagators succeed in uniting from 90 to 95 per cent of the plants.

The mode of making the graft consists ; first in taking a good healthy one year old shoot, from two to four inches long, cut the end off clean and square, and also shave off a piece of the wood about equal in length to the cut made upon the stock. The stock is prepared by selecting a smooth place upon the stem, quite near the surface of the soil, at this point make a clean tangential cut downwards varying in length from one-half to three-fourths of an inch, at its termination

1. Bailey's "Nursery Book" (Grafting)

make a transverse cut, thus removing a piece of the bark wood away from the side of the stock. The butt end of the scion may then be placed upon the notch, exercising care that the bark on one side may exactly coincide along the whole length of the cut.

Cleft grafting may be performed either with the double scion or with a single one. The latter being the more prevalent.[1]

The simplest method used, is that of side grafting performed similarly to inarching. The stock is shaved on the side for a length of one-half to three-fourths of an inch and a similar cut is made upon the scion. The two surfaces are laid together and held in place by means of raffia or grafting wax. After grafting the point of proposed union may be covered with grafting wax if the surrounding conditions are not ideal ; the gene al method being that of binding with raffia or grafting cotton to hold the scion in place.

The grafted plants, for the best results, should be laid upon their sides in a close frame which has been previously prepared by whitewashing thoroughly and putting a few inches of moss in the bottom. They should be shaded from the sun during the first few days and always well surrounded, at the base especially, with moss. The method of covering with moss requires less care to receive the best results. The stocks should be watered after this, only when necessary and watering should be confined to the roots ; care being taken that it

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does

1. Bailey's"Nursery Book"

does not touch the point of union. Any superabundant moisture in the frame may be dried up by raising the cover for a short time each morning. The object of the frame being to give the plants a constant heat and prevent excessive evaporation, without keeping too moist. Union should be complete in from four to six weeks ; at which time a callused appearance will be seen around the point of adherence. After the union is well completed, the top should be shortened back, not too severely ; many failures result from too close heading back. This is especially true in the case of Pines and Spruces which are very susceptible. In about eight weeks the plants may be taken from the frame and placed upon the regular benches in thr ppropagating house. They can now be treated similar to other plants. During the following spring they may be cut back quite closely and set out of doors in a frame ; the following winter they may be wintered in a frame and set into the nursery the next spring. While the binding remains over the base of the graft, care should be taken to see that no ties cut the scion ; ties may be removed as soon as the union is complete.

Following is a list of the stocks used for a few of the more common conifers.

Stock	To propagate
Arancaria Imbricata	Arancaria
Abies pecinata, Abies balsamea	Abies
Picea excelsa, Picea Alba	Picea
Tsuga Canadensis	Tsuga
Taxodium Distichum	Taxodium
Chamaecyparis Pisifera, Chamaecyparis obtusa	Chamaecyparis
Cupressus Lawsoniana	Cupressus
Thuya Occidentalis	Thuya
Juniperus Virginiana	Juniperus
Pinus Strobus, Pinus Sylvestris	Pinus
Taxus Baccata	Taxus
Larix Europea	Larix
Biboedrus is grafted upon	Thuya Sinensis

In general, the golden or variegated forms of Taxus, Cupressus, Thuyopsis, Thuya and Chamaecyparis are reproduced by grafting upon the common and hardier stocks most easily obtained. "Cutting" plants are very seldom used for stocks.

TRANSPLANTING

The operation of transplanting should always be performed with as little exposure of the roots as possible. The very small root hairs, or the feeding cells, upon the roots of the plant perish quickly if left exposed, for even a few minutes to the dry atmosphere. Roots of conifers are particularly sensitive, hence more careful attention should be given to these than to those of broad leaved trees. It is the case of oftentimes that trees of broad leaved species have their roots dried out and yet with proper care revive and live ; with the conifers, once dried, the roots loose all vitality.

The proper season for transplanting young trees is just before growth begins in the spring ; it is then that the seedlings are likely to receive the least injury. In parts of the country where the winter is the only season with abundant rainfall, the transplanting should be done during the rainy season. In our eastern states transplanting in the fall is quite common, though small seedlings should be carefully protected by mulching, in such cases, as a prevention against being heaved out by the frost. Conifers as a rule, with the exception of Larch and Tamarack which are deciduous, may be planted later in the season than broad leaf trees.

It is best to choose a wet or cloudy day for transplanting ; however it often happens that this work must be done at other times. If done in dry weather the nursery beds or trenches should be thoroughly soaked a few days before removing the seedlings. Many conifers as the yellow and long leaf pine, and broad leaf trees with long tap roots, should have the roots pruned in the seed bed. With small seedlings this may be done with a sharp, flat spade or implements designed especially for the work.

It is sometimes necessary, and more so if seedlings are to be transferred any distance, to plunge the roots immediately into a vessel containing a mixture of earth and water of about the consistence of molasses. This is termed "puddling" and the mixture may be prepared in a pail, tub or a barrel. By this method the roots are covered entirely and subjected to drying effects of wind and sun prove very little injurious to them.

With the conifers, where the seed are sown either broadcast or otherwise in beds, it becomes necessary to transplant the greater number of the young seedlings to the "baby" garden when they are from 1 to 2 years old. This enables the young plants to establish a larger root growth and to be far better adapted to permanent setting out. When the seedlings are taken from the seed bed they should be dipped in a puddle and if delay is necessary, they should be laid, roots together in small piles of 50 to 100 and covered with wet blankets ; the

more tender ones should always be transplanted without delay, the roots being kept in pans of water.

Coniferous seedlings, as a rule, should be set four inches apart in the rows and broad leaf seedlings, six inches apart. The rows should be two to two and one-half feet apart, and all plants should be set one to two inches deeper in the rows than they were in the seed bed.

Trees, like oaks, walnut, elm, and catalpa, which form long fleshy roots during the first season should have the root severely pruned before setting in the nursery, while seedlings with short, fibrous roots need little or no cutting back. Seedlings of many of the more common and hardier broad leaf trees are often taken from the seed bed in the fall and stored in bundles in cool, dry cellars in which the temperature is constantly a little above freezing. Here they are stored, until in January or February when time permits, they are taken into the propagating shed, thoroughly overhauled, tops and roots pruned and sorted as to sizes. They are then tied into bundles of 100 and again placed in storage until the weather will permit transplanting into nursery rows in the early spring.

In case no rain falls within ten to twenty days after seedlings have been placed in nursery, water should be applied to the rows. It is best to water after setting out if convenience will allow.

The foregoing statements apply as well to the transplanting of cuttings into nursery rows as to seedlings. The treatment of cuttings will be discussed in another chapter.

Table Showing the approximate per cent of Germination of the seed of many of our important trees.

Name of the Species	Percentage of germination in fresh seed
White Pine	70 to 80
Pitch Pine	60 to 85
Scrub Pine	50 to 80
Longleaf Pine	50 to 70
Tamarack	50 to 75
Black and Red Spruce	60 to 75
Common Spruces	50 to 75
Hemlock	50 to 60
Balsam Fir	30 to 50
White Fir	40 to 55
Bald Cypress	25 to 50
Incense Cedar	40 to 65
Arborvitae	50 to 75
Pacific Arborvitae	50 to 75
Lawson Cypress	25 to 40
Red Juniper	50 to 75
Walnut	75 to 80
Butternut	75 to 80
Hickories (common species)	50 to 75
Birch	65 to 80
Beech	75 to 95

Name of Species	Percentage of germination in fresh seed
Chestnut	75 to 95
White Oak	75 to 95
Burr Oak	75 to 95
Chestnut Oak	75 to 95
Red Oak	60 to 80
Slippery Elm	50 to 75
White and Cork Elm	50 to 75
Hackberry	70 to 80
Red Mulberry	75 to 90
Osage Orange	60 to 95
Tulip Tree	5 to 10
Sweet Gum	50 to 75
Sycamore	60 to 75
Black Cherry	75 to 80
Honey Locust	50 to 75
Kentucky Coffee Tree	50 to 75
Sugar Maple	30 to 50
Red Maple	25 to 60
Silver Maple	25 to 60
Box Elder	40 to 60
Ash	35 to 50
Catalpa	40 to 75

Approximate height attained by seedlings in one year

Name of the species	Approximate height in inches
White Pine	2.5 - 3.5
Red Pine	2 - 3
Scotch Pine	2 - 4
Tamarack	2 - 3
White Spruce	1.5 - 2.5
Black Spruce	1.5 - 2.5
Blue Spruce	1.5 - 3
Engelman Spruce	2 - 3.5
Red Fir	3 - 4.5
Hemlock	2 - 3.5
Arborvitae	1.5 - 2.5
Incense Cedar	2 - 3
Lawson Cypress	1.5 - 2.5
Red Juniper	2 - 3.5
Oak (White, Chestnut, Post, Burr)	5 - 9
Oak (Red, Black, Scarlet, Pin)	6 -12
Ash	6 -10
Walnut (Juglans)	10 -14
Hickory	6 - 9
Elm (American, Corked)	5 -10
Slippery Elm	10 -18
Hackberry	6 -12

Approximate Weights (Measured by an Optical Balance)

