THE

PROTECTION OF WOODLANDS

TO

Berthold Ribbentrop, Esq., C.I.E.

INSPECTOR-GENERAL OF FORESTS TO THE GOVERNMENT OF INDIA,

UNDER WHOSE ABLE GUIDANCE SO MUCH HAS BEEN DONE

DURING THE LAST DECADE FOR THE PROTECTION

AND THE IMPROVEMENT OF INDIA'S

FOREST WEALTH,

This Holiday Task

Is Inscribed.

THE

PROTECTION OF WOODLANDS

AGAINST

DANGERS ARISING FROM ORGANIC AND INORGANIC CAUSES

AS RE-ARRANGED FOR THE FOURTH EDITION OF KAUSCHINGER'S "WALDSCHUTZ,"

BY

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AUTHORISED TRANSLATION, WITH NUMEROUS NOTES.

BY

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PREFACE.

ALTHOUGH numerous works on Sylviculture have at various times been published in this country,—some being purely the outcome of home observations, and others translations, or, for the most part, compilations from French and German sources,—there has, so far as I am aware, never yet been any work issued from the press dealing succinctly with that most important branch of Forest Science or Woodcraft which relates to the Protection of Woodlands.

After weighing the question, whether or not it would be desirable to compile a short manual on this special subject from the larger and more exhaustive works published in Germany, the home of Forest Science, I could not but come to the conclusion that, in view of the present untutored state of Woodcraft as a Science in Britain, the translation of such a simple, terse, and, at the same time, strictly scientific and practical little work as Kauschinger's *Lehre vom Waldschutz*, in its Fourth Edition (1889), completely revised and re-arranged by Dr Fürst, Director of the Bavarian Forest Institute at Aschaffenburg, would probably be of more practical benefit to Sylviculturists in Scotland and England than a work of a more exhaustive and ambitious nature, which, from the higher price its publication would entail, even if for no other reason, might perhaps fail in reaching the class of practical foresters and students of Forestry, for whom this little book is as much intended as for those engaged in supervising and controlling Sylvicultural operations, either as owners or agents.

For the ready courtesy with which Professor Fürst granted me permission to translate the work, I have here to express my warmest thanks, and to hope that thereby he may have helped on the somewhat struggling, though on that account none the less certain, advance of Forestry in Great Britain towards its academical recognition as a science worthy of being granted a home in our Universities, where it may be taught in some degree as on the Continent.

The work was originally written by Kauschinger in 1873, but was revised anonymously for its Second Edition by two eminent Sylviculturists, and again, to a very great extent, re-cast and re-written for the Third and Fourth Editions by Dr Fürst. The utmost care was taken to confine it within narrow limits, and those desiring more detailed information on any particular point are therein expressly directed to look for it in the more exhaustive works of Hess (*Der Forstschutz*, 2 vols., 1887 and 1890) and Nördlinger (*Lehrbuch des Forstchutzes*, 1884).

In the scientific nomenclature of the insects, the older generic names have, for the sake of simplicity and of a clearer comprehensive view, been generally adopted in the text, as, for instance, *Bostrichus*, *Hylesinus*, *Cerambyx*, *Bombyx*, *Geometra*, &c., whilst only the more important of the recent names awarded to the same by entomologists have been added in brackets, *e.g.*, *Tomicus*, *Hylurgus*, *Hammaticherus*, *Gastropacha* and *Liparis*, *Fidonia*, &c., as it is of far greater importance that the Sylviculturist should at once be able to recognise an insect as belonging to a certain group than to know merely its latest scientific name, perhaps without due recognition of its close relationship to some other injurious insect. In treating of the injurious insects, I have here and there added a little to the often somewhat meagre information given, and have also occasionally, in foot-notes, added a few details about species of moths common in Britain, but not considered worthy of special notice in the original text.

In the final section, which treats of forest offences and misdemeanours, on the other hand, I have taken the liberty of omitting certain matters relative only to German conditions of forestry, and which could be of no practical use in the management of woods in Britain.

I have intentionally omitted the citations of authorities often occurring in foot-notes in the original, as those to whom alone they could be of use do not require the assistance of any translation to open for them the treasure-house of German literature with regard to Woodcraft.

It is true that with our comparatively mild insular climate, free from either the intense cold or the great heat of the continental winters and summers, our Woodlands are not nearly so much threatened with external dangers as those in many parts of the Continent; but, for all that, a thorough knowledge of the leading points in the Protection of Forests must be of great advantage from a purely financial point of view, as well as regards the technical value of the timber produced.

That our Woodlands have not hitherto suffered to any calamitous extent,—except intentionally from reckless clearance, and from fires,—I ascribe mainly to the fact of their being in great part *mixed forests;* and the formation, retention, and reproduction of such in preference to *pure forests*, as recently recommended by Sir Herbert Maxwell, Bart., in his article on "Woodlands" in the *Nineteenth Century* for July 1891, will continue to be the best natural protection against many of the inorganic and organic dangers by which the cultivation of forest growth on an extensive scale is threatened. Pure forests, particularly those formed of Scots Pine and Spruce, have throughout Germany led to enormous calamities (from insects especially); hence wherever soil and situation permit of it, consistent efforts are being made to bring back the forests to their original form of mixed woods, which long experience now shows to be in general that best suited for obtaining the safest and most remunerative permanent returns or sustained yield from the soil they occupy.

No attempt has been made to produce anything like a strictly literal translation of the German text. Wherever any deviation from the actual words of the original has seemed to me to bring out the meaning of the Author more clearly in English, I have allowed myself a very free hand, in the hope of thereby attaining more useful results.

J. NISBET.

IPSWICH, 20*th December* 1892.

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PROTECTION OF WOODLANDS.

INTRODUCTION.

1. *Definition, Aim, and Scope of Protection of Woodlands.*

UNDER Protection of Woodlands is understood a knowledge of all the dangers which in many ways threaten the well-being of woodland crops, of the best means of warding off such dangers and to a greater or less extent preventing damage being done, and, finally, of the best practical measures to be adopted for remedying or minimising damage that has actually occurred, and for stopping its further extension.

The Protection of Woodlands is the oldest and most necessary branch of Forestry. That it is the oldest may be seen from the ancient forest laws of centuries ago, in which the protection of the woods[1] against men was the principal, and not infrequently the only aim, whilst protection against domestic animals also came later. To these followed decrees relative to the replanting of cleared areas, and the moderate and rational utilisation of the forest produce. At the same time, it is the most necessary branch of forestry; for what is the use of the most careful sowing, planting, and tending of timber crops, if men, animals, and inimical forces of nature are to be allowed to act unhindered in the work of destruction? Under favourable circumstances, mere protection of forests is of itself at times sufficient to maintain a certain degree of density of crop, as in the case of selection fellings, when due protection is afforded against cattle, especially against goats.

The nature of the dangers to which woodlands are exposed is manifold, and their close consideration, together with that of the

[1] In Britain such protection of forests, following afforestation, took place at first solely for the benefit of the chase.—*Trans.*

preventive and remedial measures to be adopted, necessitates some knowledge of various different branches of the cognate sciences of Forestry. Thus *Botany* enlightens us concerning the forest weeds and fungi; *Zoology* treats of the injurious forest insects and their life-history; *Sylviculture* indicates to us the protective measures against frost and heat, snow accumulations, and forest weeds; *Management of Forests* points out how the violence of storms can best be counteracted by careful location and succession of the annual falls, and how advantageous is the proper marking of all fixed boundary points; *Utilisation of Forest Produce* teaches us in what way timber crops and minor produce can best be harvested with least interference with the natural growth, development, and reproduction of the forest.

In consequence of this overlapping with other branches, it has sometimes been objected to accord to the Protection of Woods the rank of a separate branch of Forestry; but, on the one hand, it certainly seems desirable to have a complete and comprehensive statement of all that is necessary for the protection of the forests, and, on the other hand, although zoology takes cognisance of all animals that are injurious to forest growth, yet it does not concern itself with the preventive and remedial measures which are purely in the domain of Forestry, whilst at the same time many other matters, such as those relative to drainage, to the binding of sand-drifts, to protection of boundaries, and to forest fires, find no suitable place in any other branch. Under these circumstances it can hardly be denied that *Protection of Woodlands* has a right to be considered one of the four main branches of Forest Science.

2. *Protection of Woodlands, and Forest Laws.*

As above indicated, Protection of Woodlands teaches us concerning the dangers which threaten forest crops, and the best means of obviating them so far as lies in the power of the proprietor or the forester. These means are not, however, always sufficient, and the individual proprietors would often be powerless to operate against such dangers unless supported by the State in the interest of public safety and the common weal: thus, in view of the importance and the value of woodlands for the general well-being, negligent proprietors are even compelled to adopt such reasonable protective measures as are permissible within the limitations of

the common law.[1] It is then that the State is able to assist in the protection of forests by the enforcement of rational forest laws in its capacity of supreme supervisor entrusted with the carrying out of certain duties.

Thus, whilst the discovery and notification of a forest misdemeanour, the extinction of a forest fire, the destruction of injurious insects within one's own woods, and the like, are classifiable under Protection of Woodlands, yet the punishment of the misdemeanour, orders regarding measures to be taken for the prevention of forest fires, and special rules or orders relative to injurious insects in other woods in general, are classifiable under Forest Law.

In the following, only the former is dealt with,—the Protection of Woodlands.

3. *Establishment for carrying out Protective Measures.*

The duty of carrying out protective measures in the sense above indicated extends to all those concerned in the administration of the forests, from the lowest to the highest official, but of course in varying degree.

The principal duty of the protective establishment, consisting of the foresters, assistant foresters, wood-reeves, overseers, and keepers, whose knowledge of forestry has simply been confined to the practical side, is the protection of the forests against the actions of men, against mischief or misdemeanour, whilst the administrative officers, stewards, or agents have, as a rule, only to supervise and direct the operations of their subordinates. A second part of the protective duty—that concerned with the animal world, and particularly with regard to insects—is as much the duty of the administrative as of the protective establishment, and involves a constant watchfulness to discover any impending danger, so as to take measures for its prevention. A third and highly important part of the Protection of Woods devolves solely on the administrative establishment, namely, the protection afforded by judicious location of the annual falls, arrangement of work, and tending of woodlands so as to resist storms, snow accumu-

[1] In Bavaria, for example, special orders are enforced, whenever there is danger of any insect calamity, to ensure the removal of coniferous stems to over half a mile from the forest, or else in regard to barking of the logs, in order to prevent large attacks of *Bostrichini* in consequence of the immense fellings sometimes necessitated (as at present, in consequence of the spruce moth).—*Trans.*

lations, frost, heat, or the damage the crops are liable to suffer from insects or weeds. And as the laying down of the principles of management, the approval of the working plan, and the revision of the results attained, are the duty of the head of the department or of the responsible agent, it may well be said that this branch of Forestry is one that concerns all the establishment, and that in this sense all the establishment is classifiable as protective.

4. *Headings under which the consideration of Protection of Woodlands falls.*

It is convenient to classify the dangers threatening woodlands into three groups, according to the nature of the causes of the impending damage. Thus, we speak of dangers or damage:—

i. From inorganic causes or agencies.
ii. From organic agencies.
iii. From human agency or the actions of men.

In considering these sources of danger more closely, we find that the dangers or damage may be due to the following more detailed causes:—

i. *Inorganic agencies:*
   1. Low or high temperature—frost or heat.
   2. Atmospheric precipitations—rain, snow, hoar-frost, ice, hail.
   3. Violent aerial currents—wind and storms.
   4. Lightning.
   5. Unfavourable conditions of soil—wetness, shifting sand.
   6. Diseases of trees, in so far as these are not occasioned by fungoid parasites.

To these might also be added the destructive results of fires, so far as they can be caused by lightning or the spontaneous combustion of fermenting vegetable matter. As, however, fires arise with few exceptions (through lightning) from human negligence, wantonness, or malice, it appears more expedient to classify them under section iii. below.

ii. *Organic agencies*, comprising damage done either by plants or animals.

iii. *Human agencies*, or the actions of men either in regard to interference with the proprietary rights, or with reference to the purloining of, or damage to, forest growth.

Section First.

PROTECTION OF FORESTS AGAINST INJURIES DUE TO INORGANIC AGENCIES.

CHAPTER I.

Damage caused by Low or High Temperature.

A. Frost.

5. *Different kinds of Frost, and their Injurious Effects.*

Under frost generally is understood any sinking of the temperature below the freezing point; but in regard to the time at which it occurs, a distinction is made as to late frost, early frost, and winter frost, whilst in respect to the peculiar way in which it is occasioned by winter and late frosts, freezing and lifting of the soil will be treated of in a paragraph by itself.

Under *Late or Spring Frosts* are understood those depressions of temperature below the freezing point, which take place in portions of plants after the entry into the period of active vegetation in spring. They kill the tender young shoots, leaves, and flowers that may have opened, these becoming first of all drooping and withered, then assuming a blackish discoloured appearance in consequence of the decomposition of the chlorophyll, and finally falling off. Seedlings just germinating are usually completely killed, whilst stronger plants are interfered with in growth by the loss of their young shoots, or are finally completely deformed by repeated recurrence of the damage. The prospect of a seed year can be obliterated by the destruction of the flowers, and the regular progress of natural reproduction can thus be not inconsiderably interfered with. From obvious causes, the increment on damaged plants and trees is smaller than usual in years when late frosts have been bad.

Under *Early or Autumn Frosts* are understood those occurring early in autumn, before the young shoots have had time to harden and become woody, which cause the death of the unhardened portions; they seldom kill the whole plant outright, the effects being usually confined to the portions actually damaged by the early frosts, *i.e.*, the summer shoots in particular. The leaf-shedding of Scots Pine seedlings (*see* par. 35) is also by many considered to be the result of early autumnal frosts.

The cause of plants being frost-bitten during the period of active vegetation is explainable in the withdrawal of water from the cells by the frost, the water quitting the cells and passing into the intercellular spaces, so that the power of tension (*turgor*) of the tissue becomes lost, and the portions affected wither and die off when a thaw sets in. Whether these are actually killed by the frost, or only die after thawing takes place, is a question not yet satisfactorily answered; for, although the latter has hitherto been the view generally taken, Dr H. Müller has recently adduced strong arguments in favour of the former hypothesis, supporting his view in favour of this by the fact that in hundreds of experiments he has never been able to save, by means of very gradual thawing, portions of plants that would have been killed by rapid thawing.

Frosts occurring in Winter during the period of complete rest from active vegetation do not, as a rule, do much damage to our indigenous trees or to such exotics as have become acclimatised, although we not infrequently see somewhat incompletely hardened shoots of the previous year, the summer shoots especially, killed off, or the roots of young Oaks die in consequence of long-continued hard frost when the soil is unprotected by snow, or even the killing off of older plants and stems, as could frequently be noted in the hard winter of 1879–80. Here again, too, the withdrawal of more than a certain limited quantity of water from the cellular tissue is regarded as the cause of the damage. At the same time, a drying up of the foliage of coniferous trees may be the consequence of continuous cold, in consequence of the rapid transpiration of water through the needles on sunny wintry days, without the possibility of the evaporated water being replaced by the frozen woody tissue of the stem; this phenomenon may not infrequently be noted on trees exposed to the sun at the edge of woods, and on such as stand freely exposed to the southern side.

Frost-shakes are a peculiar effect of hard frost during winter, which will also, like the freezing and lifting of the soil, be treated of in a paragraph by itself.

6. *Factors determining the Extent of the Damage done by late and early Frosts.*

The extent of the injury that may be done is mainly dependent on the *Species of Tree*, although numerous other factors are also of more or less influence, among which the age of the timber crop, the nature of the soil and situation, the time of the occurrence of the damage, and the kind of weather accompanying the frost, are often of the most importance.

The temperature at which young portions suffer from frost varies greatly according to the different *Species of Trees*, many of which bear exposure to 5 or 7° C. below freezing point. The leaves and flowers of most of our trees bear exposure to a few degrees below the freezing point, but the concurrent circumstances then become of importance, and prolongation of the frost, or simultaneous hoar-frost, stimulated by rapid evaporation of moisture from ponds and meadows, heightens the danger, whilst aerial movement decreases it. In many plants the leaves appear yellowish and drooping after a frosty night, but may gradually raise themselves again and recover their normal green appearance. The flowers appear to be invariably more sensitive than the leaves, but in the case of the hardy kinds of trees they are still less sensitive to late frost than those of other species.

In regard to late and early frosts our indigenous and acclimatised trees may be classified as under:—

Very sensitive: Ash, Sweet Chestnut, Oak, Beech, Acacia, Silver Fir.

Somewhat sensitive: Spruce, Lime, Maple and Sycamore, Larch.

Hardy, or least sensitive: Hornbeam, Birch, Alder, Elm, Aspen, Willow, Mountain Ash, then Scots, Black and Weymouth Pines.

The hardy species mostly break out early into leaf, as may be noted in the case of Alder, Hornbeam, and Birch, whilst the young flush of leaves of the more sensitive species takes place later, in some cases as late as the middle or end of May, as in the Oak, Sweet Chestnut, and Acacia, so that the danger from late frosts is to a great extent obviated. The Beech, which breaks into leaf

earlier, suffers much more frequently from late frost than the more sensitive Oak, which does not commence its active period of vegetation until later; in the case of the Silver Fir the side shoots may often be seen killed by frost, whilst the vertical shoot still lies protected in the terminal bud which is the last to develop. At the precise moment of the development of the bud, the Larch is the most sensitive species; but as soon as the needles are somewhat strengthened, it becomes much more hardy.

So far as the influence of the *Soil and Situation* is concerned, coombs or hollows on the hillsides, and depressions in the crowns of the timber crops, appear to be most exposed to danger, especially when the soil is moist, as the heavy cold layers of air produced by the evaporation of the moisture have no means of being wafted away, owing to the free circulation of air being impeded: such patches, often contrasting sharply with their immediate surroundings, either through inferior growth and development, or through the occurrence of the more hardy species, are called *frost-holes*. Woods skirting the edge of low-lying meadows in valleys, and those in the vicinity of ponds and moist meadows frequently suffer damage from frost as late as even the middle of summer, in consequence of the cold produced by the increased evaporation. Eastern and south-eastern aspects exposed to the cold, frost-bringing east winds, and southern exposures, with their tendency to early awakening of active vegetation, are more liable to danger from frost than the other aspects.

The *Soil-covering*, more or less dependent on the nature of soil and situation, is also of influence, as young plants surrounded by a dense growth of grass are more exposed to danger from frost than those on cleaner soil, in consequence of the stronger radiation of warmth by the grass, whilst a high, lightly shadowing soil-covering of thorns, juniper, broom, &c., acts as a protection.

Young plants are, of course, always most exposed to the danger; young seedlings that have just germinated are usually killed outright by late frosts, which not infrequently also happens to one and two-year-old seedlings of the sensitive species of trees when the frost is hard. With advancing age the liability to suffer from this danger diminishes, especially when the plants have attained to over the so-called *frost-height* or normal level of the cold layers of air, which is often very distinctly marked on

them, *i.e.*, the height up to which the cold layers of air, laden with evaporated moisture, and at the same time prevented from circulating sidewards, reach. The more rapidly growing species of trees consequently outgrow the danger from frost earlier than those that develop more slowly.

The later in spring a late frost occurs, or the more vegetation has developed, the greater is naturally the damage caused; and frosts which occur about the middle, or, worse still, the end of May, often do an exceedingly great amount of injury in the vegetable world. Late frosts, coupled with simultaneous hoar-frost, are usually more injurious and severer than dry frost; whilst rapid thawing of the frozen portions, occasioned by the immediate and direct action of the sun after a frosty night, is considered especially injurious, particularly in cases that might otherwise have been of a lighter and less fatal character (*see* par. 5).

Broad-leaved trees, that have lost their foliage through late frosts, regain a certain amount of foliage by means of the adventitious buds, but always to a minor extent only, so that the effects of the damage may be noted more or less distinctly throughout the whole of the current year in a degree commensurate with the reproductive capacity of the species concerned,—thus the refoliation of the Oak is more complete than that of the Beech. Soil and weather are, however, also of influence in regard to the recovery from the effects of late frosts, and the better the soil, or the damper and at the same time the warmer the weather, the more likely the damaged plants are to make a fair recovery.