Name of Item

Wheat Flour . . . . . - 1.5
Red Rose . . . . . - 3
Cocoa Puff . . . . . - 4
Cheerios . . . . . - 5
White Sugar . . . . . - 2.5
Black Sugar . . . . . - 1.0
Blue Berry . . . . . - 2
Whole Wheat Bread . . . . . - 3.
Red Tea . . . . . - .
Hotdog . . . . . - 3.5
Applesauce . . . . . - 2.0
Tomato Juice . . . . . - 3
Lemon Cookie . . . . . - 3.5
Red Jumper . . . . . - 3.
Oil (Fish, Chemical, Motor) . . . . . - 9
Gas (Red, Blue, Green, Yellow) . . . . . -12
Ash . . . . . -10
Wet Mud (Used Car) . . . . . -
Hockey . . . . . -
Egg (Duck, Goose) . . . . . -20
Alphabet . . . . . -
Hamburg . . . . . -

Name of the species	Approximate height in inches
Mulberry	8 - 10
Black Locust	18 - 20
Honey Locust	6 - 14
Kentucky Coffee Tree	6 - 12
Birch	3 - 8
Black Cherry	8 - 14
Sugar Maple	6 - 12
Red Maple	6 - 10
Silver Maple	12 - 20
Box Elder	10 - 14
Basswood	6 - 12
Hardy Catalpa	14 - 20

TABLE I

Table showing the number of tree seed per ounce and pound, and also the approximate number of linear feet of seed drill covered by each quantity.

Name of species	Number of seeds in 1 ounce	Number of seed in 1 pound	Approximate number of linear feet of seed drill covered by 1 ounce	Approximate number of linear feet of seed drill covered by 1 ounce
White Pine	1,800	28,800	36	576
Red Pine	4,700	75,180	75	1,200
Bull Pine	100	1,600	16	256
Scotch Pine		64,000	60	960
Norway Spruce	4,780	76,480	75	1,200
White Spruce	10,000	160,000		
White Fir	610	9,760	10	160
Balsam Fir	2,500	40,000		
Bald Cypress	320	5,120	20	320
Red Juniper	1,310	20,960	40	640
Hemlock	6,666	100,000		
Incense Cedar	1,260	20,160	35	560
Larch	4,375	70,000		
Lawson's Cypress	6,400	102,400	40	640
American Arborvitae	20,000	320,000		
Butternut	1( )	16		4
Black Walnut	2(-)	30		8

Name of species	Number of seeds in 1 ounce	Number of seed in 1 pound	Approximate number of linear feet of seed drill covered by 1 ounce	Approximate number of linear feet of seed drill covered by 1 ounce
Shellbark Hickory	6	80		14
Chestnut	6	98		17
Black Locust	1,810	28,960	60	960
Honey Locust	200	3,200	16	256
Hardy Catalpa	1,230	19,680	60	960
Osage Orange	820	13,120	30	480
Green Ash	1,020	16,320	25	400
White Ash	640	10,200	25	400
Black Ash	380	6,100	16	288
Box Elder	920	14,720	26	416
Sugar Maple	470	7,498	20	320
Scarlet Maple	140	2,240	50	800
Black Cherry	279	4,464	20	320
Basswood	397	6,352	15	240
American Elm	5,820	93,120	125	2,000
Slippery Elm	3,398	54,368	80	1,280
Birch	30,116	481,856	750	12,000

Note. (L) About 50 percent of the bulk of the Cypress seed in the trade consists of refuse shells of cones to a great degree.

Table showing the range of the listed market price per pound, for some of the seed of trees.

Name of species	Cost of the seed per pound
Black Spruce (Picea Rubens)	$3.75-$4.00
White Spruce (Picea Alba)	3.75- 4.00
Engelman's Spruce (Picea Engelmanni)	3.00- 8.00
Blue Spruce (Picea Parryana)	2.00- 6.00
Douglas Spruce (Pseudotsuga Douglassi)	2.50- 4.50
Balsam Fir (Abies Balsamea)	1.25- 3.00
Noble Fir (Abies Nobilis)	3.00- 5.00
White Pine (Pinus Strobus)	1.50- 3.00
Sugar Pine (Pinus Lambertiana)	2.00- 2.50
Hemlock	3.50- 6.00
Jack Pine	7.00-12.00
Lawson's Cypress (Cupressus Lawsoniana)	3.75- 4.00
Red Cedar (Juniperus Virginiana)	.50- .75
Arborvitae (Thuya Occidentalis)	2.00- 2.25
Giant Arborvitae (Thuya Gigantea)	3.00- 4.50
Incense Cedar (Libocedrus Decurrens)	3.00- 4.50
Larch (Larix)	12.00- 16.00
Big Tree (Wellingtonia)	4.00- 6.00
White Oak (Quercus Alba)	.10- .25
Burr Oak (Q. Macrocarpa)	.20- .25
Red Oak (Q. Rubra)	.20- .25
Shellbark Hickory (Hicoria Glabra)	.15- .20

Name of species	Cost of the seed per pound
Beech (Fagus)	$.50-$ .75
Black Walnut (Juglans Nigra)	.10- .15
Butternut (J. Cinoria)	.10- .15
White Ash (Fraxinus Americana)	.50- .60
Blue Ash (F. Quadrangulata)	1.00-1.50
Black Ash	.75- 2.00
Sugar Maple (Acer Saccherinum)	.75- 1.00
Red Maple (Acer Rubrum)	1.25- 1.75
Box Elder (Acer Negundo)	.35- .50
White Birch (Betula Alba)	1.50- 2.00
Yellow Birch (B. Lutea)	1.50- 2.00
American Elm (Ulmus Americana)	1.00- 1.50
Cork Elm (U. Racemosa)	1.50- 2.75
Catalpa (Catalpa Speciosa)	.50- 1.25
Black Locust (Robinia Pseudacacia)	.50- .75
Honey Locust (Gleditschia)	.40- .60
Sweet Gum (Liquidambar Styraciflua)	2.50-3.00
Tulip Tree (Liriodendron)	.40- .50
Cucumber Tree (Magnolia)	1.00- 1.50
Osage Orange (Toxylon)	.25- .30
Black Cherry (Prunus)	.40- .60
Allanthus (Tree of Heaven)	.25- .50
Holly (Ilex)	.75- 1.25
Basswood (Tilia)	1.00- 1.25
Sycamore (Platanus)	.50- .75
Hackberry (Celtis)	.75- 1.00

Table showing length of year's growth as seen in Conifers which were ten to thirty-five feet high ; measurements were taker at the end of the month of October.

	Feet		Inches
Araucaria imbricata	2		3
Abies nordmanniana	2		5
Cedrus	2		10
Cupressus macrocarpa	6		0
Cryptomeria	3		0
Juniperus Chinensis	2		6
Pinus excelsa	4		3
Pinus Gambertiana	2		10
Sequoia sempervirens	4		8
Thuja	1	to	3
	4		6
Thuyopsis	2		3
Wellingtonia gigantea	5		9

ACANTHOPANAX

This shrub is propagated most easily from seed.

It is also propagated by root cuttings and by hardwood cuttings. The root cuttings are made similar to those of Cydonia Japonica, in sections two to four inches long, and buried in flats containing medium coarse sand. Hardwood cuttings are taken in September or October, allowed to callus during the winter and planted in a light soil in the following spring.

ACER POLYMORPHUM (JAPANESE MAPLE)

These trees are most easily grown from the seed, similar to the manner in which the common maples are grown. The finer forms are obtained with the greatest ease and certainty by budding and inarching upon the common varieties.

Inarching is performed in the spring in the field, and in September and October after the two are well united the new plant is separated from the old and as the stocks are generally grown in pots ; these are then placed in a pit or cold house where they are stored until the following spring. After this time the plants are ready for the nursery rows and may be treated as the more common stock.

ACER (MAPLE)

These trees are propagated by sowing the seed soon after they are ripe, in an open seed bed and covering with from

one-half to three-fourths inches of fine earth, of a light, sandy nature. There exists a variation in the time of ripening of seeds of different species. Those ripening their seed in the fall, September and October, are : the Sugar Maple, the Pannsylvania Maple, the Mountain Maple and the Sycamore Maple; those ripening their seed in May and June are the Silver Maple and the Red Maple.

Seed sown in the fall should be covered more deeply than those sown in the spring. The seedlings of fall sown seed will appear the following spring and if kept free from weeds will atain a height of twelve to eighteen inches during the first summer. In the following spring the greater number of the seedlings may be removed and transplanted in the nursery rows, in which place they are to remain for three or four years, when the will be large enough to plant out permanently.

Maple seed are not so easily preserved as many seed, hence the necessity of sowing as soon as possible after they are ripe.

Maple are often grafted, although this practice is much more common with theJapanese than with common, more hardy kinds.

ACER NEGUNDO (BOX ELDER)

These trees are best propagated from seeds sown in nursery seed beds. The seed are ripe in early autumn, which can usually be gathered very easily. They may be gathered as

soon as ripe and planted in the seed bed, or if preserved until spring they should be stratified in sand during the winter. It is often the case that one finds a tree apparently loaded with fruit among which is to be found scarcely a vital seed.

The seed should be sown best in rows two to two and one-half feet apart and ranging from one to five inches in space, three-fourths to one inch deep. The bed if well cared for and thoroughly cultivated should produce seedlings which will attain a height of ten to fourteen inches during the first season. The young plants require no shading.

A C T I N I D I A

These plants are most readily propagated by means of cuttings either of the mature or the green wood. They emit roots easily and freely ; but the buds push out very slowly and often fail, leaving the cutting to die although having a large number of roots. The cuttings of either type may be placed immediately in the cutting bed or if in no hurry for young plants, they may be stired during the winter in sand to callus with the other hardwood cuttings.

By nurserymen the method of layering is quite frequently practiced.

AESCULUS (HORSE CHESNUT)

These trees are propagated almost entirely from seed. The large nuts should be gathered in the fall as soon as they drop from the trees, and either sown, or stratified in sand until the following spring. They should be stored in a cool, dry cellar for best results, until the spring. The nuts are sown in the same manner as all the nuts of this class. Seedlings one year old may be removed to nursery rows.

Varieties of the various species are obtained by grafting, usually upon A. Hyppocastanum, the most common species. The method of grafting is generally that of veneer grafting and inmost instances, for the best results, is performed under glass.

AILANTHUS (TREE OF HEAVEN)

These trees are propagated from seed, gathered in the autumn and preserved until spring, at which time the, are sown in nursery seed beds.

It is often desirable to obtain pistillate specimens of this tree as the flowers on male specimens possess a decidedly disagreeable odor. This is done by growing from cuttings of the roots ; which method is similar to that adopted for Cydonia Japonica.

A K E B I A

This shrub is readily propagated from cuttings of the

green wood, placed in medium coarse sand under glass.

In large nurseries it is grown from layering, either the old or the young shoots.

ALNUS (ALDER)

The species of this are readily propagated from seed, which are gathered in the fall, and preserved in a dry, cool cellar until spring. Seeds are sown on the surface of the seed bed, pressed down and covered very slightly with a light soil. The bed should be kept moist until the seedlings begin to germinate.

Varieties are propagated by grafting upon the more hardy and common stocks, Alnus Glutinosa is often used as a stock.

AMELANCHIER (JUNEBERRY)

These shrubs and trees are propagated from seed which ripen in early summer and may be sown in the fall or preserved until the following spring.

They are also grown by grafting in the early spring upon the Mountain Ash, and the more common stronger growing species of the genus.

AMORPHA (INDIGO SHRUB)

Propagated from seeds, and very seldom by the other methods, although in a few cases it is grown from green wood cuttings under glass, and from hardwood cuttings taken in the fall.

AMPELOPSIS (VIRGINIA CREEPER)

The most common method of propagation is that of seeds, sown in the spring. It is also quite readily grown from cuttings of the mature wood made below a joint, taken in August, September or October. The method of layering is frequently practiced, by slightly burying the stem in a number of places ; roots are emitted at the joints quite freely.

A R A L I A

Aralia is most easily propagated from seeds ; these should be sown in early spring upon a light soil generally in seed beds. The seedlings should not be distirbued during the first season. They are also propagated by root cuttings.

ARISTOLOCHIA

These plants are propagated from cuttings of the green wood, grown under glass, with bottom heat. They may also be propagated from seeds, if fresh, and sometimes from layers ; the last methods are nearly as satisfactory as the first.

A R O N I A

This is propagated mostly from seed ; however it is often also grown from cuttingsoof the green wood and from grafts.

A U C U B A

All the species of this genus may be readily propagated from cuttings of the green wood or from seeds. The berrylike

fruits rarely germinate until the second year after sowing. Sometimes few plants make their appearance during thefirst year, and the berries continue to germinate for three years if left alone.

These plants are dioecious, hence in many instances seed are not produced at all and the method of growing from cuttings or grafts must be used.

A Z A L E A

This genus is propagated mostly from cuttings of the mature wood, made during the late summer, in September.

When reproduced from seed, the should be sown as soon as ripe, as early in the following spring and covered but very slightly. The seeds, because of their tenderness should be sown in a frame ; the sash being removed after the seeds have germinated.

Grafting is used on named varieties ; the stocks used being those of A. Indica or A. Ponitca.

BENZOIN (SPICE BUSH)

This genus is propagated best from seeds which may be gathered in the fall and stratified until early spring.

BERBERIS (BARBERRY)

These plants are most easily propagated from seeds sown soon after the fruit matures ; or the seed may be stratified

and sown in the spring.

The evergreen species may be grown from cuttings, taken in September and placed in sand, under glass.

Many of the deciduous species can be reproduced from cuttings of the mature or green wood. Rarer sorts are often grafted upon the common stocks.

Layering the common species is also practiced ; the best time for this work being in autumn when the leaves begin to fall, using young shoots of the current year's growth. These will be rooted by the following autumn and may then be removed from the mother stool.

BETULA (BIRCH)

The birch is most readily propagated from seeds sown as soon as ripe, or in the early spring ; seeds being preserved in bags in a cool, dry place.

The purple, cut leaved, weeping, and other forms of the birch are readily produced by grafting upon the type species.

BIGNONIA (TRUMPET VINE)

These plants are increased from seeds or layering ; the former being preferable. Bignonia Radicans is easily propagated from root cuttings.

CALLICARPA

These plants are propagated from seeds, most easily.

They may also be grown from green wood cuttings in the summer under glass and also from hardwood cuttings taken in the fall.

CALYCANTHUS (SWEET SHRUB)

Propagated from seeds sown in the spring, in a frame or from layers which should be put down in the summer. It is also grown well from root cuttings.

CARAGANA (SIBERIAN PEA TREE)

Propagated most easily from seeds, sown when ripe in the fall, or preserved until spring.

It is also grown by means of grafting upon the seedling stocks of C. Arborescens.

CARPINUS (HORNBEAM)

These trees are propagated from seeds, gathered in the fall and either sown then or in the spring. These germinate very irregularly.

Varieties are propagated by means of grafting ; the stocks used being those of Carpinus Betulus and the American species.

CASTANEA (CHESTNUT)

Chestnut is propagated most easily from seed. Buts are borne quite freely, at least every other year ; thus it is an easy matter to obtain seed. These should be gathered when

ripe in the fall, after frosts, and stratified in moist sand through the winter. They should not be allowed to dry out or become mouldy in the sand. If placed in single layers between alternate layers of moist sand, in a large box, out of doors in a sheltered place the seed will winter safely. The nuts are planted one to two inches deep, and during the first year they will attain a height of ten to fifteen inches.

These trees are often grafted using the common species as a stock.

C A T A L P A

These trees are propagated from seeds, which may be sown in the fall when ripe or stratified. After one year the seedlings may be transplanted.

They may also be increased by means of grafting ; the stock used being that of C. Speciosa.

C E A N O T H U S

Grown from seeds, stratified during the winter ; layering is also a very easy method of obtaining new plants.

C E L A S T R U S

This genus is readily propagated from seeds, which should be stratified in moist sand during the winter. It may also be increased very easily from cuttings of either the green or mature wood.

CELTIS (HACKBERRY)

These trees bear seed quite freely and may be propagated by this means. The fruit is a drupe about the size of a pea. The thin, fleshy covering around the stone dries down and need not be removed before planting. These seed ripen in the fall and may be sown at once. However, if spring sowing is preferred, the seed should be stratified in sand during the winter, out of doors in a sheltered place. The box when filled with seed may be covered with a wire screen to keep out the mice, and also mulched to prevent sudden changes in temperature.

Seed should be sown in drills in good, rich soil and covered about an inch deep. If there is danger of the seed drying out before germination takes place then they should be covered from one to three inches deeper until this time, when the surplus covering of soil may be raked off. Seedlings may stand in the nursery two years before transplanting.

CEPHALANTHUS

Propagated most readily from seeds, also from cuttings of the mature wood.

CERCIDIPHYLLUM

The easiest method of propagating these trees is from seeds, when they are to be obtained.

Propagating from cuttings of the green wood and by layering is often practiced. Cuttings of the green wood are said

to do best if slightly wilted before placing in the sand.

CERCIS (RED-BUD)

These trees are propagated most easily from seed, which may be stratified during the winter. Plants raised from seeds give the best results. If not stratified the seed should be kept in a cool cellar. Layerage and grafting are also practiced with these trees.

CHIONANTHUS (FRINGE TREE)

Propagated from seeds which may be sown in the autumn as soon as ripe ; they may also be started in a frame. Varieties are increased by grafting upon the common ash.

CLADRASTRIS (YELLOW WOOD)

Propagated from seeds which may be sown in the fall or spring. Growing by means of hardwood cuttings is sometimes practiced.

C L E M A T I S

This vine is most easily propagated from seeds ; which may be gathered as soon as ripe, in the autumn ; and stratified withe following spring. All the varieties of this plant may be increased from cuttings of the green wood, under glass. Root grafting is practiced occasionally.

COLUTEA (BLADDER SENNA)

Propagated from seeds, sown in the spring and from hard-wood cuttings taken in the fall.