The damage caused by occasional early or autumnal frost, occurring before the active period of vegetation is closed and the hardening of the young shoots completed, is always less severe, as only a portion of the young shoots is lost, and neither flowers nor seedlings are affected. The extent of the damage is dependent on similar factors as in the case of late frosts, but in coppice woods the time of felling is also of influence, as in Oak coppice a late fall in spring delays the flushing of the shoots from the stool, and necessitates the prolongation of vegetation far into autumn, so that the first autumn frosts often find the young shoots at least partially unhardened. The kind of weather in general obtaining during the current year is also of influence, as a cool summer, with a damp and at the same time warm autumn, leads to prolongation of the period of vegetation and consequent

greater danger from early frosts. That the shedding of the leaves of the Scots Pine, by many considered due to late frosts (*see* par. 35), may also be due occasionally to early frosts, can be incidentally mentioned, whilst heart-shakes or frost-shake in the mature wood are also often caused by early frost.[1]

7. *Preventive Measures against Injuries from Frost.*

With the single exception to be mentioned at the close of this paragraph, there is no practical way of making good any damage that has actually taken place from frost; but, on the other hand, Sylviculture provides a variety of means by which damage to young plantations and woods can to a greater or less extent be prevented, whilst for seed-beds and nurseries a number of directly protective measures are available at our disposal.

The chief preventive measures, which can be applied on a large scale for the protection of young plantations and thickets, consist in the formation and reproduction of crops of trees liable to suffer from frost, especially of Beech and Silver Fir, under protective or parent standards, maintenance of fairly dense canopy or shelter overhead, with gradual removal or clearance of the same, avoidance of sudden, usually very injurious exposure of the young growth thus formed or reproduced, and maintenance of a protective belt on the east and north-east sides till the chief period of danger for the young crop is at an end. Hardy softwoods, like Aspen and Birch, which often assert themselves spontaneously in large numbers among the young growth, may form a very desirable protection for the more sensitive species, in which case they should only be gradually cleared or weeded out.

Where natural protective standards are wanting in localities exposed to danger from frost, they can be artifically produced by means of hardy woods of speedy growth, like Pine, Birch, or Alder, which should be planted out in rows somewhat wide apart. When these have attained a height suitable to afford protection, the planting out of the species requiring shelter can take place between the rows; and when the main crop has developed so far as to be above the frost-height, the protective species can then be gradually removed. Patches that are essentially frost-holes should always, when possible, be planted up with hardy species.

[1] Gayer classes frost among the causes of heart-shakes, but considers the damage due to the action of winter frosts (*Forstbenutzung*, 7th edit., 1888, page 53).—*Trans.*

For the planting up of localities somewhat exposed to danger from frost, or for the more sensitive species of trees, the material chosen should be large, healthy transplants, not likely at any rate to be killed outright by the cold; any rank growth of grass should be removed, and wet patches of soil sufficiently drained. In order to hinder them from flushing soon, seedlings of sensitive species should be removed from the nursery early in the spring during which they are to be planted out, and bedded in some cool place till required; by planting late they can also be protected against late frosts, at any rate for the first spring. Seedlings which, like natural growth in old woods, have hitherto stood under strong shade, are not suitable for planting out in the open, as they are equally sensitive both to frost and heat. Sowing should not be carried out too early in spring, in order that germination may not take place till after the danger from late frosts is over.

For seed-beds and nurseries other protective measures are applicable. Above all, they should only be formed in protected spots little exposed to danger from late frost, and never in frosty localities, a preference being given to northern aspects (on account of the later awakening of active vegetation), to localities protected by crops of older growth, and to open patches or blanks within the latter.

By the choice of spring sowing in place of the autumn sowing, which causes germination early in the following spring, by sowing late in spring, or by covering hard-frozen soil with leaves and brushwood in order to delay the penetration of warmth in spring, the germination of the seed can be retarded until after the chief time of danger from frost is over.

Young seedlings just germinated, and older seedlings of sensitive species, can be protected by sticking twigs and brushwood into the beds, or still better by placing or hanging a framework of small battens or of small poles interwoven with twigs over the beds.

Finally, plants that have been frozen or damaged by hoar-frost can sometimes be saved by having cold water poured over them early in the morning, as this delays the process of thawing, and gives the cellular tissue time to have a chance of recovering its normal density, and of reducing to their former size the pores of the walls of the cells expanded through the frost. This is the only measure that is of any use in the case of damage from frost

actually in course of progress; it is by no means always effective, but only when the actual damage taking place is comparatively trifling.

8. *Frost-shakes.*

In certain species of trees frost-shakes, or longitudinal clefts or fissures, not infrequently appear on the older classes of stems as the peculiar effect of hard winter frost. Beginning near the ground, they are sometimes only a yard or two long, but at other times extend into the crown, and penetrate from the circumference to a greater or less depth inwards in the direction of the medullary rays, often to the very core of the stem. Although not interfering with the vital energy, increment, or development of the tree, they render the timber less suitable for various technical purposes, and not infrequently afford an opportunity for the entrance of fungoid spores into the stem, thereby leading to subsequent disease.

The occurrence of frost-shakes is due to the contraction of the wood which takes place during great cold, much in the same way as contraction of timber is due to the withdrawal of water when it is becoming seasoned. During severe cold not only the water contained in the elementary parts of the wood becomes frozen, but also the water in the cell-walls, whilst at the same time this is drawn into the interior of the cells, so that the substance of which the cellular walls are formed is diminished in volume and contracts, the contraction being greater tangentially than radially, and greater in the outside zones with their larger quantities of water than in the drier heart-wood. Whenever this shrinkage exceeds a certain limit, a sudden division of the woody-fibrous tissue takes place in the direction of the medullary rays, the separation being accompanied with a great noise, according to direct observations,[1] and the frost-shake is formed. When the thaw succeeds, and expansion again takes place, the fissure closes and becomes overgrown by the new annual zone in the following summer, but it is usually opened again during the next winter, even by a moderate degree of cold; when, however, several mild winters pass by without causing the fissure to

[1] Precisely the same occurs, owing to shrinkage from heat, in the bamboo forests of Burma, during the hot months of March and April, when the halms burst with loud noise, often as loud as the report from a pistol.—*Trans.*

re-open, the stem may assume the external appearance of being healed, and may remain permanently closed.

Along the edges of the cleft the formation of the new annual zone is always somewhat thicker than on the rest of the circumference of the stem; and as these two cicatrised edges are close together, they often gradually form ridges or frost scars standing out about a hand-breadth from the normal outline of the stem.

Hardwoods with strongly developed medullary rays, like Oak, Elm, and Sweet Chestnut, are chiefly exposed to the danger of forming frost-shakes; they are also, but less frequently, formed in Beech, a few softwoods (Lime, Poplar, Willow), and Conifers. They are especially to be found on old isolated stems, or on standards in copse, or in high forest, and usually occur on the east and north-east sides of the stems, as the harder frosts only set in when the wind comes from these directions, and consequently work most powerfully on these sides. Low-lying tracts and localities with fresh or moist soil are more exposed than others to this particular danger.

Preventive measures can hardly be applied to mitigate this evil, but the early utilisation of trees with bad frost-shakes is recommendable in view of the liability to which they become exposed to fungoid disease, and consequent depreciation in value.

9. *Damage done by lifting of the Soil from Frost (Ground-frost); Protective Measures.*

Ground-frost consists in the raising of the soil in consequence of frost in winter, the loose, naked soil, saturated with moisture, being lifted up through the crystallisation of the water. When young plants are in the soil, as in nurseries and young sowings or plantations, these are also raised up, and when the soil sets again after thawing, they do not sink along with it, but remain with the roots more or less exposed, and very frequently perish. Thus, whilst the soil on being frozen first rises and then sets, the plants are gradually lifted by the frost.

This occurrence only takes place in light or loosened, moist, and especially in humose soil, and is most frequent at the early part of the year, about February or March, when frosts at night are apt to be followed by thaw during the day. The soil below the surface being still frozen, the percolation of the surface-

moisture towards the lower layers is considerably interfered with, whereby the drainage and drying of the upper layer is prevented.

As already stated, damage from raising of the earth chiefly occurs in nurseries, owing to the loose naked soil having no binding covering of weeds, or else on falls where sowing or planting has just been carried out. All species of trees do not, of course, suffer from its effects in the same degree, the greatest damage being done to the shallow-rooting species, headed by the Spruce, and to one and two-year-old Silver Fir in seed-beds, whilst seedlings of Oak, Sweet Chestnut, Scots and Black Pine, whose roots strike deeper into the soil from the very first year of their growth, are almost entirely exempt from danger.

Preventive Measures against plants being lifted by frost are :—

In the Open.—Draining of damp patches, avoidance of sowing in localities exposed to danger, and the use of sturdy transplants instead, if necessary with balls of mother-earth around the roots ; in very damp localities even the latter measure is not sufficient to prevent the raising of the transplants, so that tumping or the formation of mounds is advisable.

In Seed-beds.—No breaking up of the soil or rooting-out of grass or weeds from the beds should take place after September, any rank weeds that appear after that being cut away or clipped close to the ground. The spaces between the rows of seedlings can be filled during autumn with leaves, moss, or loose earth, and even the plants themselves can be banked up. Deep paths between the beds help to drain the upper layers of the soil, and thus to minimise the danger. Broad, thickly-sown seed-rills, sometimes recommended as a protection against lifting of the seedlings by frost, certainly suffer less, but have the still greater drawback of yielding only badly developed plants.

Remedial Measures when once the Damage has occurred.—In the open these are practically confined to pressing back, either with the hands or feet, the balls of earth around transplants, so as to revive the close connection between these and the soil; but in nurseries, seedlings that have been raised should be pressed back again after the thaw has taken place, and at the same time any portion of the roots still left exposed should be covered with loose soil.

B. Heat.

10. *Damage done by Heat.*

Under heat is understood an unusually high degree of warmth developed by the sun. It occasions damage directly only in the case of scorching or sun-burn, to be considered later, but has also an indirect disadvantageous effect owing to drying up the soil through exhaustion of its moisture.

Warmth, even to a very considerable degree, is beneficial to the activity of vegetation so long as a sufficiency of moisture is held in the soil, or is obtainable either from atmospheric precipitations or by artificial watering. If, however, the necessary supply of moisture is wanting, the soil becomes dried up, and the plant, whose transpiration through the leaves is greatly stimulated by atmospheric warmth and dry winds, is unable to obtain the amount of moisture from the soil necessary for the maintenance of equilibrium between evaporation and requisite amount of moisture throughout the plant, so that a disturbance sets in prejudicial to the latter; leaves and flowers first wither and droop, then turn brown and fall off; seedlings, young plants, and with continuous drought even older plants, become dried up and die off; germinating seed gets dried up, and fruits that may have set on the trees either become unproductive or are shed immaturely, as often happens in the case of Oak and Beech. Older trees naturally suffer least, although in very dry seasons there is a distinct falling off in the increment for the year, whilst the effect of intense solar warmth not infrequently shows itself in the production of immature autumn tints in the foliage.[1] Considerable numbers of trees often die off in consequence of the warmth, and in the year following any abnormally dry summer there is always a larger fall of dead wood from the crowns.

As secondary effects of continuous heat and drought, there may

[1] During a tour in the forests of the south-east portion of the Bavarian highlands, towards the end of August 1892, I had abundant opportunity of noting how soon the intense and abnormal heat of the previous fortnight had affected many parts of hillsides, particularly southern exposures, on which the soil was at all wanting in depth. Beech had in general suffered most, but Spruce had often been killed outright owing to the exhaustion of the soil-moisture. In towns the Horse-chestnuts were also shedding their leaves as if in autumn.—*Trans.*

also be mentioned the greater danger from fire, and from the numerical increase of injurious insects in consequence of the sickly growth of young crops owing to the heat and the dying off of stems and poles, dry summers being decidedly favourable to an abnormal increase among insects.

11. *Factors determining the Occurrence and Extent of the Damage.*

The above mentioned injurious effects of heat, which can be very considerably increased by continuous east winds, are most apparent in the following cases:—

(*a*) When the plants are of shallow-rooting species, like Spruce, Silver Fir, and Beech; species that begin from the very first to develop a deep root-system, like Oak, Pines, and Larch, are comparatively little exposed to danger.

(*b*) In the case of seedlings and young plants, especially when they have been recently planted out and have not had time to fully establish themselves; older transplants, or young plantations, or crops that have already begun to form canopy, seldom show any injurious effects from heat. Young crops, whether formed by sowing or planting, are often killed off to a very considerable extent by long-con-continued heat.

(*c*) When the soil is shallow, loose, and naturally dry, or on sandy peat, or very limy soils, and on southern and western exposures, which suffer more than the fresher eastern or, better still, the northern aspects. On plains and in low upland tracts, which also usually have a warmer climate, the injurious effects of heat will be more frequently noticeable than in mountainous tracts with their greater relative humidity, and their more abundant aqueous precipitations. A dense soil covering or rank growth of grass is disadvantageous on areas to be wooded, as it involves the transpiration of a large quantity of moisture, and prevents slight precipitations from reaching the soil. Damage caused by reflection of the heat is also not infrequently to be noted at the edge of the next year's fall of mature timber, or in the vicinity of individually isolated stems (standards), not only in the

earlier melting of the snow and the quickening of active vegetation in spring, but also through the dying off, or at any rate the sickliness and wilting of weakly plants in the direction in which the warmth is reflected.

(*d*) The time of the occurrence of abnormal heat is also of consequence. It is particularly injurious in the month of May, after the operations of sowing and planting have been completed, as it hinders the seed from germinating, and causes the death of the slender, shallow-rooting seedlings and of young transplants that have not had time to establish their root-systems in their new home.

12. *Protective Measures against Damage from Heat and Drought.*

The injurious effects of heat and drought can be prevented by adopting measures to retain, so far as possible, the natural degree of soil-moisture, and the atmospheric precipitations reaching the soil, or—as can only be practically applied on a comparatively small scale, and to a limited extent—by maintaining a due supply of soil-moisture by watering or irrigation.

The natural freshness and moisture of the soil can be retained by taking measures to prevent, or at any rate minimise, direct insolation of the soil or plant, or direct exposure to winds. Of the measures practically adaptable to serve these ends, the most important is the avoidance of any exposure or laying bare of the soil, as, *e.g.*, a preference for *natural reproduction* under parent or protective standards, which should consist rather of the smaller girth-classes of trees than of big stems with large crowns intercepting the atmospheric precipitations to any great degree. Under large old Beech the natural growth of seedlings is comparatively slight, weakly in development, and often succumbs quickly in warm summers. In localities where protection is especially necessary, such as stony, limy soil, or dry southern exposures, it is better to maintain closed canopy as far as possible, and only extract a limited number of mature stems here and there annually. Where natural reproduction has taken place on dry soil, a speedy clearance of the standards is necessary as soon as the young crop has been formed, in order that the latter may have the full benefit of the atmospheric precipitations (rainfall, dew), whilst any spontaneous growth of seedlings, even although unsuitable for forming part of

the subsequent crop, should be retained with a view to the protection of the soil until the formation of the young crop is well advanced or nearly complete.

Where natural reproduction seems inadvisable, narrow annual falls should be made running from north-west to south-east, and gradually advancing annually towards the south-west; thus the side of next year's mature fall protects the youngest crop from the hot mid-day sun, and often proves more beneficial than direct overshadowing.

On hillsides with southern or western aspects, thinnings must take place very carefully, and should not be carried out strongly.

The retention of the annual fall of leaves and needles, and the utmost possible restriction of their removal for agricultural or domestic purposes, are also of great importance, especially on hillsides; for the layer of leaves or moss not only acts mechanically in preventing evaporation of the soil-moisture, but also hinders the rapid running off of water received as rain or snow, and gives it time to percolate into the subsoil after the soil has itself become saturated with moisture. By means of protective belts of densely foliaged species planted thickly along the edges and outskirts of woods, the penetration of winds likely to exhaust the moisture from the soil, and to blow away the dead foliage, can to a great extent be prevented.

Although mainly intended to form a protection against the rapid running off of rain water (*see* par. 15), the formation of horizontal ditches also acts as a means of retaining and increasing the amount of moisture in the soil.

For nurseries and seed-beds care should especially be taken to select sites neither exposed to insolation nor to the action of drying-up winds; seeking the shady side of older crops, and avoiding, as far as possible, localities exposed towards the south or west, are much to be recommended.

Both for nurseries, and for sowing in the open, a deep loosening of the soil, to be repeated at times between the seed-rills and seedling-rows in the former, appears to assist in retaining the soil moist, as the atmospheric precipitations can penetrate more easily and deeply. The larger interstices between the particles of soil prevent rapid capillary ascension of moisture to the surface, and thus maintain a greater degree of moisture in the portion of soil occupied by the roots. At the same time, in loose, porous soil the

circulation of air (aeration) is always much greater than in heavy, tenacious soil, thereby directly affecting the precipitations of the moisture that is always present in the atmosphere.

On areas where sowing has been carried out, the moisture necessary for germination can best be provided by deepening the bands on which the seed is sown, and forming a ridge on the south side with the material removed, or by protecting seed-beds with a covering of moss, branches, straw, or protective frames; young plants, especially the more sensitive young seedlings, may best be protected by means of branches stuck in the ground, by frames, or by layers of moss spread between the rows.

The direct increase of moisture by watering or irrigation is seldom practicable on any large scale.

Watering can, of course, only be carried out in temporary or permanent nurseries, the seed-beds being watered both before and after the germination of the seed; it is, however, less frequently applied when the seedlings or transplants are somewhat older. It is always a more or less costly measure, especially when water is not obtainable in the nursery itself, and except in urgent cases, as, for example, long-continued drought in regard to such species as Elm or Alder, which are very sensitive and occasionally may be urgently in need of moisture, it does not take place so long as it is possible to do without it.

Where circumstances are favourable the irrigation of nurseries has certainly its advantages, and is carried out here and there in the same manner as in horticulture; but in general it is not applicable, partly owing to the cost, partly owing to the usual want of the necessary supply of water.

The *irrigation* of dry hillsides has recently, whilst so much attention has been paid to the maintenance of water-supplies in woodlands, been recommended wherever circumstances permit of it, and has actually received a certain amount of practical attention here and there, use being made of the surplus moisture obtained by drainage of higher lying, damp plateaux, and of water collected in the ditches along the sides of roads, which, in place of being conducted as formerly by the shortest way to the nearest watercourse, is carried sidewards along the slopes into horizontal ditches, whence it is allowed to percolate into the soil. According to Ney, the damming-up of smaller brooklets, and the leading-off of the water sidewards, is also a perfectly practicable measure.

As a means of preventing the bad effects of drought there may also be finally mentioned the use of *planting instead of sowing* in the formation of timber crops on localities with naturally dry soil, —as, for example, the putting out of one-year-old seedlings with long roots, instead of sowing Pine seed on dry sandy soil. Large seedlings, or sturdy transplants with consequently better developed roots, and plants with balls of earth attached, are less exposed to danger than smaller material and naked plants.

Preliminary cultivation of a species less sensitive to heat, like Pine and Birch, as nurses, or the simultaneous sowing of such species in localities exposed to danger from drought, can prove a very recommendable and advantageous means of protection.

13. *Sun-burn or Scorching of the Bark.*

Under *sun-burn* is understood that scorching effect of the direct action of the sun, which causes the bark to become dry in strips or patches, then to fissure and fall off, and the consequences of which are seen in the death and decay of the wood thus exposed, an interference with the normal growth and development, and even ultimately the death of the injured stems.

Sun-burn only occurs on the southern, western, and south-western edges of woodlands, when these, having been previously protected by an adjacent crop, are suddenly exposed to the full blaze of the sun; those trees do not suffer from scorching, which have been exposed to insolation from their earliest growth. It can also be the direct consequence of lopping off large branches from trees along roads, hedge-rows, &c., that have hitherto had a deep-reaching crown.

The trees which suffer from sun-burn are invariably such as, even in their later stages of growth, have a smooth bark without any rugged corky protection; that is to say, the Beech in particular, and in a less degree Hornbeam, Ash, Maple, Sycamore, and young Spruce and Silver Fir. Species with rough, cortaceous bark, like Oak and Elm, do not suffer at all, or are at any rate only exposed to danger during the earliest period of their growth, before the thicker, fissured bark begins to form. The danger begins about the pole-forest stage of growth, but older trees are more sensitive in this respect, and exposed to greater danger. In the case of Beech, which is very sensitive to insolation, the appearance of

sun-burn can often be noted even on large trimmed transplants, and usually results in their dying off.

Preventive measures consist in the avoidance, so far as possible, of sudden exposure of the edges of woodlands, and of the retention of all branch development there; timely formation of a protective belt by planting up with Spruce can also prove efficacious. Beech trees that have hitherto been growing in the close canopy of high forest, but are retained as standards for the production of large timber, almost invariably after a short time show the occurrence of sun-burn, so that the retention of such individual standards is not advisable. Sun-burnt stems along the edge of woods should, however, be retained as long as possible, as they remain for a considerable time in active vegetation, whilst, if they be removed, the stems immediately behind them would then be exposed to precisely the same danger.

CHAPTER II.

Damage caused by Atmospheric Precipitations.

14. *Different kinds of Precipitations.*

The precipitation of the aqueous vapour contained in the atmosphere can take place in many ways, as is well known. It may be deposited in a watery form as *dew*, always beneficial to vegetation, or, when condensed in the upper aerial layers, as *rain*, which falls with more or less violence. When the temperature of the plants sinks by radiation of warmth below the freezing point, *rime* is formed; and when the cooling down of the upper aerial layers is equally great, *snow* falls in place of rain, the flakes being small and dry if the cold is great, but large and moist if the temperature be only slightly below the freezing point. When the snow hanging to the trees freezes after having previously thawed, or after having fallen as moist snow, an *ice-accumulation* is formed, as also occurs when rain suddenly falls after previous severe cold; whilst rain-drops that have become greatly cooled in falling through the lower-lying cold layers of air crystallise into ice as soon as they come in contact with cold bodies, and cover branches, twigs, dry foliage, &c., with sometimes quite a thick layer of smooth *sheet-ice* or *frozen sleet*. *Hoar-frost* is formed when the aqueous vapour (mist) of the atmosphere is deposited in the shape of ice-crystals on bodies cooled below the freezing point, as often takes place to a large extent on branches and foliage; and, finally, the well-known injurious phenomenon of *hail* is caused by sudden depressions of temperature in the atmosphere, combined with electrical disturbances.

The influence of these phenomena on woodland growth is manifold, and under certain circumstances very injurious.

A. Rain.

15. *Injuries caused by Rain; Preventive Measures.*

In general, the effects of rainfall are in the main beneficial, as the vegetation thereby receives the supplies of moisture so essentially necessary for its thriving. The continuous want of rain in summer, especially during May, is often productive of the worst results for young sowings, and for transplants that have not yet established themselves in their new abode. A rainy year is, on the other hand, always advantageous for woodland growth, as the young crops prosper well, and plants and trees injured by late frosts or insects get a quicker and fuller flush of new foliage, so that a very large rainfall can only be injurious on soils that are of themselves moist.

But rain can also be of itself injurious if falling in sheets or descending with great violence as a water-spout, when large quantities of water reach the ground in a short time, whilst less violent rainfall is also injurious, if of long-continued duration. Scouring and washing away of the soft upper soil from unprotected hillsides, and of the layers of dead foliage and humus from better protected areas, washing out of the seed from sowings and seed-beds, interferences with the latter, more especially on slopes, and damage to ditches and roads, are not infrequently the results.

The means of preventing such damage consists chiefly in the maintenance of a suitable stock or crop of timber on steep hillsides, judicious and gradual reproduction of the same, avoidance of grubbing up the stools, and retention of the soil-covering of undergrowth, brushwood, moss or dead foliage. The very great importance of woodlands, and of their natural soil-covering on steep slopes, more especially in mountainous tracts, is now thoroughly recognised, in respect to the regulation of the running off of moisture, the prevention of the scouring and washing away of the surface-soil or of inundations, the maintenance of a gradual circulation of moisture for the perennial feeding of springs and brooks,—in short, their influence as protective forests. The woodland crops break the violence of rainy downpours; stumps, roots, and, above all, the layer of dead foliage and moss, hinder the speedy off-flow of the water that has reached the ground, and give it time to percolate into the soil; fallen leaves

and moss, together with the humus or vegetable mould formed by their gradual decomposition, imbibe, with sponge-like absorptive power, large quantities of moisture, which they retain and only gradually part with again to the soil and the atmosphere. In most countries the maintenance, tending, and economic treatment of such protective woodlands is provided for by law.

The formation of horizontal ditches for catchment of the water, is a measure that has found extensive application in recent years. The ditches, running horizontally along the hillsides, are formed about 12 inches deep, and in parallel lines about 16 to 32 feet apart, according to the steepness of the slope; as they not only catch the water flowing down from below the ditch immediately above, but retain it to percolate gradually into the soil below, they work beneficially in a double manner (*see* par. 12).

Sowings on slopes should always be carried out in horizontal rills or bands, as otherwise the seed is apt to be washed away by the down-pouring rain. Although the formation of nurseries on soil with a steep gradient should be avoided as much as possible, yet this cannot always be helped in mountainous tracts. Where this is unavoidable, something can always be done to improve matters by terracing the ground, placing the seed-beds and the paths between them horizontally, leaving bands of unbroken soil with its original covering of weeds, &c., between the beds, so as to check any tendency to scouring of the soil, and formation of narrow seed-beds in place of larger patches or seed-plots. The washing away of the seed can be prevented by covering the beds with branches, moss, or frame-work.

B. Snow.

16. *Damage caused by Snow.*

So long as the snow is dry, and does not fall in too large quantities, it does no damage to woodlands; on the contrary, it protects young growth from damage at the time of felling and extracting timber when the standards are being cleared, makes extraction easier, prevents the roads being badly cut up, and is one of the chief sources whence are obtained the winter moisture so necessary for the well-being of timber crops during the summer.

But when the snow falls in moist, large flakes, and accumulates in large quantities on the leaves, twigs, and branches of conifers,

and on the dead foliage still adhering to deciduous trees, not infrequently freezing with a fall in temperature, and then offering an increased foothold for further masses of falling snow, the enormous burden thrown on the crowns of the trees becomes too great to be borne. Wholesale damage can then often be caused by the accumulations of snow either snapping off the tops of the trees or breaking off the branches forming the crown, or else simply throwing or crushing down the whole or a considerable part of the crop, by reason of the enormous pressure exerted on the crowns.

When branches, top-ends, or even poles and stems nearer the base are snapped by snow, the damage is said to be done by *snow-break;* but when the effects of the accumulations are, as may often be noted in young plantations, even of species of trees that are by no means easily thrown, to throw individual stems, or whole patches, or larger portions of the crop to the ground without breaking the bole, so that sometimes even the roots are drawn out of the soil, the damage is said to be caused by *snow-pressure.* When poles bending under a load of snow are burdened for some time with the accumulation, they lose the power of recovering their original upright growth, remain bent or crooked, and gradually die off.

Snow-break occurs on single individual trees, or in patches throughout the crop, whilst, on hillsides, lanes are sometimes opened out by it; but, as a rule, it occurs mostly in small patches in the interior of forests, and on individual trees only near the edges of the compartment.

The damage wrought by such snow accumulations on a somewhat extensive scale are partly direct or immediate, partly secondary or indirect.

As direct or immediate consequences, may chiefly be noted the interruption of leaf-canopy, and blanks formed in the crop, with the loss of increment which is thereby entailed. The damage done is, of course, the greater, the more the continuity of the canopy is interrupted and broken, and not merely lessened in density; and the younger the crop is, the less will be the returns procurable for the timber that will have to be extracted and utilised. The damage can sometimes assume such proportions that the whole of the immature crop may have to be prematurely harvested. The growth of weeds and brushwood, and the deterioration of the soil in consequence of the injurious effects of insolation and winds on it,—for the soil, no longer

sufficiently protected, soon gets covered with all sorts of noxious weeds, whortleberry, heather, &c.,—often cause extreme difficulty in the reproduction of the crop later on.

A loss in timber is caused by the splitting and breaking of many stems, and a still greater loss arises from the fact that, in consequence of breakage and splitting, many stems and boles otherwise suitable for the higher technical purposes of timber, are no longer, or at any rate only partially, thus advantageously utilisable.

The glutting of the market with timber soon causes prices to sink, more especially as the bulk of the timber thus exposed for sale is usually of small dimensions, consisting of poles, top-ends, brushwood, and the like, so that sometimes it is perfectly unmarketable, and hardly covers the cost of extraction. And at the same time, in contrast to this, when considerable damage has been done over extensive areas by accumulations of snow, the increased demand for workmen, and the greater difficulties than usual connected with preparing the timber for sale, often lead to a very considerable increase in the price of labour.

The costs of reproductive measures entailed by the necessity of re-wooding blanks, of underplanting crops whose density of canopy has been interfered with, and of re-planting areas where immature crops have had to be cleared, are all practically classifiable under the direct consequences.

Of indirect or secondary consequences, the most important is danger from insects, owing to the favourable conditions for the increase of injurious species offered through the innumerable breeding-places formed by the broken wood, the damaged and consequently unhealthy stems and poles, and the stumps and roots remaining in the ground. Under normal circumstances, a prudent forester removes such material at a proper time; but when abnormal conditions obtain, this is often not possible, and bark-beetles (*Bostrichini*), weevils or proboscid-beetles (*Curculionidæ*), and cambial-beetles (*Hylesinini*) increase rapidly, and occasion fresh calamities.

But in addition to that, extensive damage from snow-accumulations can occasion such deviations from the ordinary course of management and the prescribed sequence of the annual falls of timber, and such consequent interferences with the rotation of fellings and the representation of the various age-classes, as to necessitate a re-survey of the existing stock of timber of all ages, and even the formation of an entirely new Working Plan.

17. *Factors determining the Occurrence and Extent of the Danger.*

The nature and extent of the damage done by snow, and the frequency or infrequency of its repetition, are due to many circumstances and influences.

Soil and Situation are perhaps of first importance in this respect, as damage is most frequent in high ranges of hills and among the outlying hills of high mountain chains. On plains and in low-lying tracts snow seldom falls in vast quantities; whilst at higher elevations in mountainous localities, the flakes are mostly dry, small, and therefore comparatively uninjurious. Timber crops that have shot up quickly with clean stems, are naturally much more exposed to danger from snow than the shorter-boled crops on less productive soil.

But *species of tree, age of crop, and density of canopy* are also of influence in the matter, as snow-break occurs when the burden of snow on the crowns exceeds the carrying power of the stem, whilst the pressure is determined by the quantity of falling snow which settles on the crown, and by the weight of the snow, which is more than twice as great in the wet state than when dry. The formation of the branches and the nature of the foliage determine the quantity of snow accumulating on the individual tree, whilst the density of canopy determines it for the whole crop. It is therefore clear that the evergreen conifers, Silver Fir, Spruce, and Pine, must be more exposed to danger from snow than broad-leaved deciduous species and Larches that are defoliated in winter, and hence offer a much smaller resting-place for the falling snow,[1] although broad-leaved species are by no means exempt from

[1] Interesting measurements made by Bühlers in Switzerland, after heavy snowfall, gave the following results:—

Depth of Snowfall in the Open.	Depth of Snowfall on the Soil inside the Forest.	Percentage consequently intercepted by the Timber Crop.
13·3 inches.	Dense Spruce Plantation, 15 years old, 3·2 inches.	76 per cent.
13·3 ,,	Natural reproduction of Spruce, 40 years old, ... 1·6 ,,	88 ,,
11·2 ,,	Spruce Forest in close canopy, 90 years old, 5·2 ,,	54 ,,
11·2 ,,	Beech Pole-forest, 35 years old, . . 10·0 ,,	11 ,,
11·2 ,,	Do. 55 years old, . . 10·0 ,,	11 ,,
13·3 ,,	High Forest of Beech, 70 years old, . 10·8 ,,	18 ,,

snow-break and snow-pressure, when snow falling early in the season finds them with foliage still attached to the crown. Among conifers, the brittle Scots Pine suffers more from snow-break, whilst the tough, thickly-foliaged Spruce suffers more from snow-pressure during the earlier stages of development. Among the broad-leaved species, Alder and Acacia suffer occasionally from snow-break, on account of their brittle wood, whilst young crops of Oak and Beech are occasionally damaged by snow-pressure, owing to their retaining their dead foliage often long into autumn.

Snow-break mostly takes places high up near the top end, as may be noted in the frequency of double leading-shoots and bayonet-like growth of Spruce in tracts exposed to danger from snow; but it can also occur in the lower portions of the stem, especially if there be any weak point from former injury, left behind in consequence of tapping for resin, or stripping of bark by red-deer in the case of Spruce, or of cankerous fungoid growth on the Silver Fir. The danger is increased by unequal pressure owing to irregularity of the branch development, as on hillsides and at the edges of the forest, whilst in snowfall during windy weather the side exposed to the wind is always most heavily laden.

So far as the age of the crop is concerned, thickets suffer from snow-pressure only, but the more so the denser they are; hence thick sowings and natural reproductions suffer more than plantations, and unthinned woods more than such as have been thinned. Older crops from the pole-forest stage of growth onwards are damaged only by snow-break; the danger is diminished as the crop grows older, and the proportion becomes more favourable between the length of stem and its diameter, the danger of breakage being commensurable therewith.

In conclusion, it may also be mentioned that extensive damage from the accumulation of snow only occurs in high timber forest, coppice being almost entirely exempt from danger, and that in copse or coppice under standards, only the youngest class of slender standards gets bent down to the ground, and becomes unsuited for the purposes intended, if the pressure be continued for any length of time. Those who advocate the superiority of crops in which there is no succession of separate annual falls, but all the age-classes occur promiscuously over the whole area, and the annual fall takes place by selection of the mature timber throughout the whole crop, claim that such are much less exposed to danger from snow

than high forest with its annual falls or crops of equal-aged growth, owing to the more vigorous development of the individual stems and patches, and the irregularity and constantly varying level of the leaf-canopy.

18. *Preventive Measures.*

The means at disposal for obviating damage from snowfall are almost purely of a sylvicultural nature, and consist in the judicious choice of the species forming the crop, in its formation by the method best suited to soil and situation, and in careful tending of the woods.

In the higher regions, where experience has shown the danger of breakage to be greatest, the cultivation of the brittle Scots Pine should be avoided, a preference being, in general, given to the formation of mixed forests, and in particular to an admixture of broad-leaved species (Beech) wherever possible in coniferous woods, which are those most apt to suffer, for the passage of the snow to the ground is thereby assisted, as well as by the varying nature and level of the canopy in mixed forests. The formation of crops by means of planting at moderate distances has shown itself to be preferable to sowing, or to the planting of seedlings in wisps. But the most important preventive measure undoubtedly lies in the proper tending of the timber-crops. When thinnings are begun early, carefully carried out, especially at first, and frequently repeated, the density of the canopy becomes moderated, thereby rendering the passage of snow to the ground easier on the one hand, and on the other favouring a more equally balanced branch-development, and a speedier and sturdier growth of the dominating poles. But such thinnings should be very carefully conducted in crops that have grown up in dense canopy, in which the stems have been rapidly drawn up, and have consequently acquired little power of resisting pressure.[1]

Under exceptional circumstances, as in parks, ornamental plantations, small thickets of valuable species, and the youngest class of standards in copse, the snow can be got rid of by means of shaking, or by knocking against the stem; but on any very extensive scale such a measure can, of course, find no practical application.

[1] *Begin early; conduct moderately; repeat frequently.*—Such is the golden rule for thinning. Light-demanding species of course require more assistance in their natural struggle than shade-bearing trees.—*Trans.*

19. *Remedial Measures after the Occurrence of Damage.*

When damage from snow-accumulations has taken place on a large scale in any forest, the duty of the forester lies partly in the expeditious utilisation and advantageous disposal of the timber thrown, and partly in the judicious treatment of the damaged crops, in order that the permanent effect on their future well-being may be reduced to a minimum.

In respect to the former, some consideration must be given to the opening out of roads and rides, so that the forest is well opened out for the extraction of the damaged timber, and to the immediate removal of broken trees and ends in such crops as are being reproduced naturally, as without this the young crop is very apt to suffer damage. In order to obviate danger from insects, and deterioration in the quality of the broken timber, it should be prepared for sale with the utmost despatch, as much as possible being ranged in the class of timber for technical purposes, both with a view to the realisation of better prices, and because it takes less time to prepare for sale than fuel which has to be cut in lengths and stacked in fathoms. Where the damage is considerable, and the quantity of wood to be prepared for sale is very large, the commencement of utilisation is made with the timber that has been completely thrown, and the stems and poles that have been entirely broken; whilst such other stems as have a few green branches left, and can still continue for a short time in active vegetation, need not be attended to until the more pressing work is ended. The best means of preserving and seasoning coniferous stems, for which there is often no good immediate market, consists in stripping off all the bark, which at the same time, also protects them from attacks of bark-beetles (*Scolytidæ*), removing them to broad roadways or other airy places, in splitting up large fuel-pieces, so that they may get rid of their moisture sooner, and in placing suitable rests below timber and fuel-stacks, to keep them free from contact with the soil.

With regard to the treatment of damaged crops, those of broad-leaved species (Beech) which are just emerging from the thicket into the pole-forest stage of growth, can sometimes be aided by raising again and supporting by props and poles the patches that have been bent down, or by tying up the dominating poles and connecting them with a neighbouring older crop. But otherwise, when these

means are not practicable, the bent poles are cut back to the place where the bend occurs, so as to restore the canopy by means of the shoots then made from the bole; or the damaged patches are simply coppiced, and canopy is formed for itself by the new shoots that spring from the stool. In thickets of conifers the choice rests only between the clearing of the patches that have been pressed down and the planting up of the blanks with quick-growing species, or, when the damaged patches are small, and the crop has already attained considerable growth, underplanting with shade-bearing species (Beech, Spruce, Silver Fir), in order to protect the soil.[1] Underplanting of broken pole-forests of Pine with shade-bearing species is also highly recommendable; all gaps and blanks in older crops which are not intended to be utilised till some considerably later period, but in which there is danger of the soil becoming over-grown with rank weeds and thus deteriorating, should likewise be filled up with one or other of these species. A choice should of course be made of that most likely to suit the soil and situation.

After any such calamity, particular attention should be paid by the forester to the injurious insects, whose increase is exceptionally favoured through the large quantity of dead, dying, and sickly growth, green stumps, &c. Against these, measures should be adopted as early as possible.

20. *Damage done by Avalanches or Snowslips.*

In the woodland regions of mountainous tracts great damage can be done in the well-known form of avalanches, particularly by such, often of enormous extent, as are formed at the time of the melting of the snow, by the gradual descent of the snow-masses as they become heavier; owing to the setting in of thaw, they slip down the smooth steep slopes gradually at first, but rapidly increase in size to such an extent as to carry away everything opposing their progress, and to destroy woodlands lying in their downward course. Innumerable avalanches annually glide harmlessly down the same well-defined channels, and damage is only done when new courses are opened out. In many mountainous regions woodlands are maintained chiefly as protective forests, with the object of preventing the formation and occurrence of

[1] Weymouth Pine, and Nordmann's and Douglas Firs can also often be advantageously used for this purpose, as, besides being of rapid growth, they can bear a moderate shade.

avalanches—for they can never have their origin in the interior of woodlands—and of forming a protecting dam or obstruction to their downward progress when once they occur on their initial small scale above the wooded areas. These are termed *Ban-Wälder*.

The constant maintenance of a sufficient number of trees on the area, avoidance of a clear fall of timber, prudent selection of only mature and damaged timber for extraction and utilisation, careful reproduction of the crop, and the judicious use of artificial methods to aid and assist the work of natural regeneration are advisable, not only in the interest of the forest itself, but also of the pastures, arable land, &c., lying below the woodland tracts. The re-wooding of areas whose crops have been destroyed by avalanches is a matter of extreme difficulty, as the latter are apt to form again annually; hence all the greater necessity for prudence and caution in maintaining the existing woodlands. All such protective forests are everywhere on the continent under the direct protection, supervision, and treatment of the State Forest Department.

C. Hoar-Frost, Ice, Hail.

21. *Damage done by the Same.*

Accumulations of pendent ice on the branches and twigs also occur less frequently in lower-lying tracts than at higher elevations, and take place principally on northern and eastern exposures, as they are mostly produced by cold north and east winds. The species chiefly exposed to danger from this cause are the evergreen conifers, especially the Scots Pine, with its long foliage affording an easy foot-hold on which the ice may accumulate, and its brittle branches, little able to resist the weight tending to snap them off. Among broad-leaved species the brittle Alder is the principal sufferer, and next to that perhaps the younger classes of Oak standards in copse, when the crowns are still covered with the dead, dry foliage. Semi-mature crops, and those approaching towards maturity, are more apt to be damaged than the younger age-classes; whilst isolated trees, young standards in copse, old trees retained throughout a second period of rotation, and trees at the edges of the woods, offer more opportunities for the accumulation of ice, and consequently suffer more by reason of it, than regular crops growing in close canopy.