CORNUS (DOGWOOD)

These shrubs are easily propagated from cuttings of the mature wood, taken in the fall. This is the method most generally adopted. With the finer varieties and rarer sorts the method of grafting is adopted ; the more common species being used as stocks. Such species as Cornus Florida are easily increased from seed.

CORYLUS (HAZLENUT)

Propagated from seeds sown in the fall or stratified until spring. Also increased by means of root grafting and layering. The varieties are mainly grown from layers put down in the fall ; and may be separated from the parent plant the next fall.

CRATAEGUS (HAWTHORN)

Propagated most easily from seeds. The fruit should be gathered when ripe and the pulp allowed to rot off by laying in a heap out of doors. The seeds sremain dormant, tusually for a period of from one to two years ; hence after removing the pulp the seeds can best be stratified for a year. Seeds, when sown, should be covered to a depth of two inches and the

bed may be kept well mulched during the first summer after sowing, in order to prevent drying out. Seedlings may be transplanted to the nursery rows when one year old. Varieties are grafted upon or budded upon the common stocks.

CYDONIA (JAPAN QUINCE)

This shrub is readily propagated from cuttings of the roots, made in lengths of from two to three inches. This method is of comparatively recent origin and is almost the only method now adopted for increasing this shrub. Cuttings of the roots are made and placed in the sand to a depth of two or three inches. This sand is kept moist and within a period of eight to ten weeks these will be well rooted.

Cydonia is also grown to some extent from seeds.

D E U T Z I A

Propagated very easily from cuttings, either of the green or mature wood. Mature wood cuttings may be taken in the fall ; green wood cuttings are taken in the summer and grown in a house.

DIERVILLA (WEIGELIA)

Propagated from cuttings of the mature wood, taken in the fall. Cuttings of the green wood are grown under glass.

D I R C A

These plants are propagated almost exclusively from seeds.

E L A E G N U S

Propagated from seeds, sown in the spring. Also increased from cuttings of the mature and green wood. Many of the seeds are often sterile and in such cases they may be sown more thickly than ordinarily.

E P H E D R A

propagated from seeds and also from root cuttings.

EUONYMUS (BURNING BUSH)

propagated from seeds, which are generally stratified and sown in the spring. It is also grown from cuttings. Evergreen species grow readily from cuttings of green wood, placed under glass. Varieties are sometimes grafted upon the stronger and more common species.

E X O C H O R D A

Propagated from seeds, which are produced only upon old plants. Until recently this plant was considered difficult to propagate. It may also be increased from cuttings, which root slowly, and by layering.

FAGUS (BEECH)

Beech trees produce an abundant crop of nuts every two or three years; these nuts ripen in the fall and drop soon after the first severe frost. If allowed to dry out, they become

rancid and lose all vitality. To prepare them for planting they may best be stratified during the winter. Before the nuts are stratified they may be fumigated with carbon bisulphide to kill the worms which often infest them. In the spring as soon as the frost is out of the ground the seed should be planted in the seed bed, from which the seedlings may be transplanted when one year old. The nuts should be sown about two inches apart in rows and will sprout in a very short time.

The named varieties are grafted upon the European or American Species. With the purple beech seedlings, one may see different shades of purple among the seedlings.

FICUS (RUBBER TREE)

These trees are propagated from cuttings of the mature wood. These cuttings are often placed in warm water for a short time, after which they are placed in the cutting bench. Another method is that of cutting a piece of bark from the tip of a branchlet and then tying sphagnum over the wound, always keeping it moist until the roots are emitted; the branchlet may then be cut from the parent and, removing the moss, be potted in a light soil.

FONTANESIA

Propagated from cuttings of the green wood, grown under glass with bottom heat. Also increased by means of cuttings

from the mature wood, and by grafting upon privet stock.

FORESTICPA

Propagated from seeds and by layering.

FORSYTHIA (GOLDEN BELL)

Propagated almost exclusively from cuttings of the green wood, with bottom heat ; also increased from hardwood cuttings. The branches of F. Suspensa sometimes root at the tips, where they come in contact with the ground.

FRAXINUS (ASH)

These two are most easily reproduced from seed, which are produced abundantly about once in three to five years. The fruit ripens in October and may be sown as soon as gathered or preserved for spring planting by stratifying in moist sand. Care should be exercised in keeping seeds over, because the vitality of the seeds cannot, with certainty be preserved for more than eight months.

Broadcast sowing of ash seed upon prepared seed beds is best. Since the percentage of germination is very low, they should be sown quite thickly and covered about one-half of an inch. The seedlings may be transplanted when one year old.

Named varieties are budded upon seedling stocks if the sorts are upright growers, and top grafted if they are of the weeping type. The stocks used are the European and American species.

GINGKO (MAIDEN HAIR TREE)

Propagated from seeds, which should be stratified during the winter and sown the following spring. The fruit is fleshy, and this may best be cleaned from the seeds before they are sown. This tree is also grown from cuttings and by grafting upon the common stocks.

GLEDITSCHIA (HONEY LOCUST)

The Honey Locust produces seed abundantly and is very easily propagated. The pods ripen in the fall, and after becoming brittle and dry, the seed may be threshed out without difficulty. Seeds should be kept in dry, cool storage over winter, and swelling them in hot water just previous to the time of sowing is a good practice. Seeds which have become very dry may require a soaking for two or three days. They should then be sown in light soil, and covered from one to two inches deep. Seedlings should be transplanted in one year ; but in case the season is very unfavorable for growth they may be left in the seed bed a second year.

Varieties are propagated by grafting upon seedling stocks of the type plants.

GYMNOCLADUS (COFFEE TREE)

Propagated from seeds which are of a very hard bony nature. These do best if soaked in warm water for a few hours before sowing, or the covering may be filed, to hasten germination.

HAMAMELIS (WITCH-HAZEL)

Propagated from seeds sown in the spring ; varieties may be grafted upon common American species.

HEDERA (IVY)

Propagated from cuttings of the green wood, grown under glass ; also grown from mature wood cuttings. Named varieties are often grafted upon seedlings or cuttings of the common ivy H. Helix.

HIBISCUS (ALTHEA)

Propagated from cuttings and seeds. The single forms by the second method and the double forms by the first. Cuttings are made of mature wood, taken with a slight heel. Seeds should be sown in the spring upon a well prepared seed bed.

HICORIA (HICKORY)

Propagated from seeds which may be gathered as soon as ripe, in the fall. These should be stratified until spring and sown to a depth of two to three inches. Hicoria is often increased by grafting under glass upon common stocks. The methods adopted are veneer or cleft grafting.

HIPPOPHAE (SEA BUCKTHORN)

Propagated from seeds sown in the spring, and stratified during the winter. Also increased from cuttings of the mature wood and of the roots.

H Y D R A N G E A

Propagated from cuttings of the green wood, grown with bottom heat and also equally well from cuttings of the mature wood taken in the fall. Commercial propagators grow these plants by layering in the summer and cutting away from the parent plant the following spring.

H Y P E R I C U M

Propagated from seeds sown in the spring, and also from cuttings of the green wood.

ILEX (HOLLY)

Propagated from seeds which should be stratified during the winter, and sown in the spring. The fleshy seed coat is often removed by rubbing in moist sand, and washing. Seeds generally require two years for germination. Varieties are increased by veneer grafting upon the common stock.

JUGLANS (WALNUT)

Propagated the same as the Hickory (see Hicoria)

K A L M I A

Propagated from seeds which should be sown in shallow pans, for best results and reared under glass until the seedlings are large enough to be transplanted out of doors. Varieties are grafted upon the more hardy stocks.

K E R R I A

Propagated from seeds and cuttings of the green wood ; also to some extent from root cuttings. It may be increased from cuttings of the mature wood ; but green wood is preferable.

KOELRENTERIA (VARNISH TREE)

Propagated from seeds which are produced freely, and ripen early. These may be sown in the fall or spring. Also increased by cuttings and sometimes from layers. The last named methods are rarely used.

LABURNUM (GOLDEN CHAIN)

Propagated from seeds, which are sown in the spring. Grafting is adopted for producing the varieties.

L E P A G E R I A

Propagated from seeds and also from cuttings of the green wood taken in summer.

LIGUSTRUM (PRIVET)

Propagated almost equally well from cuttings or seeds. Seeds may be sown in the spring. The general practice is to grow from cuttings of the mature wood taken in the fall.

LIQUIDAMBAR (SWEET GUM)

Propagated from seeds which may be stratified during the winter and sown in the following spring. Many of the seeds do not germinate until the second year.

LIRIODENDRON (TULIP TREE)

This tree is propagated from seeds, which mature in the fall and may be sown as soon as gathered or stratified for spring planting. Stratifying in the fall is advisable, since the seeds will then germinate the following spring. Sometimes when sown in the spring they are very apt not to come up until the following spring. The seed should be sown thickly in a bed of light rich sandy soil, and covered to a depth of one-half of an inch. Seedlings may remain in the seed bed from one to two years ;but not longer because of the great development of the tap root.

Named varieties are grafted upon seedlings. The seeds of this tree possess an extremely low percentage of germination.

LONICERA (HONEYSUCKLE)

Propagated from cuttings of the mature or of the green wood, rarely from seed. Seeds when used should be cleaned of their pulp by macerating. L. spinosa is sometimes grafted upon the stems of L. tartarica, thus forming a small weeping shrub.