Heavy hoar-frost, causing the formation of ice, does all the more damage when immediately followed by a fall of snow, which then finds an easier foothold on the ice-coated twigs and branches, whilst the consequences of a repetition of snowfall after the previous formation of ice, through the thawing and then the freezing of snow lying on the branches, or of a snowstorm after all branches, twigs, needles, and dry leaves have been coated with smooth sheet-ice, are also so much more injurious, that damage on a most extensive scale may often be the result. Practicable preventive measures against such natural calamities are only adoptable in the most limited degree, and consist mainly in avoiding the cultivation of the brittle Scots Pine in misty tracts, in the retention of a good belt or fringe along all edges exposed to danger, and also in some cases, to a certain extent, in strong thinnings of the crops. The courses to be adopted, after damage has taken place, are the same as in the case of damage done by snow.

Hail-storms sometimes do very considerable damage in beating down and injuring the plants in young crops and plantations, and occasionally injure older crops to such an extent by injuring the bark, stripping off the foliage, twigs, and fruits, as to necessitate their immediate clearance. Here again, Scots Pine is the chief sufferer, being more sensitive to all such sorts of injuries, whilst Spruce and Silver Fir are better protected by reason of their denser foliage and closer branch-development. In Oak coppice hail brings the disagreeable consequence that at all the damaged and then cicatrised places the bark does not strip or peel easily, whilst the withes of osiers from willow-beds that have suffered from hail break off at the injured parts when beingutilised.

Preventive measures against damage by hail are naturally not at our disposal, but forests themselves seem to exert a certain amount of influence on the formation of hail by modifying extremes and equalising the distribution of atmospheric electricity during violent storms, so that by forming and maintaining a sufficient number of properly distributed woodlands some practical means do remain at our disposal for protection against and mitigation of the damage wrought by hail-storms.

CHAPTER III.

Damage caused by Aerial Currents.

22. *Damage done by Storms.*

Violent movements of aerial currents are commonly called *Storms*, and those of still greater violence *Hurricanes*.[1] Sometimes they are merely of a local character, but at other times they make their influence felt over large areas, and either come from a certain definite direction as continuous storms, or have a more or less circuitous movement as in cyclones. Most of the storms in Great Britain come from the west, north-west, or south-west, and their injurious influence is increased by the fact that they are frequently accompanied by rainfall, and either loosen the soil, or find it in soft, wet condition, which materially weakens the resistive power of the trees, whilst the less frequent and usually less violent east winds generally bring drought or frost along with them. Violent disturbances of the atmospheric currents are most usual about the time of the spring and autumn equinoxes, and the periods immediately connected therewith.

During violent storms, not only individual trees but also whole woods are either rendered *windfall* by being torn out by the roots and thrown to the ground, or suffer *wind-breakage* by being snapped through at a greater or less height above the base; whether windfall or breakage is more likely to take place depends on the species of the tree, the nature of the soil, the general health of the stem, &c. The damage done is sometimes confined to individual trees, but not infrequently extends, in the case of very violent storms, over whole crops or portions of crops, and in the latter case takes place in scattered patches or plots, or else in strips or lanes.

The disadvantageous consequences which can ensue to a forest

[1] Aerial currents shown by the anemometer to have a velocity up to 66 feet (20 metres) per second are classified as *Winds*; those whose velocity is from 66 to 116 feet (35 metres) as *Storms*; those beyond 116 feet (35 metres) per second as *Hurricanes*.

that has been extensively damaged by a storm are very important, and resemble in many respects such as are entailed by large breakage from accumulations of snow (*see* par. 16); but those due to storms have sometimes assumed enormous proportions, involving the throwing of scores of millions of cubic feet of timber.

The immediate and direct consequences consist in the interruption of the leaf-canopy, and the formation of blanks in the crops, hence leading to loss of increment and deterioration of the soil, and not seldom necessitating the premature harvesting of the damaged woodlands,—the breakage and splintering of many stems which are thus rendered useless for technical purposes, and can only be utilised as fuel, as well as other considerable loss in timber alone by the splintered portions being of hardly any use or value at all,—damage to areas undergoing natural reproduction, especially where the first reproductive felling has just been made, or where gradual clearance of the standards is taking place, owing to the parent standards being thrown, or to young crops through the throwing and breakage of stems that are being held over for another period of rotation,—glutting of the market with timber, with consequent reduction of the prices obtainable, and complete unsaleableness of the smaller assortments of otherwise disposable wood from branches, brushwood, and stumps,—and finally a rise in the price of labour, due to the great immediate demand and to the greater risk and danger involved in working among the enormous tangled masses of timber piled stem over stem in the greatest confusion.

As indirect or secondary results or consequences of extensive damage done by storms may be enumerated the failure of natural reproductions often necessitating costly cultural operations, owing to the rapid appearance of a rank growth of weeds,—increased danger from injurious insects, owing to the increase in the number of favourable breeding-places afforded by the unusual quantity of timber often lying for some considerable time in the forest, the sickly condition of damaged stems, and the stumps which it cannot pay to utilise,—the interference with the conditions for the maintenance of continuous, regular, or approximately regular annual outturn, with the distribution of the various successive annual crops throughout the stock on the total area, with the due succession of the prescribed annual falls, and generally with the whole arrangements of the Working Plan.

23. *Factors determining the Nature and Extent of the Damage.*

The occurrence of damage from storms, and the nature and the extent of the injury done, are dependent on many factors and influences.

The species of tree is, on the whole, the factor of greatest importance. The ever-green conifers—Spruce, Silver Fir, and Pine—retaining their foliage throughout the winter, and offering a much larger extent of surface to the violent winds that occur chiefly between the late autumn and the following spring, suffer damage to a far greater extent than the Larch and the broad-leaved trees which are then defoliated. And of these three ever-green conifers, Spruce is most exposed to danger, owing to its dense foliage and its shallow root-system; whilst the equally densely-foliaged Silver Fir is better protected by its deeper root-system, and, as far as concerns danger from storms, may on the whole be placed on about the same level as Scots Pine, which, though lightly foliaged and deeper rooted, is for the most part to be found on light, sandy soils. Among broad-leaved trees, Aspen, Birch, and Hornbeam suffer most in exposed situations, owing to the shallowness of their root-systems, and during violent storms also the Beech, whilst the deep-rooting Oak suffers least of all.

Young crops are damaged only exceptionally by storms: *the danger begins with advancing age*, and increases with the same, and consequently with long periods of rotation. Coppice-woods run no risk whatever, copse only comparatively little, and then according to the nature of the standard species, whilst it is only in high forest that extensive damage is done. Those high timber forests, whose yield is not harvested in regular annual falls or clearances, but by the selection of the mature stems here and there throughout the whole area under wood, and in which the individual trees have freer space for their development, acquire much greater power of resistance than such as are grown with the stock consisting of regular annual or periodic falls of equally aged crops. In the latter, too, the method of reproduction is also of influence, for where the smaller areas that would otherwise be allotted to several annual falls are included in one periodic fall for the purposes of natural regeneration, the interruption of the canopy during the preparatory and reproductive fellings, as well as throughout the subsequent clearances of the parent trees, causes the crops to

become an easier prey to the violence of the storm than is the case with high forest in which close canopy is maintained till the end of the period of rotation, and reproduction takes place only after the annual total clearance of the mature crop.

Besides the density of the canopy formed, the *general growth* of the trees is also of importance, as length of bole of course increases the danger of being thrown, on account of the leverage afforded by the stem, whilst this is diminished by shortness of bole. Sturdy stems that have been allowed to develop in comparatively free enjoyment of light and air are little exposed to danger, whilst such as have been drawn up rapidly in close canopy, and then suddenly admitted to the enjoyment of a greater amount of light and air, are most liable to suffer. Sickly stems affected with red rot, or perhaps damaged through former tapping of resin, or through stripping of the bark by red-deer, are very apt to break at the injured part.

Soil and Situation are also factors of essential importance, as localities exposed to storms suffer in a far greater degree than such as are protected by hills, ridges, or other timber crops lying to the windward. Shallow, light (sandy or marshy), damp soil increases the danger, whilst deep, stiff, stony, and rocky soils diminish it: when damage does however occur, it for obvious reasons mostly takes the form of windfall on the former, and of breakage on the latter. By soaking and softening the soil, rainfall increases the danger, whilst frost lessens it; and here again windfall will be the rule in the one case, and breakage in the other.

24. *Preventive Measures.*

Against very violent storms, hurricanes, and the much less frequent cyclones, no practical preventive measures can be adopted, as even in sheltered localities, and when forming good uninterrupted canopy, very great damage can be done to species, like the Beech for example, which are otherwise well capable of resisting the action of strong winds. But, on the other hand, Sylviculture and the Management of Woodlands furnish us with a variety of practical measures, by means of which the damage likely to be done by moderately violent storms can to a not inconsiderable degree be obviated. Such practical measures are included among the following:—

The Formation of Mixed Forests, in which the species most

liable to be thrown or broken are grown along with other species less apt to suffer,—as, for example, the growth of Conifers along with the Beech, or of Spruce along with Silver Fir and Scots Pine. In particularly exposed localities the growth of species very liable to danger should be avoided to as great an extent as possible.

Artificial Reproduction, and in the case of the Spruce, clearance of the annual fall in long, narrow strips, with subsequent artificial reproduction, in preference to natural regeneration, as the necessary thinnings and partial clearances both before and after the seed year would particularly expose the parent standards to danger.

The maintenance of a good *protective belt or outer fringe* of hardy, weather-beaten trees, long accustomed to the violence of storms, until the natural reproduction of the crop sheltered by it has been completed; or, if necessary, the formation of such a belt for the protection of young crops of species liable to suffer.

Prudence in regard to the Retention of Standards, only such being selected as are of species well capable of resisting the action of wind, and only stems of sturdy growth, and with well-developed root-systems. In very exposed localities, or on indifferently protected areas with light or moist soil, the idea of retaining standards should be given up, in order to avoid the damage that may subsequently ensue to the younger crops, should the standards become windfall.

Thinnings that are early begun, and repeated whenever necessary, exert a beneficial influence by promoting sturdiness of growth and a good development of the root-system. A careful *maintenance of close canopy* should be the rule; all felling operations that are likely to interrupt it, and form blanks or holes in it, should be avoided, especially in the case of the evergreen conifers most exposed to danger.

Particular influences are also exerted by the *proper location of the annual falls*, and a *judicious succession of the annual crops*, which should receive very careful attention at the time of arranging the Working Plan that is to form the basis of management.[1]

[1] Denzon, in 1880, recommended for forests on the plain, whose compartments are marked off by regular rides or paths crossing each other at right angles, that the apex of the angle, and not, as hitherto had been the rule, the long side of the compartment, should be turned towards the west, so that the rides or divisions between the annual compartments should run from north-east to south-west and from north-west to south-east, in place of from east to west and south to north; in the former case only two sides of the compartment, those towards the west are endangered, and they

The *Fall of mature Crops* should always be begun from the side opposite to the direction of the prevailing winds; as has already been remarked, the most frequent and violent stormy winds come from west, north-west, and south-west, so that the annual falls should be commenced on the east side, and conducted in such manner that the line of clearance runs north and south (or from north-west to south-west), the succession of annual falls advancing gradually in the direction of the prevailing wind, under the lee and protection of the close canopied crops of slightly younger age. For coniferous forests especially, attention to this rule is of essential importance.

Further, whilst harvesting mature timber crops, care should be taken to *avoid the sudden exposure* of younger crops that have hitherto lain in their lee, but are of an age liable to be damaged by storms. In order to obtain a properly regulated and judicious allocation of the successive annual falls of timber, it is not infrequently necessary to delay the utilisation of older crops, and harvest younger ones somewhat prematurely when the Working Plan is formed and being worked for the first time.

One method of making such younger crops independent of the protection of older crops lying to windward of them, is the *system of cutting free or strengthening*, extensively practised in the Thüringer Wald. This consists in making a clear fall of timber in the older crop along a narrow strip from 33 to 50 feet broad, drawn between the sheltering wood and the younger one protected by it, and at right angles to the direction of the prevailing storms; the object is here to afford the younger crop the opportunity of developing a stronger root-system and more branching growth of the trees near the edge, and of thus naturally forming a protective belt strong enough to resist successfully the effects of stormy winds when the older crop is cleared away. An essential condition for the success of this system of cutting young woods free is that it must take place during the pole-forest stage of growth, whilst the younger crop is still endowed with the capacity of clothing itself with a thicker mantle of foliage. The cleared strip in the older crop should be at once replanted, so as likewise to form an artificial

can be protected against storms by judicious allocation of the annual falls and arrangement of the crops, whilst in the latter case there are three sides to protect, namely on the west, south, and north. This proposal, which is approved of by Borggreve in his work on the Management of Forests, is quite rational, but unfortunately comes too late to be applied in the case of any of the forests which have already been subdivided and formed into compartments under the old system.

belt when the former is cleared away. Although undoubtedly sound in principle, this system of strengthening young crops by cutting them free from the shelter of older woods has, up to the present, not enjoyed any very extensive or general adoption.

When fixing the *period of rotation* of a forest, that is to say, the particular age at which any crop shall be utilised, it should be borne in mind that, with increasing age, the danger from storms is also essentially increased, and particularly that the number of sickly and rotten stems gets larger as the crop grows older, and consequently tends likewise to augment the danger from stormy winds.

Two other methods may also be mentioned here in conclusion, which have as yet found application only exceptionally, but have hitherto proved useful, namely the lopping of the crowns of trees at the edge of the wood, and forming stone walls or heaping stones along the ground above the roots on the outer edge. The application of these means is based on the observation that storms are especially destructive wherever they have formerly formed blanks in the crops, so that it is essentially important to try and secure the stability of the trees at the windward edge of such blanks and interruptions of the canopy; and this security of the trees at the edge has practically been attained in Spruce woods with shallow root-system, by loading the roots on the windward side with a heavy mass of stones. A couple of strong poles were first of all placed over the roots, then cross pieces of $3\frac{1}{3}$ feet along the poles, and again a couple of long poles, and on this framework large stones and bits of rock lying about on the ground were piled up to a height of $1\frac{2}{3}$ to $3\frac{1}{3}$ feet. The windward trees and those immediately behind them were at the same time lopped at one-third of their height above the ground, so as to shorten the leverage obtainable by the wind; a similar measure was carried out on several individual trees standing further back, but towering high above their neighbours. As already remarked, the success of both measures was highly satisfactory.

25. *Remedial Measures after the Occurrence of Damage.*

The chief measures to be adopted after considerable damage has been caused by a storm are, so far as concerns the utilisation and disposal of the timber, and the treatment to be accorded to the damaged crops, in the main the same as have already been de-

tailed in regard to damage done by accumulations of snow (*see* par. 19). In the case of storms, however, there is this more favourable circumstance, that the windfall timber is generally older, of larger dimensions, and therefore easier to prepare for sale, and more likely to fetch a fair market price, than in the case of damage done by snow, when young crops and pole forests are chiefly injured.

But it must be particularly mentioned that in preparing the windfall timber for sale, attention should first of all be paid to the speedy removal of the parent standards which have been thrown on areas undergrowing natural reproduction, as they are often blown down in large numbers, and are very apt to kill any young seedling crop on the ground, if they are left lying for any length of time. If the quantity of timber thrown is so large as to forbid its immediate clearance, the windfall trees should at any rate be immediately topped, the branches and brushwood being removed to the roads and rides, and piled along the edges of the compartments. Similar remarks also apply in the case of standards that have been retained to grow in girth for another period of rotation, along with the younger crop forming the underwood. Where the trees thrown have been torn out of the ground with huge masses of earth attached to the roots, efforts should be made to kip or tilt these back into their former position after sawing through the stems, especially when numerous seedlings are noticeable in the soil thus lifted up, as the latter can easily be saved by this means.

The greatest attention is here also necessary in respect to injurious insects, the danger from which can best be obviated by working up the windfall timber as fast as possible, by removing the bark from all the coniferous stems thrown, by grubbing up the stumps, &c.

26. *Evil effects of Winds; Preventive Measures.*

It is not only the more violent storms that can do damage to forests, for continuous winds blowing always from about the same direction, though less violent in character, can also have a distinctly injurious effect on the well-being of woodland crops. Among such effects may be first of all noted the *blowing away of the dead foliage* near the edges of woods and of their compartments, and from exposed knolls and ridges; this hinders the formation of humus or vegetable mould, and dries up, hardens, and exhausts the

soil in some places, whilst in others it occasionally causes the dead leaves to be piled up to such a depth as to be positively injurious. All kinds of broad-leaved woods, Oak and Beech, high forest and coppice, are very sensitive to the blowing away of the dead foliage from the soil, and speedily show this in backward growth. But on the actual vegetation itself, continuous winds from any particular direction also exert their influence, as may be noted in abnormal, malformed crown-tops, lop-sided, rugged development of the crown, and crooked growth of the trees in the vicinity of the sea, or on lofty exposed heights.

Besides that, *dry east winds* exert a further injurious influence by exhausting and withdrawing from the soil the supply of moisture so necessary for the well-being of woodland growth, whilst at the same time stimulating the plants to an increased evaporation which tends to result in their withering (*wilting*) and drying up. These dry winds are most to be feared in spring, while sowing and planting operations are being carried out, and immediately after the cultural season.

The means at our disposal for the prevention of such injurious effects include the following:—

The Formation of Protective Belts or Fringes along the edge of woods and skirting threatened crops in the interior of the forest,—a measure which can, perhaps, best be attained by planting several rows of the thickly foliaged and shade-bearing Spruce. Where it appears possible or likely to succeed, the underplanting of patches or clumps exposed to danger with shade-bearing species (Beech, Hornbeam, Spruce, Silver Fir) is also of great advantage.

Limitation of the *thinnings* along the edge of the wood, and retention of all undergrowth and spontaneous natural reproduction, both near the edges and in the interior of woods exposed to danger. Hedges skirting woodlands should be carefully tended and trimmed in order to increase the density of their foliage.

The turning up of coarse clods near the outskirts of the woods by means of hoes and similar instruments also acts beneficially in retaining the layer of dead leaves and the soil-moisture. Should planting have to be carried out during dry east winds, particular care must be taken to keep the roots of the seedlings and the planting-pits moist, the former being wrapped up in wet moss or dipped in thin loamy mud, the latter being only formed, if possible, immediately before the planting takes place.

CHAPTER IV.

Damage Caused by Lightning.

27. *Occurrence and Nature of Damage.*

Lightning, as is well known, strikes trees comparatively frequently, either killing them or damaging them to a greater or less degree, although the damage done to woodlands from this cause can hardly be considered important; and even though there are no practical means at the disposal of the forester to obviate or mitigate the danger, still the matter is of sufficient interest to justify some short notice being taken of it.

When a tree is struck by lightning, the effects may be extremely various. In many cases it merely destroys a strip of bark about an inch broad, following the direction of the fibres, and hence assuming a spiral course in trees of a tortuous growth. With some broad-leaved species the wound thus inflicted cicatrises, and the trees continue undisturbed in growth, as may often be seen in the case of Oaks, whilst conifers struck by lightning seem invariably to die quickly from the effects. In other cases, the bark of the trees struck by lightning peels off almost entirely, being not infrequently completely smashed, split up, or thrown far around in little splinters. The leaping of lightning from one tree to another is a peculiar phenomenon that may sometimes be noted; whilst still more remarkable is the manner in which quite a large number of apparently uninjured stems gradually die off in the vicinity of a tree that has been killed by lightning, as may not infrequently be seen in Pine woods.

Dry stems, or such as are inwardly unsound and rotten, may occasionally be ignited and burned down by flashes of lightning, but in the case of sound green trees this has never been proved to be the actual fact; under such circumstances, lightning may be the direct cause of a forest fire, although this is seldom the case (*see* par. 117).

So far as regards the liability of the various species to be struck by lightning, none is totally exempt from the danger, although practically some are more and others less frequently damaged. Those most frequently struck are the Italian Poplar and the Oak, as both often stand in a more or less isolated position, towering above their surroundings, and therefore offering the readiest point of attack to the electric fluid; Spruce and Pine are also frequently struck, whilst this is much less often the case with the Beech, which is in some places erroneously considered to be proof against lightning. According to Hellmann's observations, if the liability of the Beech to be struck by lightning be assessed at 1, that for conifers is 15, for Oak 54, and for other broad-leaved species 40.

CHAPTER V.

Disadvantages arising from unfavourable Soil and Situation.