LYCIUM (MATRIMONY VINE)

Propagated from seeds and from cuttings of the mature wood. Seeds should be sown in the spring.

M A G N O L I A

Propagated very readily from seeds, which should be sown in the spring. When the covering of the seed is pulpy this should be cleaned off before sowing. Varieties and weaker species are grafted upon the hardier stocks such as M. acuminata. Cuttings are but very seldom used.

MENISPERMUM (MOON SEED)

Propagated from seeds sown in the spring, and also from root cuttings.

MORUS (MULBERRY)

These trees bear fruit abundantly ; the seed may be separated by macertaing, and washing the seed. After drying the seed should be kept in a cool, dry place until a week or ten days before the time of sowing. In some cases the seeds may be sown as soon as ripened ; but the better practice is to wait until the following spring so that the seedlings will have an entire season during which to grow before the coming of cold weather. The seed should be sown about one-half of an inch deep, and will germinate in ten to fifteen days. Seedlings may be transplanted after the first year.

Fancy varieties are commonly crown worked under glass during the winter. Weeping and other ornamental sorts are worked upon the Russian type.

NYSSA (SOUR GUM)

Propagated from seeds which may be sown as soon as ripe, or stratified ; they usually do not germinate until the second year.

OSTRYA (IRON WOOD)

propagated from seeds which may be sown in the spring. The European species are grafted upon Carpinus Betulus.

OXYDENDRUM (SOREL-TREE)

Propagated from seeds, which should be given careful attention in order to obtain the best results in the germination. These trees are very seldom propagated from layers.

P A U L O W N I A

Propagated from seeds, sown in the spring in a frame.

PHELLODENDRON (CORK TREE)

Propagated from seeds and also, in rare cases, from root cuttings. The varieties are grafted upon the common stock.

PHILADELPHUS (SYRINGA)

Propagated from cuttings of the mature wood, made in the fall. It is also increased from green wood cuttings and from seed.

PHYSOCARPUS (NINE BARK)

Propagated from seeds and also from cuttings of the mature wood.

P L A T A N U S

Propagated from seeds which are sown in the spring. Also increased from cuttings of the mature wood.

POPULUS (POPLAR)

These trees produce seed quite freely ; these ripen in early summer and should be sown immediately. They are also equally well grown from cuttings of the mature wood taken in the fall.

The weeping forms are grafted upon stocks of the upright species ; the stock most generally used being that of Populus Grandiddentals.

PRELEA (HOP TREE)

Propagated from seeds, sown in the autumn, or stratified until spring. Varieties are grafted upon the common form, P. trifoliata.

PRUNUS SEROTINA (BLACKCHERRY)

The fruit, which is borne almost every year by trees in the open, ripens in late August and may be collected by hand from low trees or by shaking upon a canvas. The pulp should be washed off by rubbing with wet sand, and afterwards washing. The surface of the pit or stone should then be dried to precent moulding. For preservation during the winter the pits should be stratified in moist sand. In the spring they

should be planted in drills eight to twelve inches apart and covered one inch deep ; seed should be two to three inches apart in the drills. Planting should be done immediately after removing the pits from the sand, because a very small amount of drying at this stage is fatal. Seedlings may be transplanted when one year old. Mahaleb and Mazzard stocks are used for the grafting of ornamental cherries.

PYRACANTHA

PYRACANTHA

Propagated from seeds, sown in the spring. Varieties are grafted ; the stocks used being those of the Hawthorn. P. Japonica is far more beautiful when grafted upon the former stock than when grown upon its own roots.

PYRUS (MOUNTAIN ASH)

Propagated from seeds, which are stratified during the winter. These usually lie dormant until the second year. Varieties are budded and grafted upon stocks of the common species.

QUERCUS (OAK)

Most of the common species, and all of the oaks used for lumber are grown from seed, while the rarer species are propagated by grafting, using some of the common species as stocks. The acorns should be gathered as soon as ripen and sown at once, either in beds or often in the open ground ; they may be sown in drills or bradcast. In sowing the seed, first loosen

the soil to a depth of fifteen to eighteen inches ; take soil from the top to a depth of five inches and throw out of the bed upon either side, leaving a level surface upon which to sow the acorns. These may be sown as thickly as possible in a single layer, after which they may be covered with the soil. Acorns if not sown as soon as ripe may be stored in a cold, moist cellar or stratified in moist sand. They should be sown not later than the first of March for best results. At the end of the first season the young seedlings will have primary roots of often more than a foot long and much larger than the stem. Seedlings should rarely remain in the seed bed for a longer period than one year, without transplanting, because of the growth of the vigorous tap root.

Oaks may be grafted ; this is practiced to the greatest extent with the European species and Horticultural varieties. Budding is almost never practiced. In grafting the stocks used are from Q. Rubra for native oaks, and from Q. Robur for European oaks. The types of grafts used are veneer, tongue, and cleft grafting ; the first method is most generally practiced. Young seedlings are dug in the fall and kept in a cool, moist cellar until sometime in January or February at which time the seedlings are sorted over and the stronger and more vigorous ones are root grafted. These are set in nursery rows in the spring and left to grow for two years before r removing.

RHAMUS (BUCKTHORN)

Propagated from seeds almost exclusively ; these may be sown in the fallor the spring. Evergreen species may be propagated from cuttings of the mature wood, under glass. Rarer sorts are sometimes grafted.

RHODODENDRON

Propagated from seeds, which are very small and light, snd should be handled very carefully. They may best be sown under glass in the spring and covered with a glass frame. Seedlings should be shaded and allowed to remain in the boxes for a year. Rhododendrons are extensively increased by grafting, usually upon R. maximum as a stock. Grafting is performed in the house ; the veneer method being used. Layering is also practiced to some extent.

RHODOTYPOS

Propogated from seeds, similarly to Kerria.

RHUS (SUMACH)

Propagated from seeds sown in the spring. Also increased from root cuttings and cuttings of the mature wood.

ribes 9currant-

Propagated from cuttings of either the green or the mature wood. Eyes should be rubbed off from the lower portion

of the cutting. All the species may be increased from seed, if necessary ; in which case the seeds may be cleaned by rubbing the fruit in sand. They should then be at once sown in frames or in boxes under glass with a slight bottom heat.

ROBINIA (LOCUST)

Propagated from seeds which may be sown either in the fall or the spring. Soaking in warm water previous to the sowing assists themin germination. Varieties are grafted ; the common type, R. Pseudacacia being used as a stock.

R O S A

Roses may be propagated by most any of the general methods cited ; the two most widely used, beine those of seeds and cuttings. (Refer to p. 312, Bailey's "Nusery Book.")

RUBUS (BRAMBLE)

Propagated from seeds which may be preserved until spring if necessary. Also grown extensively from root cuttings. The seeds of some species require two years in which to germinate.

SALIX (WILLOW)

The common and best method of propagating these trees is from cuttings. It naturally propagates from either seed or cuttings. Cuttings of the mature wood may be taken from vigorous trees in the fall and callused during the winter.

They are best if taken from well ripened one year old wood, and made from eight to ten inches long.

S A M B U C U S

These plants may be propagated equally well, either from seeds or cuttings. Cuttings are taken from green or mature wood and treated similarly to those of Poplar or Willow. The fruit is fleshy, and consequently should best be stratified previous to sowing, or macerated and washed in order to clean the seeds thoroughly.

SALISBURIA

Propagated from layers and also from seed.

S A S S A F R A S

Propagated from seeds and also from root cuttings.

S M I L A X

Propagated from seeds almost exclusively. Sometimes increased from layering.

SOLANUM (NIGHT SHADE)

Propagated from seeds and from cuttings of the mature wood, grown under glass.

S O R B U S

Refer to Pyrus (Ash)

S P I R E A

Propagated from seeds, sown as soon as ripe, or preserved in a dry, cool place until spring. Also increased from cuttings of the mature wood taken in the fall.

STAPHYLEA (BLADDER-NUT)

Propagated from seeds sown as soon as ripe, or stratified until spring. These trees are increased easily from layering in the fall and cutting away on the succeeding fall.

SYMPHORICARPUS (SNOW BERRY)

Propagated from seeds, which should first be cleaned from their covering and sown immediately.

SYRINGA (LILAC)

Propagated from seeds, sown in the spring ; this method is adopted only with the more common types. Varieties and rarer species are increased from cuttings of the greenwood with bottom heat. Grafting, when practiced, is performed in April or May ; the stocks used being those of Syringa Vulgaris.

T E C O M A

Propagated most easily from seeds, which are often times very irregular in the quantity produced. Seeds are generally sown in the spring. Commercial propagators increase this vine from root cuttings and grafting. Grafting is performed upon the roots of T. Radicans.

TILIA (BASSWOOD)

Propagated from seeds, stratified during the winter. Also increased from cuttings of the mature wood ; the finer varieties are grafted upon the more vigorous, common stocks.

ULMUS (ELM)

The preproduction of these trees is from seeds. The oval winged fruit is produced freely each year, and ripens in May ; when it should be gathered. It is much safer to use home collected seed, because elm seed cannot be preserved for more than a few weeks without losing vitality. The seeds may be gathered by sweeping them up from the pavements or by spreading a large canvas beneath the tree. They should never be allowed to become dry from the time they mature until germination is completed. Seeds are sown in shallow drills eight to twelve inches apart and covered one-half an inch deep ; they are dropped quite thickly. Seedlings may be transplanted at the age of one to two years.

Varieties of this genus are grafted upon the common type U. Americana.

V A C C I N I U M

These plants are propagated mostly from seeds, which may be washed from the fleshy coverings and stored in a cool cellar, in sand, until early spring. Seeds if very carefully treated, will germinate in a month ; but they often lie dormant for as long as a year. Root cuttings and layering are also used to increase these plants.

V I B U R N U M

Propagated from seeds, which should best be stratified during the winter. The seed usually lie dormant during the first year. Layering is also used as a means of increasing many species. V. dentatum and V. opulus grow readily from cuttings of the mature wood, taken in the fall. Finer varieties are grafted, using V. lantana and V. dentatum as stocks.

V I T I S

See method for propagating the grape, in Bailey's "Nursery Book."

W I S T A R I A

Propagated from seeds, sown in flatsunder glass, in the spring, with bottom heat. Seeds may be covered to a depth of one inch. Seedlings should be potted and kept in a warm frame for a few weeks and later placed in a cold frame to remain for a season. Layering is practiced in the autumn or early spring ; the layered shoot may be detached from the parent plant during the succeeding fall. Increasing by means of cuttings of the mature wood, and from grafts is common.

XANTHOXYLON

Propagated from seeds and also from root cuttings. Seeds should be sown in the spring.

ABIES (FIR)

These trees are most easily propagated from seeds which, with few exceptions, are produced quite freely. The cones are ripe and the seeds ready for collection during September and October. As with the other conifers the seed should be gathered before the cones open, at which time a greater or less percentage are shed and lost. The method of obtaining seed from their coverings is the same as that adopted with all the cone bearers, and described on a preceding page.

Cones should be stored in a cold, dry room until March or April, this varying with the climatic conditions, at which time the seed should be extracted from the cones and sown upon the seed bed ; each cone contains about 500 seeds. The best method of sowing the seed is that known as broadcast ; upon seed beds about four feet wide, consisting of well worked soil, of a free, open texture and clear of weeds ; the seeds being of good size should be sown rather thinly, allowing sufficient space for the young plants to develop.

Press the seeds down upon the surface of the bed with the back of a spade or light roller, and cover with one-half to one inch of fine soil. On very dry days, and when subjected to the effects ofdrying winds and sun the bed should be screened ; this is also often necessary when the young plants

are showing through in order to keep off the birds which pick the husk of the seed at the top of the plant, thus being known to destroy an entire bed in a few hours.

The seed beds should be covered on frosty nights and shaded from the sun during the heat of the day, the covering may be matting or laths as described in chapter Under careful treatment the seeds germinate in about six weeks ; at this time the young plants are very tender and too much moisture will rot them ; in a single day's time plants at this stage may be killed from over watering or excessive exposure to the sun.

Young plants should remain in the seed bed until the following spring and generally for two years ; they should then be removed to blocks in the nursery, previously prepared, to receive the seedlings. In all operations of transplanting great care should be exercised that the roots of the young plants are not exposed to the dry air for an unnecessary length of time. The seedlings should be transplanted at a distance of six inches from row to row and three inches apart in rows, if taken from the seed bed the first year ; while if taken the second year the distance should be 12 inches and six inches. In planting, the earth should be pressed firmly about the roots and in exceptionally dry seasons the rows should be watered once or twice every week. Plants should be shaded to protect from wind and sun until the young roots have taken hold, after which time it will be only necessary to keep clear from weeds.

Here they should remain for two years, and if well handled may then be planted out in the forest plantation, or elsewhere, where they are to remain permanently ; but in case larger plants are desired they had better be transplanted a second time into the open nursery allowing a greater space for further development. The best time for transplanting is April, just before spring growth starts ; moist weather will be very advantageous to best results in this work. The distance in the nursery rows should be at least four feet from row to row and two feet asunder in rows, sufficient space being allowed to excite good root development and ease of removing without unnecessary cutting of the root system ; this is especially desirable if they are to be removed at a time for nurserymen's retail trade. In planting to the nursery the easiest way is to draw a line across the field and along this line make a trench. In this trench the young stock is placed and the earth well compacted about the roots ; the degree of tamping depending upon the texture of the soil,--a light soil requiring more than a heavier one. Most species of firs may be removed at a height of six to seven feet ; but those of two feet are much better adapted to transplanting and will in time develop into better specimens than will those taller.

While, as stated, most species of this genus are readily propagated by seed, it happens once in a while that certain species produce fertile cones very seldom and that finer varieties are better obtained by other methods. The most usual

method is that of grafting. This is practiced with Abies Amabalis, and Grandis to a greater or less degree. While many claim that the plants of the latter grown from grafts are not as magnificent as those from seed, yet in sections of the country the scarcity of good seed is such that grafting must be resorted to. The stock most commonly used for the Firs is that of the European Silver Fir (Abies Pectinata). The method of grafting is that generally used with conifers and described under the head of grafting of conifers.

The more common species, as Abies Balsamea, and Concolor are quite easily propagated from cuttings ; these being taken with a heel and placed in a propagating house will root in four and five months.

ARAUCARIA

These trees are propagated almost equally well by seed and by cuttings. The seed are quite as large as Brazil nuts; and are emitted freely from the immense cones, by drying gradually in a warm room. It is recommended by authorities that the best method of planting the seed is to "hold them by the thick rounded end between the finger and thumb and to push the pointed end into the soil at an angle of 45 degrees." The seed may be planted quite thickly and should, in this climate, be given a slight amount of heat. The radicle will descend into the soil in from three to four weeks ; but the first young shoot will often not appear until the following year or even

eighteen months after planting. The seedlings should be transplanted when they have attained a height of four to five inches.

When propagated by cuttings, the cuttings should be taken from the leading shoots otherwise the young plants are quite apt to be unsymmetrical and branchlike. The treatment of the cuttings is the same as that recommended for coniferous cuttings in general.

The larger number of Araucarias are imported in the seedling state, from Belgium to this country. In the former country the raising of these plants is one of the leading specialties[1] in many nurseries.

CEDRUS (CEDAR)

These trees do not begin to bear seed until they are of considerable age and size, seldom before they are fifty to sixty years old.

They are propagated by seed, treated with few exceptions similarly to those of other conifers. Both the Lebanon and the Deodar are raised from seed, in the nurseries ; however in some sections it is seldom that good ripe seeds are produced. Hence many seed are imported.

The cones of the cedars are very resinous when first gathered, and should be left for a year after being taken from the tree before the seeds are removed. During this time much

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of the resinous character of the cones has passed off and the seeds have become hardened. The seeds may be best taken from the cones by steeping cones in water and splitting them open soon afterwards. Seeds will keep for many years without losing their vitality, if properly stored.[1] They should be sown in April, and covered about five-eighths of an inch.

Culture of the seedlings is same as that outlined for Spruce, Fir, Pine, etc.; they may be transplanted when one year old.

CHAMAECYPARIS

These trees are propagated from cuttings, most extensively; the method of making and caring for cuttings is outlined fully in the chapter upon that subject.

Many species are propagated from seed, which are quite small and easily obtained from the cones. They are sown on a very light earth and rarely covered to a depth of more than one-eighth of an inch.[2] It often happens that many of the seed will not germinate until the second year ; at two years of age the seedlings should be transplanted.

In most of these trees the cones remain upon the tree two years before ripening and becoming mature. Hence there are very apt to be two sets of cones upon the same tree and collectors should be careful to select only the ripe cones,

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1. Chapter upon Seeds
2. Chapter upon Seeds and Seed Beds

which may be readily recognized from their dry, brownish appearance, as compared with the younger set of cones which are of a greenish color, hard and succulent. Both sets of cones are of about the same size and shape, about the size of a bullet.

Horticultural varieties and tender species are often most easily produced from grafts.[1] The stocks used are Chamaecyparis Pisifera and Cupressus Lawsoniana.

CUPRESSUS (CYPRESS)

This genus, often confused with Chamaecyparis, is propagated by the same methods as employed for the latter.

Cupressus Lawsoniana is however best produced by cuttings or grafts, because when raised from seed the seedlings are very apt to show a decided variation in size, form and habit of growth ; although the seed used may be all collected from the same tree.

C. Lawsoniana is the stock used, upon which to graft, as it is the most hardy and one of the easiest to propagate from cuttings.

JUNIPERUS (JUNIPER)

These trees are propagated very readily either from seeds or from cuttings. The berries when ripe, in the fall may be gathered and buried in sand for a year or they may be soaked for some time in warm water, then mixed with sand and kept

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1. Chapter upon Grafting

slightly moist until the following year. They may be planted in the fall a year from the time they were gathered or kept until the following spring. If planted the same season that they are gathered they will lie a whole year in the ground before vegetating. In the former case, germination should take place a few weeks after sowing. Seedlings will grow to a height of from two to four inches during the first season.