A. Excess of Moisture; Wetness.

28. *Causes of Surplus Moisture in the Soil; Disadvantages due to the Same.*

Wetness, or excessive moisture in the soil, a condition that is not infrequently to be met with in woodlands, may be due to one or other of various causes. It may be caused either in consequence of springs without any proper off-flow channel; or it may be due to plastic, clayey, impermeable subsoil hindering and rendering impossible the percolation towards deeper layers of the atmospheric precipitations and of the water formed by the melting of snow on the ground; or finally it may be the result of temporary inundations, after the subsidence of which there has been no suitable means of a portion of the water draining off again. Stagnation of water in the soil may also be caused by the undue increase of soil-moisture percolating horizontally from neighbouring water-channels, or lakes, or ponds in the immediate vicinity. When there is a high degree of wetness, the soil becomes a *marsh*, *bog*, or *swamp*.

The vegetation forming the soil-covering offers a ready practical means of estimating off-hand the amount of superfluous moisture contained in the soil, and the ruling degree of moisture generally. The occurrence of Bulrushes (*Scirpus*) and Rushes (*Juncus*) already indicates stagnating moisture, as also the common Wire Bent or mat grass (*Nardus*), and the Hair-moss (*Polytrichum*); Sedges (*Carex*), Cotton-grass (*Eriophorum*), and Knot-grass (*Polygonum*) show a still higher degree of wetness; whilst Bog-moss (*Sphagnum*), in association with Cranberry and Bog Bilberry (*Vaccinium*

oxycoccos and V. uliginosum), and Marsh Cistus (*Ledum*)[1] indicate true bogs or swamps.

Essentially important as a certain degree of soil-moisture undoubtedly is for the thriving of woodland crops, yet too great a degree of moisture produces many disadvantageous results.

Most species of our forest trees have a *bad, often a crippled, development* on wet soils, in consequence of the want of due circulation of air in the soil (*æration*), of its low temperature, of the incomplete decomposition of the organic débris, and the formation of free humic and similar injurious acids.

Owing to the strong evaporation, *damage from frost* is especially frequent in wet localities, resulting in the dying off of the tender portions of the plants, and in the lifting of the soft soil and the consequent death of the seedlings or transplants; this danger can, on very moist soil, assume such proportions as even to lift out of the ground the stronger, larger classes of transplants that have been put out with balls of earth attached to the roots.

On old stems, and particularly in the case of the Spruce, the appearance of *red-rot and disease of the stool* is very often directly due to excess of soil-moisture.

Windfalls are also much more frequent on soils that are constantly soft from moisture, especially when a clayey layer, the cause of the wetness, at the same time prevents the roots of the trees from working their way down into the subsoil. *The ordinary operations of forestry*, and particularly the preparation and removal of timber for disposal, are also considerably interfered with when the soil is always wet,—so much so, in fact, as to be only carried out during, and often to be practically dependent on, continuous hard frost during the winter (*e.g.*, massy Alder crops).

But all *species of trees* are not affected to anything like a similar extent by wetness of the soil and the drawbacks consequent thereon. Thus, the common Alder and the majority of the Willow tribe can not only bear, but actually prefer, a high degree of moisture, whilst a few species of Poplar, and also Ash and Hazel in a less degree, can thrive quite well even on a very moist soil; but in all these cases it is always moisture in circulation, and not stagnating moisture, which suits them. Among conifers the Spruce can stand a high percentage of moisture in the soil better than any other species.

[1] According to Hooker's *Flora*, it is doubtful if *Ledum* occurs in Britain.—*Trans.*

29. *Remedial Measures; Principles of Drainage.*

In order to counteract excess of moisture, and to succeed in obviating its injurious consequences, the predisposing cause of the wetness must first of all be ascertained.

Should this be occasioned by the exit of *subterraneous springs* without any proper channel for the off-flow of the water, these should have proper basins dug round their mouths, and the water should then be drained off by means of ditches.

If, on the other hand, the wetness is due to *impermeable subsoil*, this can also easily be remedied, if the gradient be sufficient, by means of ditches conducting to any lower but not very distant water-level; should, however, such difference of level not make itself apparent, the task of carrying off the surplus moisture is increased in difficulty, but can still be arranged for by boring a passage for the water through to the subsoil, or by lowering the water level by means of ditches. When the impermeable stratum (of plastic clay, moorpan, ironband, &c.) is only of slight depth, and the swampy tract of moderate extent, the water can be conducted to the subsoil by tapping or boring through the impermeable layer at its deepest point; the hole made should not be too small, and should be covered over with large stones to prevent it being soon choked with silt. In many other places[1] the water-level is reduced by digging over the whole area, ditches of sufficient depth, and not too far apart, and allowing the water to collect in them; and as at the same time the out-throw from the ditches is distributed regularly over the intervening spaces between these, the surface of the soil is thus artificially raised to a considerable height, and the intended sowing or planting can take place favourably on these raised banks or beds.

Inundations can be prevented by the facing and banking up of the sides of small brooks and streams, by clearing the river-beds of accumulations of silt, by increasing the gradient through cuttings and corrections of the water-courses,—most of which, however, are works going beyond the proper sphere of the forester.

The following may be considered *the main principles of drainage.* Only the excess or surplus of moisture should be removed from the soil, as too extensive depletion of moisture can have injurious consequences, not only for the actual areas in

[1] This is the general method of treatment of moorpan in Hanover.—*Trans.*

question and their vegetation, but also for their immediate vicinity and their further surroundings, on account of the general sinking of the water-level and the excessive withdrawal of the supplies of necessary moisture. Many very unfortunate experiences have already been made in this direction, in consequence of the too rapid off-flow of the atmospheric precipitations, a too great drying up of the soil, the fall of the water below the level necessary for working saw-mills and other works, the drying up of springs, &c.

The water obtained from the drainage of elevated tracts should be utilised, wherever necessary and possible, for the benefit of lower lying woodlands, by being conducted along dry slopes, as can also be done with the water collecting in ditches along the sides of roads (*see* par. 12). The drainage of an unwooded area should always be carried out some time before it is intended to stock it, in order to allow the soil to set. The drainage of woodlands should be conducted with great caution, and only to a very moderate extent; drains which pass through older crops, in order to carry off surplus moisture from other areas, not infrequently have an injurious effect on the former, owing to sinking of the ground and consequent exposure of the roots, as in the case of the Spruce, or even cause drying up of the tops of the crowns, as in Alder woods.

In the planting up of tracts that have been drained, but are still somewhat moist and inclined to a strong growth of rank grass, choice should be made of strong transplants of such suitable species as are little sensitive to frost, which should be put out during dry autumn weather, with balls of earth attached to the roots, if necessary; whilst for moist localities, tumping, or planting on mounds or on beds as above described, is highly recommendable.

30. *Carrying out of Drainage by means of Ditches.*

The removal of surplus water generally takes place by means of open ditches, and less frequently by drains covered with stones or brushwood, or through pipes. It is essential that there should be a sufficient fall towards some adjacent pond or water-channel whose level under normal conditions is constantly, or at any rate as a rule, below that of the water in the area to be drained. In the former case, the drainage can be carried out at any time without difficulty; but in the latter, water-gates or sluices must be formed

at the mouth of the ditch, in order to hinder the ingress of the water whilst it attains a higher level than that in the ditch.

Accurate levelling should take place before any extensive drainage work is undertaken, and is also necessary even in smaller cases when the difference in level is slight; but otherwise, for unimportant drainage works with a considerable difference between the levels, the ditches may be marked off with the naked eye, or with the use of the most simple instruments.

The leading off of the water from a large area generally takes place by means of small feeders, which conduct the water that collects in them into side drains, and these again lead it into the main drain.

The main drain is best formed along the line connecting the lowest points, and thence conducted at once in the direction of the strongest gradient towards the pond or water-course into which it is to debouch. If the difference in level is so great that any scouring out of the ditch or damage to its walls may be apprehended, owing to the velocity in the flow of the water being drained off, the danger can be obviated either by a terrace-like arrangement of the bottom of the ditch, in which case some sort of paving is requisite, or, if possible, by prolonging the course of the drain by sinuosities. Its width and depth depend on the quantity of water to be drained off, the depth of ditches and drains being reduced merely to what is absolutely necessary, not only to lessen the expense, but also on account of the usual desirability of draining the upper layers of the soil only; for anything like a thorough drainage of the soil is very apt to exert an injurious influence on the vegetation. The width of the ditches and drains depends on their depth and their scarp, which can be steeper in proportion to the tenacity of the soil; they must be the more sloping, in proportion as the soil is loose, and apt to get washed away or to fall in.

The side-ditches may debouch into the main drain either at right angles or at an acute angle, the latter arrangement being preferable when they have any considerable gradient, and are likely to conduct large quantities of water into the main drain; for in that case, if debouching at right angles, the water would be apt to scour out or undermine the opposite side of the main drain. Width, depth, and distance between the side-ditches, as well as in

the shallower and narrower feeders which lead into the latter, are regulated by the nature of the soil, and depend mainly on its greater or less degree of wetness.

The execution of drainage works should be carried out at the driest time of the year, during late summer or in autumn, work being begun with the main drain and at the lowest level, and gradually working upwards towards the higher levels, as otherwise work would be interfered with by the water descending in the drains as they were being formed. The earth removed from the drains and ditches should be thrown out on either side; for if merely banked up at the edges, it might easily be washed back again into the ditches by heavy rain.

When once formed, the ditches must be kept clean and in good condition as long as necessary, reeds and other aquatic weeds being cleared away, earth that has been washed in being dredged out, and any damage to the scarps repaired. It may not infrequently be observed that areas, which, when unwooded, have an excessive quantity of moisture, gradually get rid of this through the crops imbibing larger volumes of water for transpiration through the foliage as they grow older, and in such cases the retention of the drainage ditches has no longer any object, so that they can be left to choke and fill up.

Open ditches are certainly the cheapest means of drainage for temporary requirements, but they are easily damaged in many ways by rain, frost, &c., as well as by cattle and by men; they are also apt to interfere somewhat with communications, and especially with the extraction of timber, besides necessitating frequent outlay for repairs. Instead of such, therefore, covered drains constructed with stones, fagots, or brushwood, are also occasionally formed. The ditches dug are, for the most part, filled up with fascines or bundles of brushwood on which a layer of moss or turf is laid, and then earth is piled over this; the interstices between the brushwood, which remains undecomposed for a number of years, form the channels through which the water percolates, and suffice for a merely moderate and often the most advantageous degree of drainage.

On account of the greater cost involved, the filling up of the drains with stones in place of brushwood takes place less frequently; it depends for the most part on whether the necessary material can be found in the immediate vicinity, and

consequently at a cheap rate, or not,—although, of course, such stone-drains remain active for a much longer period.

The execution of drainage works by means of the subterraneous pipes, which are so much employed for similar purposes in agriculture, will, on account of the much greater outlay involved, only very exceptionally find application in woodlands. But at the same time it may be remarked that very wide drain-pipes may here and there be advantageously utilised in road-making in place of the more expensive culverts formed of masonry.

B. Deficiency of Moisture; Dunes, Shifting Sand, or Sand-Drifts.

31. *Definition, Causes, Disadvantages.*

Sand-drifts are composed of small particles of quartz devoid of all binding or cementing (clayey) material, which, owing to their minuteness and lightness, are apt to be carried from one place to another by the wind; they are consequently never stationary at one spot, but keep continually moving about.

Such shifting sands are mostly, and in greatest quantities, to be found skirting the sea-shore and along the banks of many rivers, in consequence of the cementing particles having been washed out by the water and deposited at the bottom, whilst the fine particles of quartz have been thrown on the bank or shore by the waves, and have, in course of time, collected often in enormous quantities (*Dunes*).

Shifting sand is, however, also found inland, mostly on areas which formerly formed part of the ocean, and whenever robbed of its soil-covering and its protection, is liable to drift. Such inland sand-drifts are common throughout the great north German plain, stretching from near the Rhine to the eastern confines of Prussia.

Even when bound together by means of some vegetable soil-covering, such soil is naturally very unremunerative, so that at best only small returns can be obtained from it by means of timber-production; but when once the sand is allowed to drift, in consequence of the soil being denuded of its covering, it at once threatens neighbouring fertile land, often buries it deep under unproductive sand, and converts it also into sand-drifts,—a process that has unfortunately too often taken place over very considerable areas.

Shifting sands are of special interest to the forester, not only from the fact that most sand-drifts are dedicated to the production of timber, but also because the retention or formation of woodlands on such areas is the best, generally indeed the only, means of preventing the sand from drifting, and of binding the shifting soil in order to protect neighbouring areas which have better soil. And at any rate some return may thus be obtained from the land.

The binding of sand-drifts and the reclamation of dunes are generally carried out by means of the Sand-reed (*Arundo arenaria*), the Lyme-grass (*Elymus arenarius*), and the Sand-sedge (*Carex arenaria*). All of these are plants with halms ramifying under the surface of the soil, and consequently suffer no injury from being covered with sand; but tree growth (of *Pinus montana*) is also employed to a much less extent. The binding of dunes is generally the work of men specially qualified for the task, whilst the fixation of inland drifts forms part of the duties of the forester; in the following paragraph therefore, only these latter will be taken into consideration.

32. *Prevention of the Occurrence of Sand-drifts.*

The safest means of preventing the occurrence of new sand-drifts is the careful retention of the soil-covering, whether consisting of woodlands, or of weeds of any description.

If the area in question be wooded,—and as a rule Scots Pine is the accommodating species forming the crop in such cases,—the harvesting of the timber must take place with a due amount of caution; any extensive clearance should be totally avoided, and the fall should be mainly confined to the clearance of very narrow strips,[1] and not repeated, or proceeded with further, until the rewooding of the fall last cleared has been assured. The series of fellings must take place in the opposite direction to the prevailing winds, and each annual fall should be at once planted up without any delay. The grubbing up of stumps, the removal of dead foliage for manure, and the exercise of pasturage, leading to loosening of the soil, and loss of soil-covering, should all the more be guarded against, as the dead leaves are more urgently

[1] Natural reproduction under parent standards, which has also been recommended for such circumstances, can not be satisfactorily carried out on sand so dry as to be liable to drift.

required here than in most other places for the formation of humus, whilst the pasturage can really only be of very small value.

When reproductive measures are being carried out, which can most advantageously take place by means of planting, care should be taken to avoid any unnecessary breaking up or loosening of the soil, or removal of the soil-covering, whatever it may be, as even the presence of heather, under other circumstances a noxious weed, is welcome at the time of replanting.

33. *The Binding of Shifting Sand.*

Without taking into account the cases in which sand may be allowed to drift in consequence of injudicious treatment, and especially of want of caution in the harvesting of the mature timber, natural causes, such as insect calamities, forest fires, and storms, may also result in a sudden laying bare of the soil, followed by drifting, and it then becomes the duty of the forester to bind or fix them again.

In order to bring sand already in motion to a standstill, efforts must be made to transform it into woodland, but this has its special difficulties, owing to the mobility of the sand, which leads to small seedlings being laid bare in some places, or buried under sand in others; hence, wherever the areas to be reclaimed are at all extensive, preliminary measures must first be adopted to interfere with the free motion of the sand, before proceeding to the operation of planting up the tract.

This takes place either by covering the area in question with sods, &c., or by forming fences or hurdles of woven twigs or brushwood, or by a combination of both of these methods.

The covering of the sand with sods is either carried out completely over the whole area, or else only partially, the latter generally being the case, owing to the greater expense involved in the former. The material used for covering is either turf, peat of little value, or brushwood. The first is either laid down in strips over the area, or more or less like the pattern on a chess-board, hillocks and bunkers especially being carefully and closely covered, whilst brushwood (as a rule, only that of the Scots Pine is available in such localities) is stuck into the ground with the thick end turned towards the direction from which the wind

comes, so that, with the tops pointing to the ground, it covers the soil somewhat in the same way as slates lie on a roof.

The woven fences or hurdles, which have also the object of breaking the violence of the wind and preventing the raising of the sand, are of special use in operations conducted over extensive areas very much exposed to the wind. They are erected facing the direction of the prevailing wind,—that is to say, they run from north to south and face westwards, where westerly winds prevail,—and are bent into a half-moon shape at the ends in order still to form a protection even when the winds are deflected to north or south; they subdivide the whole area into a series of strips, whose breadth, or the space between the parallel lines of fencing, is dependent mainly on the local circumstances of each case, but varies from 100 feet on sloping, broken ground, or more exposed localities, to 200 feet apart on level tracts.

The erection of the fences takes place by driving piles or poles of Scots Pine, about 4 to 6 inches in diameter, and about 5 feet in length, into the ground at distances of about $2\frac{1}{2}$ to $3\frac{1}{2}$ feet apart, according to the nature of the material available for filling in the woven work, the posts being driven in to such a depth as only to leave about 40 inches out of the ground. Between these upright posts green Pine branches, or occasionally broom, or reeds, or sedges, are woven in horizontally, but not too closely, only to such an extent that drifting sand may sift through to the other side when blown about by the wind, and thus prevent the hurdles being thrown by the pressure of sand heaping itself up against them; the object of the hurdles is not so much to intercept the sand, as to prevent its becoming drift through the action of the wind. In some cases, Poplar and Willow poles are used as the uprights, in order that, if there be any subsoil-moisture, they may take root, and thus be saved from rotting; whilst in other places, in order to reduce the requisite number of dear poles, the hurdles are formed with uprights up to 10 feet apart, lashed together by means of horizontal battens between which the Pine twigs, brushwood, &c., are woven vertically; this kind of fencing has found the most extensive application in many localities.

By breaking the violence of the wind, these lines of fencing give the sand a chance of remaining at rest; whilst by a simultaneous covering of that part of the intermediate strips, furthest removed from the lee and shelter of the hurdles in front, with sods of turf,

&c., the object is more securely attained, and at the same time the possibility offered of erecting the rather expensive lines of hurdles somewhat further apart.

The commencement of operations is, of course, always made from the windward side,—that is, in general, from westwards down wind towards the east.

It may be mentioned that on the island of Seeland very good results were obtained by covering the sand with a thin layer of loamy soil, which is certainly expensive, but much to be recommended in the case of bunkers or other small patches particularly exposed to danger. The loam is conveyed in autumn in little heaps to the area to be operated on, and there becomes so acted upon by the frost in winter as to be easily pulverisable in the following spring, when it is scattered in a thin layer over the sand; during the next few years it binds this to a sufficient extent to permit of Scots Pine, which may be sown or planted out, establishing itself in growth.

Another means, strongly recommended, of aiding the work of wooding sand-drifts is the use of the *Helianthus tuberosus*, a species of tuberculous plant closely allied to the common sun-flower: it makes very little demand in regard to the quality of the soil, grows even on the poor sand-drifts, can easily be reproduced and increased by means of its tubers, from which it throws out in spring long flexible stalks of 7 to 10 feet in height, that sway about in the wind without breaking, and that remain standing throughout the winter. Thus, whilst this plant protects the soil against the wind throughout the whole year, it is also able to protect the seedlings planted out against insolation and drought, and to a certain extent against the action of frost.

The wooding of the area should at once proceed hand in hand with the binding or fixation of the sand by means of covering with turf or erecting hurdles. The consideration of the most suitable species of trees, and the most suitable method to be adopted in the formation of the young woods, properly belongs to the domain of Sylviculture; but it may be briefly referred to here for the sake of completeness.

Scots Pine seems, on the whole, the most suitable species, and the one by far the most generally chosen in such cases, although Birch and Acacia are also capable of thriving on poor sandy soil. When the subsoil is moist, Canadian and Black Poplars, and a few

species of Willows, are also suitable for cultivation. As a timber crop simply and solely for the protection of the soil, and in particular for the formation of protective belts along the coast of the Baltic sea, satisfactory results have during the last few years been attained by the cultivation of the Mountain Pine (*Pinus montana*), which is the more especially suited for such an object on account of the lower branches, that are longer than the upper ones, not dying off but remaining alive down to the very ground.

Planting is certainly the safest means of effecting the formation of woodlands on shifting sand, and has now everywhere taken the place of the former method of sowing which was apt to be uncertain in its results. For very apparent reasons, strong transplants are preferable to small seedlings, and transplants of Scots Pine, with balls of earth attached to the roots, preferable to one or two-year-old naked seedlings or transplants. But as in such sandy districts plants retaining balls of earth around the roots are not often obtainable, one is not infrequently compelled to make use of naked transplants; these should be made to develop as deep roots as possible in the nursery, and be planted out somewhat closely. When Poplars or Willows are utilised for this purpose, they are put out as poles or strong layers.

All young plantations should be frequently seen to, and blanks at once carefully filled up, as the plants often die off in very considerable numbers in dry years; this matter should receive proper attention in preference to pushing on the work of reclamation further in any hasty or imperfect manner.

CHAPTER VI.

The Diseases of Timber Trees.

34. *Definition, Causes.*

Under diseases of trees are comprised all disturbances of the organism, in consequence of which the whole plant or any portion of it dies prematurely. In the former case, premature interruption of the canopy formed by the crop, and loss of increment will be the result; whilst in the latter, the individual stem is frequently totally, or partially, useless for the more valuable technical purposes.

Disturbances in the normal development will always precede or accompany any total or partial death; but not every such disturbance in growth or development, as so often happens in consequence of want of nourishment, light, or moisture, can be termed a diseased condition.

The predisposition of a tree to disease is any condition, even if only temporary, which, although not in itself involving any injurious consequences, and perhaps even quite consistent with the normal appearance of all plants at certain times, may ultimately develop into a disease by the addition of any second external factor. Such predisposition to disease may be occasioned by either extreme of age, (old age in particular rendering many species liable to disease), by early or late flushing of foliage in spring, by smoothness of the bark (scorching or sunburn), by growth in shade or on moist soil, or else through wounds or injuries which open a door to infection with fungoid disease, &c.

Diseases of trees may be occasioned as follows:—

1. By external injuries.
2. By influences of the soil.
3. By atmospheric influence.
4. By plants, phanerogamous or cryptogamous.

The diseases which are occasioned by plants will be treated in the second section under the chapter "*Damage caused by Plants,*" as more properly belonging there; but in the following the other diseases of woody plants will be treated of in the briefest possible manner, some reference, however, being made to the preventive measures that can be employed against them.

35. *Diseases of more Common Occurrence, and their Prevention.*

(1) *Results of External Injuries.*

Wound-rot, or rot in wounds, can take place, without the presence and co-operation of fungal parasites, on portions of the plant exposed to the air, in consequence of bruises, stripping of bark by deer, scorching of the bark, and the like; although fungoid growth, as a rule, finds its way into such weak spots. The wood at the same time assumes a more or less dark colour; but when the process of decomposition has advanced further, it resumes a lighter hue in consequence of the disappearance of the dark humic solution. Through injuries to the roots, such as are especially frequent in the case of shallow-rooting species, and are caused by the extraction of timber, treading of cattle, &c., rot can easily set in, which often works its way up into the stem; the brown patches noticeable on the stumps of mature Spruce that have been felled are mostly the consequences of such injuries. Covering the damaged places with moss or mould stimulates the action and progress of the rot, and wood-ants forming colonies often hollow out the stems up to a considerable height.

Stripping of the bark by red-deer, gnawing by mice, or extraction of resin from conifers, likewise give rise to wound-rot, and it may also be occasioned by imprudent or badly executed removal of branches; for if the branch cut or sawn away be too thick, and the wound arising therefrom too large, the place may be attacked by rot before it has time to cicatrise sufficiently. In such cases the rot often works its way deep into the stem. The avoidance of all injuries so far as possible, caution in the felling and extraction of timber, avoidance of the removal of branches that have already attained large dimensions, and tarring of the wounds

at the time of lopping branches, are the usual means of preventing the rot from taking place.[1]

(2) *Diseases due to the Influence of the Soil.*

Stag-headedness, or decay of the summit of the crown, may be the consequence of want of nourishment and moisture, or also due to old age. In high forests of Beech it may be noted long before the trees are mature, when the removal of the fallen leaves from the soil has been continued for any length of time; in forests of Oak, in consequence of interruption of the canopy, and consequent deterioration of the soil; in Alder crops, as the result of too thorough drainage; and on Oak standards also, as the effect of being suddenly admitted to free enjoyment of light, warmth, and air, which stimulate the development of the adventitious or dormant buds along the stem. Decay of the topmost portion of the crown in conifers is invariably quickly followed by the death of the whole stem; whilst stag-headed, broad-leaved species survive it for many years. The preventive measures mainly consist in the preservation of the layer of dead foliage on the ground, protection of the soil against deterioration by the underplanting of high forests of lightly-foliaged species unable to protect it for themselves, moderate drainage confined to the removal of surplus moisture only, gradual accustoming of standards to the freer enjoyment of light and air, or avoidance of maintaining individual standards at all.

Root-rot may also take place in consequence of stagnating water and defective circulation of the air in the soil. Under normal circumstances, a sufficient degree of aeration takes place through the variations of temperature in the upper layers, through the infiltration of moisture charged with oxygen, and through diffusive processes; but when the exchange or transfusion of gases is hindered, owing to the tenacity of the soil, or to its constant wetness, the roots of the plants are apt to be choked, and to rot away,—as may be especially noted in regard to many young crops of Scots Pine,—in which case the rotting of the tap-root is particularly characteristic, whilst the shallower side-roots remain

[1] In some of the public gardens of Munich, endeavours have been made to stop the further progress of rot, ensuing after the removal of large branches, by filling up the holes with plaster and cement, in order to prevent the lodgment of rainwater and snow, and to cut off the air.—*Trans.*

at any rate partially sound. This phenomenon is more seldom observable in the shallow-rooting Spruce, and hardly ever in the case of any of the broad-leaved species.

Drainage, removal of layers of moss hindering the penetration of the air, and cultivation of other species less likely to suffer from this special evil, appear to be the best means of obviating danger.

(3) *Diseases in consequence of Atmospheric Influences.*

Frost-shakes and *Sun-burn* have already been considered (*see* paras. 8 and 13) as consequences of intense cold and of the action of intense heat on species of trees with smooth bark; both of these kinds of injuries are usually followed by rot in the vicinity of the damaged places.

Cankerous diseases are usually caused directly by infection with fungi; but on broad-leaved trees cold can also give rise to the so-called *frost-canker*, which is characterised by fissuring and scaling of the bark (usually near the ground), and by the formation of excrescences which often also become fissured and scaly. They are especially common on Oaks, but still require more accurate observation and explanation.

The characteristic *leaf-shedding of the Pine* should also be considered under this heading, as in the opinion of many investigators it is due to the drying up of the needles, and to the action of frost, although it must also be said that others hold it to be due to a fungus. As this infant ailment or distemper of the Scots Pine, as it has been termed, has increased to an extraordinary extent during the last decades, so as in some localities to assume the proportions of a calamity, and has caused very considerable destruction in nurseries and young crops raised by sowing or planting, its closer consideration may not be out of place here.

Under *leaf-shedding* is understood that peculiar disease of the Pine in which the foliage of one to five-year-old plants often in the course of a few days turn brown (*wilt*) and die off, whilst in the case of older plants, only the under branches show signs of being affected. The plants attacked, especially the weaker ones, and those growing thickly as in sowings, or one and two-year-old seedlings in nurseries, often die off to a large extent. Though the sturdier and stronger plants recover to a certain extent, they are unfit for

transplanting in the year of the disease, and are frequently rendered unfit for transplanting at all.

The explanation at first given of this morbid appearance was that it was due to *dessication or drying up of the leaves* (according to Ebermayer), occasioned in winter and early spring, when, owing to bright warm sunshine, the foliage was stimulated to strong active transpiration, whilst the frozen ground could not as yet yield the necessary supplies of soil-moisture; thus much the same process of exhausting the water in the stem, and drying up the tree, went on, as can take place in the case of continuous heat and drought in summer. The leaves become regularly and equally brown all over, and show no traces of fungoid growth. From many observations it appears probable that in not a few cases the cause of this leaf-shedding is to be looked for in this process of drying up or dessication; hence the practice, often recommended and applied, of covering over seed-beds during winter and spring with branches or frame-work, and the formation of temporary nurseries under the lee and side protection of older crops, must be admitted to be a good practical means of obviating this effect of insolation.

These protective measures will, however, be of no avail, and may indeed be directly and actively injurious, when the disease of the foliage is caused by *Pine scab or scurf* (*Hysterium pinastri*), as can also be the case, according to many experiments and observations (made by Prantl, Hartig, Tursky). Here the leaves first show in autumn a lightly mottled appearance, occasioned by the mycelium of the fungus developing in the interior of the foliage. In the following spring the needles rapidly assume an entirely brown colour, die off, and show the spermogonia of the fungus as black pustules, into which the dark spots have now developed. But as the spores are scattered and carried across to young foliage by the wind in May and June, producing first of all disease in the autumn, and death in the following spring, the state of the weather at the time of the ripening of the spores is certainly of great influence as regards the spread of the disease. And in the face of this circumstance, any covering of the seed-beds with Pine twigs, on whose dead foliage the fungus is apt to be found in considerable quantities, would be just as risky as the formation of seed-beds inside old Pine woods, or the continuous use of temporary nurseries where seedlings have already been killed off by this leaf-shedding disease.

Professor R. Hartig recommends, as a preventive measure and special precaution against fungoid infection, the formation of Pine nurseries in woods of broad-leaved species, or, at any rate, as far away as possible from any cultural area infected with the leaf-shedding disease. Particular care should also, he says, be taken to avoid locating the seed-beds to the westward of infected areas, as it is for the most part the rain-storms coming from that direction which carry the spores to the young crops, and thereby cause infection and spread of the disease. Hartig further recommends the location of the nurseries at the edge of the forest, so that the west winds may sweep over fields before reaching the former, the formation of nurseries of a moderate size only, and their enclosure with closely fitting boarding to a height of 6 or 7 feet on the woodward side, so as to intercept the passage of the spores which are wafted along in the layer of air close to the ground,—and finally, a light covering of foliage from broad-leaved species (leaves, not needles) during the winter, in order to catch any spores that may have been carried to the beds.

Frosts have also been blamed as the cause of this disease, and not only the early frosts occurring in autumn, but also hard winter frost, followed by warm sunshine (according to Alers and Nördlinger). The covering up of the seed-beds, or the lifting out of plants early in autumn and storing them up in covered ditches, or collecting them in beds and covering them up with a thin layer of leaves, have been by them recommended as protective measures,—without having always the desired effect.

Experience has shown that young plantations suffer less than dense thickets formed by sowing, and that even in nursery seed-beds, *leaf-shedding* is less destructive when the plants are further apart, than when very close together; two-year-old Pine seedlings standing crowded in seed-beds almost invariably become infected with this disease.

Whilst the reasons for leaf-shedding may quite well be found in one or other of these causes, the disease is probably very often due to a combination of them.

Section Second.

PROTECTION OF FORESTS AGAINST INJURIES DUE TO ORGANIC AGENCIES.

CHAPTER I.

Damage caused by Plants.

36. *Different kinds of Damage arising from the Same.*

Vegetation or plants may be injurious to woodlands in two ways, either by covering the soil densely as *noxious forest weeds* overtopping and interfering with the growth of young timber crops, or as *parasites and fungi* growing on or in trees, and endangering their well-being and not infrequently their existence. The drawbacks and injuries arising from noxious growth will accordingly be considered under these two headings.

A. Noxious Forest Weeds.

37. *Definition; Disadvantages, limited Advantages.*

Under *Forest weeds* are comprised all such vegetation or growth, commonly occurring in large quantities in woodlands, as tends to prevent the natural reproduction or the artificial cultivation of the various species of forest trees, or as interferes with their normal growth and development.

The disadvantages which may accrue to woodlands from such forest weeds vary according to the nature of the latter, and to the circumstances under which they are naturally developed.

Natural reproduction is often not infrequently for the most part rendered impossible or out of the question when forest weeds cover the soil densely; and essential difficulties in the

artificial formation of crops, have often to be overcome by a special preparation of the soil, rendered necessary before sowing or planting operations can be carried out. Especially in the case of woody-fibrous weeds, like heath and heather, the soil is often matted with a thick, close net-work of roots, which is alike antagonistic to natural reproduction and artificial formation of woodlands; thus the costs of wooding or re-wooding such areas are often considerably increased, owing to the necessity of using stout transplants in place of the cheaper seedlings, which might often suffice under more favourable circumstances.

A dense growth of weeds also withdraws from the soil large quantities of mineral nutrients which are practically lost for the timber crops, when these weeds are, as is often the case, repeatedly utilised for manure, litter, &c.; the penetration of atmospheric precipitations, and of light rainfall in particular, into the soil is hindered, for no small portion of it remains hanging on the weeds, whence it is rapidly evaporated again.

Quick-growing weeds, and especially grass, over-top young timber crops owing to their slower development at the youngest stages of growth, and consequently interfere with their well-being through the withdrawal of air, light, and dew from them; when dying in autumn, the weeds are apt to overlay the young plants to a considerable extent, pressing them down to the ground under the weight of snow which collects on the top, and not infrequently completely smothering and choking them. Creepers and twining weeds, like brambles, honeysuckle, and wild hops, often completely cover the young plants, and gradually suffocate them or stifle them in their embrace. Some plants, like swamp-mosses, can occasion excessive moisture in the soil, and give rise to the formation of bogs, with all their drawbacks, whilst on other places, and especially when there is a strong growth of rank grass, rapid drying up of the soil takes place in consequence of the active transpiration of the moisture held in the upper layers of the soil; plantations in which there is a rank growth of grass often show these evil effects most. And in consequence of the rapid transpiration taking place in spring, plants standing among grass may frequently be seen to suffer from frost; whilst similar plants, not surrounded with a thick growth of transpiring grass, sustain no damage, although growing on precisely similar soil.

Injurious animals, like mice or voles, and certain kinds of

insects, also find a favourable shelter and abode in a dense soil-covering of grassy tufts, in which the former make their breeding-places.

Forest weeds do not, however, under all circumstances, exert injurious influences, but can at times have their distinct advantages. Thus, for example, they are of direct benefit in the binding of the soil on very steep slopes, and of light soil like drifting-sand, or in the protection which, if of sufficient height and not standing too thick, they (furze, juniper) can afford to young crops against frost and insolation. In many cases they also serve as fodder, being harvested as hay, or utilised as pasturage on a very extensive scale in many localities; or used as litter or manure (heath, heather, bracken, broom, furze, dry grass); or employed for technical purposes (sea-grass); or, finally, the fruits of not a few are gathered and often collected for sale in enormous quantities (whortleberry, cranberry, raspberry, brambles, juniper-berries). Even the collection of grass-seed yields here and there a not inconsiderable indirect return.

And in conclusion, it should be noted that certain forest weeds can carry many a valuable hint to the Sylviculturist in respect to the quality of soil and situation, for they furnish him with facts enabling him to draw tolerably correct conclusions as to the physical conditions, and partially also the chemical properties, of the soil.

38. *Factors determining their Growth; Names of the more important Forest Weeds.*

When close canopy of crops is maintained, and retention of the dead foliage or soil-covering of moss is suitably provided for, few forest weeds, if any, take possession of woodland soil, owing to the want of light necessary to their growth. But when the leafy canopy of high-forest crops becomes interrupted and broken here and there for the purposes of natural regeneration, or when a total clearance of the mature crop takes place, with a view to artificial reproduction, a thick growth of grass and rank development of weeds often take place in a very short time; and a similar observation may be made in the case of crops whose density of canopy has been interfered with as a result of natural causes, or

in consequence of removal of the layer of dead foliage. Indeed, it is extraordinary with what rapidity an area, hitherto free from weeds on account of the shade in which it stood, is taken possession of when once the area is cleared and laid bare,—a phenomenon explained by the extreme lightness of seeds provided with feathery crowns and similar means of facilitating transport, by their capacity of retaining their germinative capacity for a long period whilst lying undeveloped on the soil in consequence of the want of a due measure of light and air, and by the carriage of many seeds in the excreta of birds.

But weeds are not to be met with on every soil to the same extent, or of the same species or energy of growth. The fresher and more powerful (minerally) any soil is, the greater the quantity of the weeds is likely to be, the more energetic their growth, and the greater their variety; whilst their appearance on poorer soil is more limited in all these three directions, so that sometimes one single weed (like the heather) asserts itself as the sole or principal species over extensive areas. The appearance of numerous different varieties of forest weeds can always be regarded as the favourable sign of a better soil, and particularly in regard to its freshness. Climatic conditions also play a not unimportant role in respect to the species of weeds likely to be met with, as the flora of the mountains and higher hills is essentially different from that of the plains and lower uplands. And in the same way the degree of light enjoyed, whether full insolation or merely partial, broken sunshine, is also of essential influence in determining not only the species of weeds, but also the extent to which they occur. Thus, for example, whortleberry thrives best and grows most luxuriantly in a kind of half-shade; whilst grass, heather, and broom revel in the full enjoyment of light.

The forest weeds are partially herbaceous, dying off annually, as in the case of grasses, epilobium, foxglove, and partially perennial, with woody-fibrous stems; and in this latter case they may either be plants that creep along the soil, like heath, heather, and whortleberry, or else shrubs proper, like hawthorn, dog-wood, and similar brushwood. And in the more extended sense, a number of quick-growing species of trees, apt to propagate themselves extensively where not wanted, are also reckoned among the forest weeds, as, for instance, Aspen and Saugh, or even Birch and Alder; but it seems preferable, and more correct, simply to dub them as soft-

woods, and to keep them quite apart from the forest weeds, especially as some of them (Birch, Alder) frequently form the object of cultivation.

The following are the most important forest weeds, and at the same time those of most frequent occurrence, classified according to the nature of the soils on which they are to be found :—

1. *On wet or boggy soil:* Bog-mosses (*Sphagnum*), Hair-moss (*Polytrichum*), Cranberry (*Vaccinium oxycoccos*), Bog-bilberry (*Vaccinium uliginosum*), Marsh Cistus (*Ledum palustre*), Cotton-grass (*Eriophorum*), Sedges (*Carex*), Bulrushes (*Scirpus*), Rushes (*Juncus*), the last three in many different species.

2. *On fresh, fertile soil, or soil rich in humus:* Raspberry (*Rubus idæus*), Bramble (*Rubus fruticosus*), red Foxglove (*Digitalis purpurea*), Willow Herb (*Epilobium angustifolium*), deadly Night-shade (*Atropa belladonna*), Balsam (*Impatiens noli-me-tangere*), stinging Nettle (*Urtica dioica*), Hemp-nettle (*Galeopsis tetrahit*), Vetches (*Vicia*), and Clover (*Trifolium*) species, as well as ferns and broad-leaved grasses of different sorts.

3. *On drier and more sandy soils:* Heather (*Calluna vulgaris*), Whortleberry, Bilberry, or Blaeberry (*Vaccinium myrtillus*), Myrtle-Bilberry, Cowberry, or red Whortleberry (*Vaccinium vitis idæa*), Furze, Gorse, or Whin (*Spartium scoparium*), Broom or Greenweed (*Genista*), Groundsel or Ragwort (*Senecio*), the Mullein (*Verbascum*), Hawkweed (*Hieracium*), Spurge (*Euphorbium*), the last-named genera occurring in various species, and the narrow-leaved meadow-grasses.

The shrubs which occur most frequently on hills and valleys, especially when the soil is fresh, are :—Black Dogwood or Black Alder (*Rhamnus frangula*), Blackthorn or Sloe (*Prunus spinosa*), Hawthorn (*Cratægus oxyacantha*), Spindlewood (*Euonymus europæus*), Dogwood (*Cornus sanguinea*), Barberry (*Berberis vulgaris*), Holly (*Ilex aquifolium*), Honeysuckle (*Lonicera periclymenum*), Elderberry (*Sambucus*); on drier soil, Juniper (*Juniperus vulgaris*), and on sandy soil, Sea Buckthorn (*Hippophae rhamnoides*).

In how far forest weeds are indicative of certain classes of soil may be seen from the above classification; but it is principally with reference to the physical properties of the soil that safe conclusions can be drawn from the appearance of one or other of

the species in larger quantity. So far as the chemical composition of the soil is concerned, the conclusions deducible are much less reliable, as the number of plants among the true forest weeds, which are constant on certain kinds of soil,—that is, which only occur on soils possessing certain mineral constituents,—is comparatively limited. The number of plants, however, which show a distinct and decided preference for certain mineral classes of soil, is already much greater; whilst most numerous of all are the indiscriminating, easily satisfied genera and species whose occurrence and thriving are more intimately connected with the physical properties of the soil, than determinable by its chemical composition.

39. *Preventive and Exterminative Measures.*

The prevention of the occurrence of forest weeds in such large quantities as to be productive of injurious consequences is best effected by avoiding, so far as possible, the conditions most favourable to their growth and thriving. Careful maintenance of closed canopy, and of the layer of dead foliage and moss on the soil, stoppage of the removal of the dead leaves for litter or manure, which invariably ultimately leads to gradual deficiency of the coronal foliage of the timber crops, cautious and gradual natural reproduction, conducted with all the more prudence wherever the soil is strong and fresh, and therefore more apt to become overgrown with grass and weeds, and finally, early drainage of areas that are too damp, and therefore likely to get covered with rank grass, are the chief means of obviating danger from weeds. But wherever any circumstances may have prevented the hindrance of the first appearance of weeds, the Sylvicultural measures at our disposal to give the young crops the greatest advantages in the competition with the weeds that make their appearance one after the other, and to prevent or minimise as much as possible any damage that may be done by the latter, consist mainly in the preference of planting instead of sowing, in the choice of sturdy transplants in place of small seedlings, and in the immediate re-wooding of areas from which the mature crop has been cleared.