The method of propagation from cuttings is as described for the other trees of this group under the head of cuttings.

Finer varieties are grafted upon Juniperus Virginiana as a stock.

LARIX (LARCH)

These trees are propagated almost exclusively from seed which are borne in small upright cones that fall during the second year, and are produced plentifully. Seed should be gathered from trees standing in airy places ; because the larch, being intolerable to shade, it is here that the best and most vigorous specimens are apt to be found. As a rule the cones of these trees require much labor in order to extract the seed. The cones should be spread in the sun, or kiln dried, and also threshed ; after which they may be drawn aside and the seeds removed. It is recommended that all seed so obtained should be put in a heap, sprinkled with water to moisten thoroughly, left for two to three hours and then spread out to dry. A temperature of over 130 degrees in the

kiln often destroys the vitality of the seed.

The seeds should be sown in the spring in carefully prepared beds in shallow drills six inches apart, and covered lightly one-fourth inch with fine moist earth.[1] The seedlings should be transplanted after two years ; the larger seedlings being placed farther apart than the smaller ones. In transplanting these trees it is quite essential that the work should be done in very early spring, as the buds start early and a disturbance of the roots after growth has once begun, means serious injury to the seedlings.

The Weeping Larch and forms of the European Larch are best produced by the general methods of grafting and inarching applied to conifers.[2]

LIBOCEDRUS

Propagated most readily from seeds, which should be sown in the spring, and treated similarly to those of Thuya and others from the same group.

It may also be propagated from cuttings of either the mature or the green wood ; the former being preferable. For treatment of cuttings refer to Chapter upon cuttings.

PICEA (SPRUCE)

The methods of propagation applied to this genus are very similar and in many cases identical with those used for the

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1. Chapter on Seeds and Shading
2. Chapter on Grafting

genus Abies. Spruce trees bear seed, as do many other conifers, much more heavily during some years than during others. The Norway Spruce, for example, is considered a heavy seeder and generally bears a full crop every two or three years. The cones come to maturity in September or October and these often cling to the trees until late in the season, often remaining until February and March, at which time seed may be seen upon the surface of the snow. The seeds are light and winged and hence they are easily carried by the wind for great distances.

The seeds of the Norway Spruce may easily be shaken from the open cones ; while those of Picea Alba, if taken before the cones are quite mature, also come from the cones readily, if spread upon the floor in a warm, dry room and stirred occasionally. With Picea Mariana it becomes necessary to place the cones over heat, sometimes raising the temperature as high as 130 degrees F, and continuing it for three to five hours, before the seeds are ready to be taken out.

If carefully stored, the germinating power of these seed may be retained for from three to five years ; the vitality remaining longer if the wings are not detached. In sowing the seed, those as large as Picea Alba should be covered to a depth of one-third of an inch ; those as small as Picea Mariana should be covered much less. Sowing in drills is preferable to the broadcast method because of the ease of weeding. The shallow drills should be six to twelve inches apart ; seeds may be scattered one-fourth to one-half inch apart.

Germination takes place in from three to five weeks, and during the first year the young plants should attain a height of one and one-half to two and one-half inches. The seedlings should remain in the seed bed for a period of two years before transplanting. During the first year the seedlings should be shaded ; but during the second year it is not necessary except under abnormal conditions.

Spruces may be propagated from cuttings with comparative ease and the finer varieties and species are, as a rule, produced from grafts. The union of the stock and scion is very quick and easily obtained under the proper conditions.[1] Picea Excelsa and Picea Alba make the best stocks ; and the method of grafting most universally adopted is that known as veneer grafting.

PINUS (PINE)

The best and almost the only method by which these trees are obtained is from seed. The seed of this tree are ripe during the latter part of September and are best gathered by the method described under "Collection of Conifer Seed"; if delayed until the cones are too ripe the seeds fall and are lost in being carried away by the wind. The cones are best if gathered before fully matured, as it is quite easy to place them in the sun, under which conditions they will usually dry and emit the seed with little difficulty. Various devices

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1. Chapter on Grafting

and methods are employed for extracting seed of cone bearing trees ; these are described in their place.

Pine seed may be sown at almost any season of the year if the conditions are favorable to germination. The most favorable time is from the last of March to the latter part of April ; after being sown the seed bed should be shaded by one of the various methods, usually lath screens or pine boughs. The seed are generally sown broadcast, upon very light, almost sandy soil and covered lightly ; the covering varying with the species to which the seed belongs. If the spring be very dry the bed should be kept somewhat moist by means of frequent waterings, as the coverings of the seeds are of such a degree of hardness that they need moisture to vegetate.

After the seedlings come up the bed should be but sparingly watered, and shaded from the sun especially during the heat of the day. In very dry seasons the seeds have been known to remain in the seed bed for months before germinating. If weather and soil conditions are favorable and conducive to good growth, the seedlings should appear in from five to six weeks after the time of sowing. The same general directions as those given for Firs and Spruces may thereafter be observed. If watered too heavily or if sufficient light and air is withheld, the ideal conditions for the destruction by fungus diseases exists. The result is that the young stems rot off and large numbers of the young seedlings are destroyed.

The growth of Pine seedlings is from one to two inches

during the first year and when two years old they range from three to five inches in height. After one year the seedlings should be transferred from the seed bed to the nursery block. The young plants being very tender, great care should be exercised to prevent drying out ; this is done by choosing if possible a cloudy day for transplanting, and placing the seedlings in shallow pans of water, thus conveying them to the place where they are to be planted. They may be planted in beds in rows four inches each way and the beds covered with lath screens in order that they may be shaded from the intense sun until firmly rooted. Seedlings which remain in the seed bed where they were sown, die away in patches, and those surviving never grow as vigorously as those which are pricked out when young. In these beds the plants may remain until the following spring, by which time they will be fit to transplant into the nursery rows.

Finer varieties of this genus are often grafted upon related species of the more common types. The most common stock is that of Pinus Sylvestris, and the method is that of veneer grafting.

Budding

This method has been adopted from time to time as a means of propagating certain varieties of the Genus Pinus. It is performed as follows : "as soon as the growth of the pine is nearly complete for the year, and while the shoot is still soft, the terminal bud is nipped out. During the following

year a fascicle of leaves taken off with a piece of bark, as in the usual method of budding, and inserted into the nearly mature young shoot of any congenial stock will unite quite freely. The chief objection to this methodis, that including the preparation, it requires three years to obtain a plant of sufficient size."

PSEUDOTSUGA (DOUGLAS SPRUCE)

Like the other trees of this group, the Douglas Spruce is propagated almost exclusively by means of seed. These are produced in abundance and are very easily removed from the small cones. Thomas Dougles writes thus : "The seed of Pseudotsuga germinate readily ; but like the Fir seed they rapidly lose their germinating powers with age." He further says that, "Seed from trees growing in the valleys and the foothills of Colorado will not produce trees that are hardy north of the Ohio River. There is no differance between trees produced from valley seed and from mountain seeds. The former have short green leaves and a stunted look ; the latter have longer leaves, a more glaucous appearance and great rapidity of growth." Hence it is seen that care should be esercised in the selection of seed from which to grow seed for different localities.

Methods adopted for the Spruce and Fir apply to this genus.

SCIADOPITYS (UMBRELLA PINE)

These trees are propagated, preferably from seed, although they grow well from cuttings. The seed from which it is grown are imported as a rule from its native country.

Cuttings of the half-ripened wood, taken during late summer or early fall strike root quite readily.

SEQUOIA (WELLINGTONIA)

The best method of propagating these trees is from seed, which should be sown in a frame or shaded place.[1]

Cuttings of these trees will strike root quite as readily as many coniferous trees if treated as recommended for cuttings of this group. If good promising shoots are taken for cuttings one will obtain symmetrical plants as a result and they will not have the tendency to the branchlike characters of some of the coniferous cuttings.

The Golden and the variegated varieties are grafted upon the types[2]

One instance is recorded in which a tree had upon it some variegated and some clear green branchlets. Cuttings of both kinds were taken from the tree and in the spring and in October all of the young plants were alike and each produced a variegated appearance.

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1. Chapter on Seeds
2. Chapter on Grafting

TAXODIUM (BALD CYPRESS)

This is propagated by seeds, sown in the spring and also by cuttings of the mature wood placed in very wet sand or even water. Loudon says that Taxodium cuttings root best in water. It is very difficult to root in the ordinary cutting bed as used for most other conifers.

When grafted, the stock used is that of Taxodium distichum. It is recommended that the grafting should be performed in August or September out of doors, and in early spring, under glass.

T A X U S

These trees are propagated from seeds and cuttings. The seeds are enclosed within a fleshy covering and are of such a character that they do not germinate until the second year. They may be sown any time from March to October or they may be stratified immediately after gathering ; if sown as soon as ripe they shoule be cleaned of their pulp and after being dried they are ready to sow.

Seedlings should be transplanted at two years of age, and during their youth they should be shaded as these trees thrive best, when young, without too great an amount of sunlight.

Grafting is often practiced ; the stock used being that of the common species, Taxus Baccata. These plants root slowly from cuttings and when so propagated, are treated the same as coniferous cuttings in general.[1]

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1. See Chapter on Cuttings

T H U Y A

These plants should be propagated in one of two ways ; from seeds or cuttings. It is the general practice in this country to propagate from cuttings ; in Europe the general method is that of seed.