Not infrequently, however, the weeds or grasses may have already taken possession of the areas to be planted up, or else they at once make their appearance in threatening numbers as soon as

the mature crop is removed; in other cases, again, natural causes, like windfall or snow-break, interrupt the density of the canopy, or throw down the parent standards in areas undergoing reproduction, and thereby afford the weeds an opportunity of rapidly increasing. Forest fires, too, and insects can easily, and unfortunately often do, interfere with the growth of woodlands to such an extent, over larger or smaller areas, that they become at once covered with weeds hindering reproductive operations. In these cases the removal or annihilation of such rank growth is the first duty of the forester.

This can take place in many ways, as, for instance, by permitting the removal of such weeds as can be utilised as litter or manure (heather, broom, bracken), from which sometimes even a small revenue can be derived. But where this can not be arranged for, at any rate a partial clearance of the objectionable soil-covering must be made in belts or strips, especially in the case of heather and berries, before the planting operations can be carried out; and even this sometimes requires to be repeated again afterwards. The temporary use of the soil for agricultural purposes, or agricultural utilisation of the soil between the rows of plants, is in many districts a means of annihilating the growth of weeds, and at the same time of securing the advantages desirable from a thorough breaking up and loosening of the soil.

A strong growth of grass, apt to cause damage by overshadowing and choking young plants in summer, and overlaying and crushing them in winter, can be removed from sowings by being pulled out along with the roots in wisps, or from regular plantations by being cut with the sickle, and in many localities such grass is in good demand as fodder. Even the pasturing of sheep and cattle in coniferous woods (Spruce) can, under certain circumstances, take place very advantageously with a view to reducing the growth of grass through the grazing and treading with the horny feet, for the cattle will not attack the young plants so long as they have a sufficiency of grass at their disposal. It is better to have bramble-shoots trampled down than to stimulate them to throw out fresh shoots by cutting them back; whilst ferns, often occurring in large quantities on hill-sides and mountainous tracts, can best be checked in growth by lopping them at the time of the development of their very brittle rolled-up young fronds.

Woody-fibrous shrubs should be hacked or cut through, or even removed altogether from the soil, by means of a hoe or mattock. Cutting should take place in the middle of summer, as at that time the shoots from the stool are not only less in number, but are also more likely to be interfered with in growth by the frosts in autumn and winter, owing to the shoots not ripening properly into hard wood. Blackthorn and hawthorn are apt to give most trouble, both because of their reproductive capacity from the stool, and because of their thorns rendering the task of cutting them more difficult. When thoroughly carried out with heaps of earth not too small in size, the piling up of earth over the stools in spring, immediately after cutting, can often be successfully applied, in the case of shrubs and softwoods, to hinder the development of stool-shoots.

In seed-beds and nurseries a noxious growth of weeds can best be prevented by a judicious choice of the locality,—avoiding places with damp soil, or near areas covered with young crops whence the seeds of the weeds can be wafted by the wind, and choosing, wherever available, old agricultural land free from weeds,—by prudence in the application as manure of compost formed by the heaping together of all sorts of garden rubbish, as this often contains a large proportion of weeds removed about the time of their seeding, which should only be used after having lain for a long time, and having been turned over frequently,—and by covering up the spaces between the rows of seedlings with leaves, moss, or, if the spaces are narrow, with battens or split poles, in order to offer a mechanical hindrance to the growth of weeds. Whatever weeds make their appearance, despite these precautions, should be removed by diligent weeding during damp weather, when they can easily be pulled up with all their roots, so as to prevent their at once sending out fresh shoots.

B. Parasitic Plants.

40. *Mistletoes, their Growth, and Evil Effects.*

There are two parasitic plants belonging to the family of the *Loranthaceæ* which are outwardly visible on trees, and especially on a number of forest trees, and which obtain their requirements

in the way of water and inorganic nourishment from the latter, whilst their supplies of organic nourishment is obtained by the leaves from the air: these are the common mistletoe, and the *Loranthus* or large misteltoe of the Oak.

The common Mistletoe (*Viscum album*), occurring on fruit trees, as well as on many woodland species,—as, for example, on Lime, Poplar, Acacia, Scots Pine, and especially Silver Fir, but never (in Germany) on Oak, Beech, Alder, Spruce,—and there often forming large bushes, with its greenish-yellow leaves persistent throughout the winter, probably owes its wide extension and reproduction principally to thrushes, which eagerly consume its white berries, and, in cleansing their beaks from the very sticky flesh of the fruit, leave a portion of it on the bark of the tree along with some of the seeds contained in it. It does occur, though rarely, on Oak in Britain.

When the latter is smooth and without thick corky bark, a rootlet of the germinating seed finds its way, under favourable circumstances, into the woody-fibrous tissue, and forms the first penetrating rootlet. This becomes overgrown and enclosed in the new annual ring formed during the next year, but continues to retain its direct connection with the plant flourishing outside of the partially interruped cambial layer of the part of the tree in question; this first penetrating rootlet extends itself sidewards in the same way into the young sapwood, annually forming new penetrating rootlets near its point. These penetrating rootlets have a long life, especially in the case of the smooth-barked species of trees, become overgrown with a considerable number of annual rings, and thus often extend into the wood to a depth of 4 inches; when they die off, they rapidly undergo decomposition, whereby the timber has the appearance of being bored through with holes, and is thus rendered useless for technical purposes. On branches, the portion above the swollen, crop-like excrescence occasioned by the mistletoe, usually dies off after some time, probably in consequence of the withdrawal of the necessary supplies of water and mineral nutrients.

The damage that can be occasioned in timber crops, especially of Silver Fir, by the appearance of mistletoe in large quantities, is at times not inconsiderable, especially when it is apt to show itself on the stem, for it deforms the bole, and, as above explained, renders it useless as timber for technical purposes. There is, however, no means of preventing the growth of mistletoe in

woodlands: the horticulturist tries to exterminate it by an early clearance of the easily visible growth from his fruit trees.

The Oak Mistletoe (*Loranthus europæus*), injurious to Oaks and Sweet Chestnut, and of especially frequent occurrence in Central Austria, affects trees in a similar manner by producing excrescences, often the size of a man's head, above which the stem or branch sickens, and even dies off. Preventive measures for obviating danger from this parasite are also wanting. It is not found in Britain.

It may here be mentioned in passing that *Lichens* are not parasites, but are merely to be considered a sign of damp air and want of energy of tree-growth. With the very gradual thickening of the girth of the tree, and the slow peeling off of the bark scales, the lichens have points of contact and places of abode offered to them which would be wanting if the bark were smooth. By stopping up the numerous *lenticelles* or air-holes of the bark, through which the tree takes up oxygen in summer, direct injurious consequences to the tree can however follow, and the dying off of branches inside the crown, that are thickly covered with lichens, may frequently be noted.[1] The horticulturist therefore removes lichenous growth; but this can hardly be carried out in Sylviculture.

Ivy (*Hedera helix*) is also no parasite, for it derives all its nourishment from the soil, and all the rootlets appearing on stems and branches are merely supporting rootlets.

41. *Fungi: their Evil Effects, and the Preventive Measures adoptable against them.*

Not a small proportion of the disturbances that take place in the growth of plants, from minor injuries quickly healed again up to such as lead to the death of the plant or tree, is occasioned by parasitic, cryptogamous vegetable organisms, *fungi*, living in or on the plants in questions.

Until the last few decades, this pathological branch of phytology had received extremely little attention, so far as concerned the fungi parasitic on forest trees; many of these were totally

[1] In the *Centralblatt für das gesammte Forstwesen* for 1889, page 275, a case is detailed in which the woodlands, in a damp mountain valley, with a crop of Spruce, Larch, and Scots Pine, suffered to such an extent from being overgrown with eight species of lichens, that about 50 per cent. of the trees were dying prematurely.

unknown, and treated with contempt, whilst in the case of others, cause and effect were confused, the appearance of many fungi, (*e.g.*, species of *Polyporus*), being regarded as the consequence of rot instead of its cause. Not a few of these phenomena still remain unsolved riddles to the Sylviculturist.

Among many other scientists and observers, Professor Robert Hartig of Munich has been foremost in studying this branch, in clearing up many of its mysteries, and in giving practical hints as to how the results of his investigations can be of practical use in forestry. For the scope of this little work, confined to the Protection of Woodlands, the latter alone are strictly of interest. We may perhaps, however, be allowed to remark that it is expected of the well-informed forester that he should know the reason of the sickening and dying off of the trees and plants under his charge, even although in many cases preventive and remedial measures against the causes have not yet been discovered.

For a closer study of the diseases of plants generally, and of those occasioned by fungi in particular, R. Hartig's *Lehrbuch der Baumkrankheiten*, 2nd Edition, 1889, is to be recommended. In accordance with the consistent aim of this little work, only the more important, and more frequently occurring, fungal diseases, capable of being obviated by practical measures, are referred to in a short sketchy manner, the data being drawn from the above work.

(1) *Fungi on Leaves and Needles.*

The Beech-seedling fungus (*Phytophthora omnivora*—*P. fagi*), principally occurring on the cotyledons of Beech-seedlings, but also on those of the Maple and Sycamore, the Spruce, Silver Fir, and Larch, makes itself apparent by the blackening of the shoots, cotyledons, and primordial leaves, or by the breaking out of black spots on these, which is soon followed by the death of the seedlings. In consequence of this fungus, whole seed-beds, covered with rills of coniferous sowings, may be killed off even before the germinating seedlings have made their appearance above the soil.

This disease occurs extensively in seed-beds, and especially in seed-fellings during the natural reproduction of the Beech, particularly when the spring weather is damp and warm. As the spores are easily carried along by men and animals, the dying off of the young seedlings is usually very apparent along paths and roadways leading through Beech-woods undergoing natural regeneration.

Preventive measures include the careful removal of all infected plants from the seed-beds as long as the disease is only of sporadic character, and avoidance of the use of the same place again as a seedling nursery;[1] but for the schooling of transplants it can quite well be utilised, as the disease only attacks germinating seedlings.

The Spruce Rust or Blight (*Chrysomyxa Abietis*) occurs on the young needles of Spruce, partially colouring them an intense yellow, while the part not infected remains normally green. Up till Autumn golden yellow puffed up pustules develop, which in the following spring burst and scatter their sporidia over the new flush of needles. After the emptying of the fungous pustules the needles fall off, but any thing like serious injury to the tree is only occasioned when the disease has continued annually for some length of time. Special measures for counteracting the effects of blight are therefore not really necessary, but could in any case hardly be applied.

Similar appearances of rust or blight also exhibit themselves on the needles of the Larch (*Caeoma laricis*), and of the Silver Fir (*Caeoma Abietis pectinatæ*), and also on the leaves of the Willow (*Melampsora salicina*). The scab or scurf on needles of the Silver Fir (*Hysterium nervisequium*), and of the Spruce (*Hysterium macrosporum*), cause a browning and dying off of the whole needles, which are then very soon defoliated.

The scab or scurf on the needles of the Pine (*Hysterium pinastri*) is a very common appearance, which not only makes itself noticeable everywhere during the natural death of the needles, but also extends by infection to sound, healthy foliage, and forms one of the causes of leaf-shedding. This phenomenon has already been noticed in treating of the diseases of trees, and other causes besides this fungus have also been mentioned as occasioning it; hence to avoid repetition a reference need here only be made to the paragraph in question (par. 35).

2. *Fungi on the Roots.*

The Root-fungus (*Trametes radiciperda*) is the most dangerous enemy of coniferous woods, occasioning red-rot and consequent

[1] Watering of the seed-beds with a solution of 4½ lbs. of copper vitriol (blue-stone) and 1 quart of ammonia in 50 gallons of water, has been recommended as yielding good results.

interruption of the canopy of the crops, especially in the case of Spruce, Scots Pine, and Weymouth Pine. Young plants, poles, and trees are suddenly seen to die off, and soon afterwards others in their vicinity follow suit, so that not inconsiderable blanks are often formed in consequence. The snow-white receptacles or spore-producers are then to be noticed externally on the roots, and the fine mycelial threads between the scales of the bark; whilst the roots, and often the stem itself, for some distance above these are rotten, in consequence of the red-rot produced. The spread of the disease may take place in two ways,—either by direct infection from the roots of neighbouring trees that are in contact with those of the diseased stem, or else by the spores being conveyed to other individual plants by animals, especially on the furry coats of mice, voles, and the like.

Against this latter mode of infection, there are, of course, no means of adopting preventive measures; but against the former Hartig recommends the isolation of infected places by removal of the diseased stems, and the digging of ditches around the infected spots. This proposal has recently been energetically objected to as directly tending to favour in a high degree the further extension of the disease, in consequence of the particularly luxuriant development of the spore-bearing receptacles of the fungus produced on the diseased roots that are cut through in digging the ditches.

The common edible Mushroom or Honey-fungus (*Agaricus melleus*) is also a very common, and in many places a very dangerous, parasite in young crops of conifers, which, however, also occurs extensively as a saprophyte on dead stools and roots of old trees, especially of Beeches. Young plantations of conifers on soil formerly under crops of broad-leaved species, which are now so frequent in consequence of the deterioration of the soil, due to the improper treatment of the latter, appear to suffer from this fungus to a much greater extent than seems to be the case elsewhere. The blackish-brown mycelial threads, that extend themselves under the surface of the soil, push their way into the bark of the roots with which they happen to come in contact, and develop themselves under it as long, white, ribbon-like filaments, ultimately causing the death of both young plants and old trees. Infected plants exhibit a strong outflow of resin at the base of the stem which penetrates and cements the soil round the foot of the tree. Before the true explanation was known, this gave rise to the belief

that the disease was probably due to excessive formation of resin, or canker of the soil. During the autumn the sporophorous receptacles (mushrooms) make their appearance on the dead plants —Scots Pine, Spruce, Larch, Weymouth Pine,—often breaking out with their honey-coloured heads (*pilei*) in large numbers around the stem of the plant, though not on all the plants attacked and killed, and producing the spores that are carried elsewhere by wind, animals, &c. On beech-stumps they occur numerously, and with much larger *pilei* as edible mushrooms.

Although older stems also succumb to the attacks of this fungus, by far the greatest damage is done by it in young crops. Characteristic features of its occurrence are the dying off of the plants here and there in patches, and also the rapidity with which plants in excellent growth are attacked and killed off, after having perhaps during the same year developed very good growth in height. Thus damage arising from this cause is at once distinguishable from that occasioned by insects, drought, and the like, when individual plants gradually succumb after a period of sickly growth. Such blanks, often occurring in considerable number and extending over large patches, may sometimes render replanting and filling up of the blanks necessary for several years in succession; this should if possible be done with broad-leaved species only, as conifers are more exposed to a recurrence of the danger.

The best practical means of preventing the spread of the disease appears to be the pulling up of the plants attacked with all their roots and burning them, and the isolation of the infected spots by digging small trenches round them about 1 to $1\frac{1}{2}$ ft. in depth, so as to hinder the extension of the mycelial filaments under the soil. Careful collection of the larger mushrooms on old stumps is also to be recommended, and none the less on account of their being edible.

The Oak-seedling fungus (*Rosellinia quercina*) attacks the roots of young 1 to 3-year-old Oak seedlings, especially in nursery beds, and occasions fading and drying up of the plants. The roots appear to be woven round about with fine filaments, in the vicinity of which the bark-tissue turns brown, whilst black pustules about the size of a pin-head make their appearance here and there on the main root. The further spread of the disease, which is favoured by damp weather and hindered by dry, can be obviated by the

formation of small trenches so as to isolate the parts of seed-beds infected.

3. *Fungi in the Stem or Branches* (*in the bark or in the wood*).

Canker of the Pine (*Aecidium* (*Peridermium*) *pini*, var. *corticola*), often very conspicuous on young trees of Scots, Weymouth, and other species of Pines, on account of the semi-spherical or oval pustules filled with reddish-yellow spores, occasions the inspissation of resin and the formation of pockets of it inside the stem, owing to the action of the mycelium. In consequence of this the growth of the tree ceases at these places; and when this occurs to any great extent, the whole of the tree above the infected part ceases its vital functions. The dying off of the tops of old Pine trees is very often caused by this fungus.

The Silver Fir fungus (*Aecidium elatinum*) occasions the peculiar cankerous swellings that are not infrequently—indeed in some localities very frequently—noticeable at a greater or less height up the stem in crops of Silver Fir, mostly encircling the bole, and known as Canker of the Silver Fir. The bark gradually dies off from the excrescences formed, often of very considerable size, and the wood is laid bare and begins to rot. This process is stimulated and hastened by the advent of other fungous spores (*Polyporus*); according to the place where the canker occurs—and two or three cankerous places may sometimes be seen on one tree—the bole becomes more or less unsuited for technical purposes, and under any circumstances loses considerably in value. Such stems often break at the diseased parts during storms.

Along with this cankerous disease there also very frequently occur yellowish-green, loranthus-like excrescences or deformities, like twig-clusters, on the branches of the Silver Fir, (called "*witches-brooms*" in Germany), which are likewise occasioned by *Aecidium elatinum*, although the connection of these two different forms of disease arising from the same fungus has not yet been satisfactorily explained. In the latter case the spores are developed on the lower side of the needles, and the reproduction of the fungus, and later on the formation of canker, is the result—not directly, however, but by the assistance of some host or plant acting as go-between, not yet discovered and identified. The spores are never developed at the cankerous place itself.

The cutting out of all cankerous poles and stems is to be recommended at the time of making thinnings, and even special fellings should take place with this object when the disease is frequent in any crop; the removal of the twig-clusters, by means of which the disease is reproduced and extended, should also be carried out as far as possible.

The Pine-shoot Fungus (*Cæoma pinitorquum*) principally attacks young Pine woods of 1 to 10 years of age, although young crops up to about thirty years old are liable to be attacked. Pale yellow spots, bearing the spermogonia of the fungus, make their appearance about the beginning of June on the green epidermis of the young shoots. With the development of the sporophore under the bark, this is raised up in pustules, and finally fissures longitudinally, whilst the cellular tissue dies as far down as the woody fibrous tissue below the spore-bearer's. At the diseased place the shoot assumes somewhat the shape of S, but raises itself again at the apex. When this process is repeated, as can be particularly favoured by damp weather in May and June, the Pines often become completely deformed, a portion of the shoots dies off, and the young plants have somewhat the appearance of having been badly damaged by late frost.

The removal of any Aspen that may be growing in Pine woods affected with this disease is recommended, as *the Poplar rust* (*Melampsora Tremulæ*) occurring on the leaves of the Aspen is considered the cause of the pine-twisting.[1]

The Tree-fungi (*Polyporus*) are partly saprophytic, living only on dead wood, partly also true parasites, and causes of disease and rotting of timber. In this latter case their mycelium develops in the interior of the stem, whilst the well-known spore-beds of different shapes, often bracket-like, are situated on the outside of the stem. The timely removal of trees thus infected with fungus is advisable, not only in order to have any use from the timber itself, but also to prevent the further spread of the disease through the formation and scattering of spores.

Canker of the Larch (*Peziza Willkommii*) is a very widespread disease, causing the sickening and death of many Larches, and, according to Hartig's opinion, the chief reason of the unfortunate

[1] The *Cæoma* is polymorphous, the spores of *C. pinitorquum* producing the *Melampsora tremulæ* with the Aspen as a host, whilst the Teleuto-spores of the latter form of the fungus cause infection with *C. pinitorquum* in the following spring.—*Trans.*

results that have in many places been achieved with the cultivation of this species. On the spores germinating, the mycelium enters under the bark wherever it can find any damaged place, resulting from hail, insects, bending of the branches under ice, &c.; it then penetrates into the woody-tissue and kills the portion attacked, whilst the cankerous spot makes itself outwardly visible by the bursting of the bark and an outflow of turpentine. Small cup-shaped fungi, with bright red receptacles, also appear on the infected places, indicating the cause of the disease. If the cankerous spot be large, and finally extends itself all round the circumference of young trees, the stem dies off above the diseased ring; but when it only extends partially round, the stem may continue alive for decades.

The wide distribution which this fungus has obtained in low-lying tracts and uplands, in contrast to its much less frequent occurrence, and much less dangerous results, in the true alpine home of the Larch, Hartig thinks can be explained by the fact, that in the damper, stagnating atmosphere of dense forests in close canopy, into which the Larch has been introduced as a subordinate species, the fungi at the infected parts attain a more luxuriant development, and the spores ripen to a greater extent. In the dense forests good opportunities are given to the spores of finding and making use of a germinating bed, whereas in the light, open Larch forests of the Alps, constantly exposed to currents of air, the fruits of the fungus generally dry up without attaining maturity.