Seeds should be sown in the spring, soon after ripening. These often lay in the ground for two years before germinating. Seedlings should be well shaded during the first year and it is best to shelter slightly during the succeeding winter ; in the following spring they may be transplanted. Miller says, "wherever possible these plants should be propagated because, after the first two years, the seedling plants will greatly outstrip the others in growth, and the plants will grow with their branches much closer."

These plants are also largely propagated from cuttings, taken from October to January and treated as outlined for coniferous cuttings in general. When grafted, the stocks used are those of Thuya Occidentalis ; these being imported in the seedling form from Europe.

T H U Y O P S I S

This genus is propagated from well ripened hardwood cuttings taken during the months from October to January. The cuttings are made and treated the same as those from the other trees of this opposite leaved group, including Thuya, Chamaecyparis, etc. Rehder says that plants produced from cuttings

usually grow into bushy, round headed specimens ; hence he prefers seed.

Varieties are grafted upon stocks of Thuya ; but the products are said to be short lived, hence by some the method of seedage is considered the best. There is little difference, however, between growing from seed and from cuttings ; it is nevertheless a fact that nurserymen propagate this almost entirely from cuttings.

T O R R E Y A

Torreya is propagated perhaps most easily from seed, which are rather large and covered by a thickened shell. They are treated similar to Conifer seed in general, and plants grow much faster from seed than from cuttings.

These trees are also grown from cuttings and from grafts. Cuttings grow very slowly and usually remain bushy. For grafting Cephalotaxus is frequently used as a stock upon which to grow the finer varieties of Torreya.

TSUGA (HEMLOCK)

The most general method of propagating these trees is from seed, which although produced abundantly, they have the lowest percentage of germination of any of the conifers. The seeds are shed from the cones at different periods of the year ranging from autumn until the following spring ; fertile seeds have been found in the cones as late as the latter part

of April. They are sown on seed beds and cared for similar to the seed of other conifers.

The young seedling plants are very tender and quite susceptible to unfavorable conditions of moisture and sunlight. They are capable, however, of enduring a great range of climatic and other conditions. As seen in the table of growths, these trees are the slowest of all the species during their seedling state.

Often it becomes necessary to produce rarer varieties other than by seed ; this is done by grafting upon Tsuga Canadensis as a stock.[1]

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1. See Chapter on Grafting

DISEASES OF CONIFER SEEDLINGS

The study of insect and fungous diseases of seedlings is yet a subject to be thoroughly investigated. There is practically no literature bearing directly upon seedlings, and the article cited, the summary of which is here given is the only article I have found of the sort.

A fungous disease called "camping off" sometimes causes thousands of little trees to wilt and die when but a few weeks old. It is best prevented by not allowing the seed bed to become too moist, and by keeping up a free circulation of air. All seedlings attacked by the fungus should be burned, and beds in which diseased plants occur should not be again used for the same purpose.

There is also an insect of some kind which injures conifer cuttings, by stripping the bark off in patches ; hence causing much damage. If of sufficient vitality, some of the cuttings often recover from the ravages of this insect, and healing the wound as seen in Plate emit roots and continue to develop.

The Scotch Pine which is one of the most prolific of the seed bearers develops very few seedlings in the natural forests. The seedlings may be seen in large numbers from May

to September, and allowing 80% to perish by the natural agencies, to the effects of which seedlings are exposed, one still sees in but rare cases a one year old seedling in a clear Scotch Pine forest.

The explanation of this fact is, that the dead foliage of this tree decays less rapidly than that of most trees ; the process of decomposition is assisted by several saphrophytic fungi ; the mycelia of which permeate the layer of decaying needles, immediately below the surface. The roots of seedlings push freely into this layer, and it is here that the seedlings receive their injuries. It is in or immediately above this layer that the majority of seeds germinate and the young seedlings invariably perish in it within a few days after showing themselves above the surface.of the ground. That the mould itself is the chief factor in their destruction seems entirely probable. An important authority has examined thousands of these seedlings growing, or that were growing upon this medium in the shade of the Pines, and found two out of every three that were growing in this mould-infested area to be either dead or dying before they had passed two weeks of existence. The portion of the seedlings usually affected is the upper part of the radicle, which dies or "damps off" in the same way as seedlings of annuals which are kept in a confined atmosphere in a crowded condition.

The strong peculiarity to be noted in the damping off of the Pine seedlings is that the central axis of the plant only

to September, and allowing 80% to perish by the natural agencies, to the effects of which seedlings are exposed, on still area [illegible] one year old seedling in a clear Scotch Pine forest.

The explanation of this [illegible] this tree decays [illegible] than that of many trees, the process of decomposition is assisted by [illegible] fungi; the mycelium [illegible] permeate the layer of decaying needles, immediately below the surface. The roots of seedlings push freely into this layer, and it is here that the seedlings receive their injuries. It is in [illegible] immediately above this layer that the majority of [illegible] and the young seedlings invariably perish [illegible] within a few days after erecting themselves above the [illegible] of the ground. That the mould itself is the chief factor [illegible] seems entirely probable. [illegible] thousands of these seedlings [illegible] growing upon this medium in the shade of the Pines, [illegible] of every three that were [illegible] to be either dead or dying [illegible] existence. The portion of the [illegible] the upper part [illegible] the same way as seedlings [illegible] moist atmosphere, in a crowded condition.

The strong peculiarity [illegible] the Pine seedlings [illegible]

appears to be affected by the fungi, and not the secondary roots, when these have had time to develop. When the seed germinates in moss, or any other medium of sufficient depth that may overlie the fungoidal area or layer, the extremity of the radicle may be observed to perish after reaching the layer ; but the portion above, that has not come in contact with it throws out secondary roots, and sometimes a pseudo-radicle, which, although reaching the dry matter, appears unaffected by it, although the plant usually fails to establish itself in the ground. The exact stage in the seedling's life at which death ensues varies much. Sometimes it occurs before the cotyledons have properly expanded ; at other times, and especially in wet weather, it appears to survive much longer, but in all cases it takes place while the tissues of the young plant are still soft and succulent.

That this fungoidal layer, in itself, is fatal to seedlings, and that their decay is not due to any atmospheric conditions caused by the shade of the trees, is probable from the following observations. In fht first place, wherever the surface has been cleared of this debris, either by an artificial agency such as dragging of timber, or by natural causes, such as being washed off by heavy rains from the ground having considerable slope ; and seedlings have germinated upon these bared spaces, they invariably thrive more or less if unmolested by vermin.

Seedlings, too, frequently germinate upon the decaying

roots of cut trees, and even in the fissures of the bark of standing ones, and may sometimes be found several year's old in such situations. Here the roots penetrate between the bark and wood of the stump, or between the scales of the bark. This instance seems to dispose of any theory that might consider the shade of the growing trees to be the cause of the decay, and also of another ; that the damping off of the seedlings was caused by lack of nourishment.

Before this theory could be entertained it must first be explained, how it is that the seedlings of larch, spruce, silver fir and various hardwoods are able to exist in the same material as that in which Pinus Sylvestris seedlings die off ; for seedlings of all the former trees may be found to exist in the fungi-infested debris, and apparently unaffected by it, although many of them are (Larch) quite as delicate and liable to injury as these trees. Moreover, that the latter tree is able to obtain a fotting in situations where many other plants would perish is proved by its establishing itself upon the face of almost bare rocks and in other unfavorable positions ; while its indifference to the matter in which it grows is equally marked ; for healthy seedlings are found to grow in pure sawdust, ashes, decaying wood and even in the holes in old fir stumps from which animals had made their exit.

Although the fungoidal layer is believed to be the main factor in the destruction of the seedling plant, there are probably other agencies at work in the same direction. In

the thick woods, an Aphis, preys upon the young roots and fibrils of the trees, principally attacking those roots growing in the decaying matter. Although extremely numerous, these aphides appear to do no estimable damage to trees of any age ; but with the seedlings the case may be otherwise. They attack seedlings at all stages of their first annual growth, and at any portion of the roots frequently congregating around the collar, and appear to kill off a great many that have germinated in places nearly free from the fungi. It is probable that the seedling, even when not actually destroyed outright by them, is yet so weakened as to be unable to withstand the ordinary vissicitudes of life to which it is exposed ; and thus the Aphis may be said to be chiefly instrumental in its destruction.

Such appear to be the two general agents in obstructing the regeneration of the Scotch Pine woods ; such has been shown not to be the case with other species mentioned previously. It is not peculiar to the pine genus. When the fact is taken into consideration that the Scotch pine seed must have been shed in far greater quantities than those of the Weymouth pine, the presence of the seedlings of the latter, viewed in conjunction with the absence of such in the former, goes far towards confirming the theory that the Scotch pine stands almost alone in regard to this peculiarity in natural reproduction.[1]

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1. Transactions of High. and Agr'l Soc. of Scotland

B I B L I O G R A P H Y

The following is a list of magazine articles, written by various men and mostly not signed by the author ; they bear upon the various phases of propagation and the methods employed with different plants.

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