That in damp coombs, hollows, and similar situations, the Larch suffers to a very great extent from the disease caused by this fungus, is well known; hence the best way to prevent its occurrence will lie in the avoidance of such unsuitable localities, and in growing the Larch in mixed forests, by means of giving it some advantage in growth to start with.

The Pine fungus (*Trametes pini*) is much more common in the Pine forests of northern than in those of southern Germany, and occurs also, although to a less extent, on Spruce, Larch, and Silver Fir, producing ring-shakes or heart-shakes extending downwards from the crown. It generally occasions rapid decomposition of the timber, owing to the mycelium developing in the wood: it betrays its presence in the stem through its brown, woody, mostly bracket-like receptacles or spore-producers. The immediate re-

moval of trees attacked by the fungus appears advisable, not only in order to be able to utilise the timber before decomposition has proceeded too far, but also in order to prevent the spread of the disease by the scattering of the spores produced in large quantities in the sporophores, and easily wafted about by the wind.

CHAPTER II.

Damage caused by Animals.

42. *The Animal World in relation to Forest Growth; Classification of Animals injurious to Forests.*

Numerous as are the various kinds of animals dwelling in our woodlands, just as manifold are the relations in which they stand to timber crops in respect to their nourishment, their reproduction, and their whole habit of life. Not a small portion of these animals is directly nourished by the products of forests and of woodland soils; another also lives indirectly therefrom through the nourishment obtained from animals of the woods, either exclusively or in combination with vegetable products; whilst a good many birds and insects do more or less damage to trees, not only externally, but also internally, by forming their breeding-places there.

The question, as to which of these animals may be regarded as useful, and which injurious, from a sylvicultural point of view, can be answered absolutely in the affirmative or negative only as regards a portion of them. Thus, for example, the parasitic insects and the predatory species, as well as insectivorous birds, are unquestionably useful, whilst, on the other hand, animals of the chase (except those of predatory habits), mice and voles, and so-called true forest insects, must undoubtedly be considered injurious to woodlands. With regard to a great many other animals, only a modified answer can be given, as, for instance, in the case of birds (Finches, Jays) which eat seeds and grain as well as insects, and of predatory animals (Owl, Buzzard, Marten, Weasel) that, besides preying on injurious animals (Rabbits, Mice and Voles, Insects), also devour useful birds and disturb their breeding. The grazing of domestic animals in the woods is also, as a rule, disadvantageous, although there may be cases in which the grazing of cattle may be of advantage in keeping back the growth of

grass in young plantations, and where the wallowing of swine in search of pannage contributes to the annihilation of destructive insects.

The struggle against such animals is often very ineffective, and experience has shown that the smaller these are, the more difficult is their extermination, as the means which can be successfully adopted against the larger animals are inadequate for adoption against insects, swarming often in millions.

For the purpose of considering their sylvicultural importance it will be sufficient to subdivide the injurious animals into three groups, as follows :—

A. *Mammals* (*Mammalia*).
B. *Birds* (*Aves*).
C. *Insects* (*Insecta*).

A. Mammals (*Mammalia*).

43. *Classification and Enumeration of Injurious Mammals.*

The Mammals that are in the habit of doing a certain amount of injury to our woodlands, but which may extend to very great damage indeed, may be subdivided into three classes, viz. :—

a. *The Domestic Animals:* Horses, Cattle, Sheep, Goats, and Swine, which are turned out into the woods to graze on the grass and weeds, and the mast and fruits of the trees.
b. *The Animals of the Chase:* Red-deer, Fallow-deer, Roe-deer, Wild-Boar, Hares and Rabbits.
c. *The smaller Rodentia* living in woodlands,—Mice, Voles, and Squirrels.

This classification has an additional advantage, in so far as human action in combating these enemies varies essentially in the case of each of the three groups. Thus damage from domestic animals can be entirely obviated either by closing the woods to them, or by only permitting their grazing under proper supervision, and under certain prudential conditions; injury by animals of the chase can easily be minimised at any time by reducing the head of game to the number desirable ; combating the attacks of the animals belonging to the third group, the Mice and Voles in

particular, is a much more difficult task, which can often only be accomplished with the aid of nature herself.

a. The Domestic Animals.

44. *Damage done by Grazing Animals.*

The damage that may be done to woods by the driving in of Horses, Goats, Sheep, and Cattle for grazing purposes, consists in the nibbling of buds, leaves, and young shoots, the gnawing and stripping of bark, the injury of roots from the rough pressure of the hard hoofs and horny feet of heavy animals, the forcible bending back of young growth and stronger plants, the dislodging of soil on slopes, the stamping down of damp and heavy soils, the loosening of light sandy soil, and finally the damage done to drains and protective ditches.

But these different species of damage vary greatly in extent, according to the class of animal driven in for grazing.

Of all the above animals *goats* do most injury, for they appear naturally to enjoy grazing on foliage, buds, and the young shoots of woody fibrous plants, in preference to grass and weeds, even when the latter are much more abundant. And as they can reach high up by standing on their hind-legs, even the crowns of sturdy saplings are not safe from their attacks. The destruction of the forests in many of the mountainous tracts of the Tyrol, Switzerland, Istrya, and Greece, is in no small degree attributable to the unrestricted grazing of herds of goats, which has rendered impossible the natural reproduction of areas that had been cleared of mature crops.

Although not so frequently driven into the woods for grazing, and generally in less numerous droves, *horses* disdain the rank grass growing on loose woodland soil, and prefer to crop the short meadow-like grass on sward and along old roads. But at the same time they are very fond of the foliage and the young succulent shoots of saplings, which, on account of their size, they can strip from a considerable height; young horses also love to gnaw the bark. With their heavy tread, and their iron-shod hoofs, they also do a good deal of damage to the shallow, superficial roots, as well as injury to young seedling growth.

Although fond of nibbling the grasses on the soil, *sheep* show a certain relationship with goats in their love of gnawing and

browsing on woody fibrous plants, and consequently do a considerable amount of damage when they are frequently grazed over the same place, especially in regard to the breaking up of loose soil with a thin growth of grass or binding weeds.

But on the other hand *cattle*, which from the remotest times were driven in the largest numbers into the woods, differ from the two already named kinds of animals, in their decided preference for soil-grazing, and only attack woody fibrous growth when there is a dearth of that; still they browse on it also, so long as the leaves and shoots are young and succulent, bending down strong saplings under their chests in order to get at the crowns, and being fond of rubbing themselves against poles and sturdy transplants put out on grazing lands. From the heavy pressure of their feet they loosen and easily dislodge the soil on slopes, damage young growth by treading on them, and often tear out the plant along with the earth held by its roots; where they are often herded in woodlands, they stamp down the earth wherever they may be penned.

Young animals of each of the above-named kinds do more damage to the woods than old beasts; for even when there is plenty of grass, they nibble and gnaw the woody fibrous growth, partly out of pure mischief and excess of spirits, and partly to assist the operation of teething, when changing their teeth. When cattle in poor condition are driven into woods for grazing after having had poor supplies of fodder throughout the winter, they do all the more damage to the young seedling growth and plantations, as they partake, without much choice, of all the nourishment coming within their reach.

Endeavours have been made to classify grazing animals with respect to their injuriousness, but this is to a certain extent difficult, for the sum-total of the damage done depends on a whole chain of other circumstances as well as merely the kind of animal grazed; hence in some cases one sort, and in other cases another kind, may do the greater amount of injury. But on the whole, the most correct approximate sequence of injuriousness is, *Goat, Horse, Sheep, and lastly Cattle.*

45. *Factors determining the Extent of the Damage done.*

As has already been remarked above, the occurrence of extensive damage at all, and the extent to which it may be committed,

are determinable not only by the kind of animal grazed, but also by many other circumstances, such as species of tree, nature of the woodland crop, and of the soil and situation on which it grows, also the method of treatment accorded to the crop, as well as the number of the animals forming the herds, and the time and manner of their being driven into the wood.

Every *species of tree* is not equally readily attacked by the grazing herds, and the extent of the actual damage done also varies with the kind of tree that has been damaged.

All kinds of grazing animals almost always prefer the broad-leaved species to conifers, and only attack the latter when the former are wanting. But on the other hand, injuries inflicted on conifers are more serious than on broad-leaved species, because they are not endowed with the strong recuperative power of the latter in repairing the damage done, though at the same time, the extent to which conifers are endowed in this respect varies very considerably with the species. Scots pine, that has been badly bitten during its early period of development, usually remains more or less crippled and damaged in growth, whilst the Silver Fir is endowed with a very great amount of recuperative capacity. The shallow-rooting Spruce is most exposed to danger from the tread of the animals grazed, whilst deep-rooting species are little apt to be damaged.

Leaves, buds, and young shoots of Beech, Hornbeam, Ash, Elm, Oak, Maple, and Sycamore are particularly toothsome to grazing herds, whilst those of Aspen, Willows, and Lime are less cared for, and those of Alders and Birch only exceptionally partaken of. Among the conifers, of which only the young succulent shoots and leaves are eaten, the Silver Fir, and then the Spruce and Larch, are the first to be attacked, whilst Scots Pine has generally least to suffer. The taste of the herds, however, varies according to their species and habits of feeding. Horses and sheep prefer young Oak foliage to all other; but in the North German plain, sheep also love to browse on Scots Pine and Birch, and apparently the change of nourishment must in this case be the cause of making certain species of trees appear tasty, which are otherwise usually avoided.

The younger the crops that are injured, the greater the damage generally is. It is greatest in young seedling growth and plantations, and least of all in old crops where it is often confined

entirely to superficial injuries on shallow roots, occasioned by the horny feet of the cattle. When there is any rank, rich growth of grass in the young hags and falls, the extent of any damage done to the seedling growth by cattle and sheep is often very nominal, and is at times more than counterbalanced by the benefit done in retarding the growth of the grass by grazing off it, and by crushing and treading it down under foot; hence, in fact, cattle and sheep are sometimes driven in, as a cultural measure, where there is a danger of the young crop suffering through the rank growth of grass and weeds.

A certain influence is also exerted by the nature of the *soil and situation*, for the fresher and the more powerful the soil, the richer is the growth of grass, and the less likely, consequently, are the herds to attack the woody-fibrous plants; the recuperative power of the latter is, at the same time, always greater on fresh, strong, fertile soil. The damage done on steep slopes by dislodgement of the soil is often not inconsiderable, whilst, at the same time, the animals have got a much more favourable opportunity of feeding on the crowns of the plants growing below them, than they could possibly have on level or merely gently sloping ground.

In the method of treatment by selection-fellings here and there,—a system leading to the more or less irregular intermixture of old trees with young seedling growth over all the area under woodland,—the damage done to tree-growth by grazing is more pronounced, for it is impossible to shut off the hags or falls undergoing natural reproduction, as may easily be done in the case of high timber forest, where the annual or periodic falls may be closed against grazing, so as to reduce to a minimum the damage done to the young crops. And, indeed, the very apparent injury done by grazing in such irregularly stocked woods has been one of the reasons for transforming them into growing-stock with a regular series of annual or periodic crops of equal age, from the period of their formation up till the time of their maturity. Coppice-woods not only quickly outgrow the reach of cattle, owing to the speedy rate of growth of stool-shoots, but, at the same time, they possess so strong a reproductive power that the damage done is seldom considerable, even when the hags are actually grazed over; in very young coppice-growth, however, some injury may be done by treading down young shoots, and breaking

them off from the stools. In Copse, or coppice under standards, much the same happens as in coppice-woods, and only saplings of seedling growth are liable to be much damaged by grazing.

When herds have been driven into the woods too early in spring, before sufficient grass has come up, or have been kept there too late into the autumn, after the grass has grown hard and untoothsome, or if they have been allowed to go in in too large numbers relatively to the grazing area, or if they have been allowed to graze too long in any one portion of the woods, so that the grass browsed on has not had time to grow again sufficiently, then naturally more damage is done by the herds to the young woodland growth. It has also been noted that herds prefer the foliage of young growth to grass during wet weather, which is no doubt due to the more rapid drying of the former.

46. *Protective Measures advisable in regard to Grazing.*

The best means of preventing damage from grazing consist in the following measures, of which the first three are in many countries imposed on all proprietors of woodlands by rules, framed under Forest Acts, and having the force of law :—

1. *The closing of Falls bearing Young Crops.*—How long the protective time should last is of course dependent on the species of crop, the conditions of its growth, and the nature of the grazing; but in any case protection must at least be given until the young woods have outgrown the reach of the cattle. The protected areas are usually distinguished by some well-known mark or visible sign, like wisps of straw bound to poles stuck in the ground, or by means of boards with the notice "*Grazing forbidden.*"

2. *Adequate Supervision.*—Grazing should only be permitted under the supervision of a herdsman, with one or two lads under him in the case of large herds. In some localities it is prescribed that all the cattle, or at anyrate the majority of the animals, must be provided with bells attached to their necks, so that cases of straying away from the herd, or getting lost in grassy plantations, may the more easily be prevented or discovered.

3. *Prohibition of Grazing during the Night.*—As supervision is impossible during the night-time, grazing should neither be allowed before sunrise nor after sundown.

4. *Grazing herds should not be driven into the woods too soon in spring,* nor should they consist of a more numerous head of animals than is likely to be amply provided with fodder from the area, whilst, at the same time, there should be a regular and adequate change in the localities grazed over. Too long-continued grazing in autumn, after the grass has begun to dry up and wither, should also be avoided.

5. *Grazing paths, green lanes, or drives* should be kept clear where large herds are in the habit of being led out and back; and where they pass through young woods, these green lanes should either have ditches at each side, or else be fenced off with poles. This latter method should, at the same time, be adopted to protect, as well as possible, young woodland growth where it marches with the land that is being grazed over.

6. When put out on grazing land, *saplings should be protected* by being bound round with thorns, or by means of three poles inserted triangularly, and secured so as to keep off the animals from the stem.

7. Where injuries are to be feared from the treading and tramping of the cattle, the intervals between grazing should be longer, as also on steep slopes during damp weather, favouring the loosening and dislodgment of the soil.

It may also, in a general way, be remarked that woodland grazing has now lost much of the importance it once had agriculturally. The acknowledged superiority of stall-feeding, the increase in the number of, and the improvement in, the meadows, and the cultivation of feeding-stuffs, have in many localities almost caused woodland grazing to be a thing of the past. It is only in mountainous districts that it is still of some importance, where the rearing of cattle is extensively engaged in, and where there is usually a dearth of meadow-land; but there the freshness of the soil on the one hand, and the atmospheric humidity on the other, combine to produce a lively growth of grass within the forests. In such places woodland grazing is still carried on to a considerable extent, and very often without the enforcement of any of the above-mentioned protective precautions; for whilst the rich growth of grass and the usual crops of conifers tend to minimise the damage done, the injury done to the forests is of less importance from a national economic point of view than the maintenance of the cattle-rearing industry.

47. *Injuries done by Swine; Preventive Measures.*

Swine eagerly consume Oak and Beech mast, and also the cotyledons of both these species when the seedlings have germinated; whilst wallowing and snouting in the ground in search of insects and mast, they injure many plants by grubbing up small ones completely, or damaging the roots of large ones. Weakly saplings and sturdy transplants on grazing land they also damage by rubbing themselves against them. In consequence of their wallowing propensities, the different layers of fallen leaves are mixed up together so as to interfere with the normal process of decomposition and the formation of humus or leaf-mould.

When conducted in an irregular and inconsiderate manner, the herding of swine can be very detrimental to the wellbeing of the forest, although the damage can easily be reduced to a minimum, if limited in extent, and only permitted under adequate supervision. But in many cases the driving in of swine into the woodlands is a sylvicultural measure productive of no little good, as, for example, in the preparation of the soil in seed-fellings of the Beech, and in providing a soil-covering for the Beech mast; towards the effective attainment of both of these objects the wallowing of the swine materially contributes, as well as towards the destruction of injurious insects, whose larvæ and chrysalides, eagerly devoured by pigs, are to be found in their hibernating quarters in the soil.

In order to obviate damage, the herds of swine should only be driven into the older woods, where the trees are little likely to suffer any appreciable injury of the roots, and only when adequately supervised by herdsmen. If, as is usually the case at mast time, they are to remain in the woods for the night, they ought to be securely penned at nightfall.

In Beech woods undergoing reproduction, the herds of swine should be driven in during mast years until the fall of the beech-nuts begins to be general; but when it happens to be a good seed year, the herds may still be allowed to seek pannage in the enclosures undergoing regeneration, in order that the seed may be worked into the soil by their feet, and by their breaking up the ground with their snouts in quest of worms, larvæ, &c. Care should, however, be taken only to drive in the herds of swine into such woods after they have been feeding well elsewhere, otherwise they

may consume a larger quantity of mast than is desirable, before they begin to wallow and break up the soil to any extent. Too early a commencement of herding, before the acorns and beech-nuts have begun to fall, and too large herds proportionately to the area at disposal for feeding over, increase the likelihood of damage being done to the roots of seedling growth already on the ground.

Like the grazing of sheep and cattle, the driving in of swine for pannage in the woods, formerly of considerable importance, has lost much of its earlier consequence. It is in many parts practically in abeyance, partly on account of the more extensive cultivation of the nutritious potato, and partly also as the result of the shrinkage in the area now under Oak and Beech woodlands; and with this shrinkage the danger of damage to the woods from this particular form of minor utilisation has of course proportionately decreased.

b. The Animals of the Chase.

48. *Damage done by Game.*

The animals of the chase that inflict injuries on our woodlands comprise red, fallow, and roe deer (wild-boar in Germany), hares and rabbits; but the nature and extent of the damage done varies essentially, according to the kind of game doing it.

(*a*) The damage done to woods by *Red-deer* (*Cervus elaphus*) consists partly in biting off the buds and young shoots of most species of trees, thereby causing the immediate death of young plants, and when often repeated, crippling and stunting older plants, and interfering completely with their normal development; under any circumstances, plants are always more or less injuriously affected. Deer also eagerly devour acorns and beech-nuts, as well as their cotyledons after germination of the seedlings, and are endowed with considerable skill in finding out the seed in areas undergoing reproduction, and in turning it up out of the ground. When rubbing the velvet from their antlers in early summer, or when striking during the rutting season, the saplings or poles, on which both operations are carried out, are more or less denuded of their bark, and sometimes injured to a fatal extent.

Red-deer can also do a considerable amount of damage by treading down and injuring young seedling growth, especially

where cultural operations have been carried out in strips or bands. On hill-sides and undulating ground they prefer to follow the horizontal lines formed by the strips on which sowing has taken place; and when once a run has been frequented by a herd of deer for any length of time, the damage done may be very considerable.

And last of all, great damage is done in many places by deer stripping or peeling off the bark of trees,—a process that, on account of its special peculiarity and its importance, will be treated of in a section by itself (*vide* 51).

(*b*) *Fallow-deer* (*Dama vulgaris*) do somewhat similar damage to that committed by red-deer in biting plants, devouring Oak and Beech mast, and rubbing off bark when cleaning their antlers and when rutting; but, on the other hand, they only exceptionally peel off the bark with their teeth when the head of game is very strong in deer-parks, whilst in the freedom of the open woods they do not indulge in it at all.

(*c*) *Roe-deer* (*Cervus capreolus*) also nibble and browse on the buds and tender shoots of many species of trees, and devour acorns and beech-nuts, but never strip off the bark for food. Roe-buck, however, do a good deal of damage by cleaning off the velvet from their horns, and in doing so exhibit a very stong preference for the species of trees of more infrequent occurrence, selecting Larch, Silver Fir, Weymouth Pine, Acacias, &c., that have been interspersed among other ruling species, or planted along the fringe of compartments, drives, green lanes, and the like. Where a strong head of roe-deer is maintained, the rearing of these subordinate species of trees is often only possible when special measures are adopted to secure them against the bucks.

(*d*) *Wild-boar* (*Sus scrofa*) are particularly fond of acorns and beech-mast, as well as of seedlings with the cotyledons attached, and of the succulent rootlets; but they also often do very considerable damage in young seedling crops and plantations, especially of the broad-leaved species, whilst breaking up the soil with their snouts in quest of insects and grubs. By thus destroying the larvæ and chrysalides of insects in the soil, they at the same time do a considerable amount of good, and particularly in coniferous forests, which are most exposed to attacks from dangerous insect enemies. The breaking-up of the soil by wild-pigs here and there in certain crops not infrequently indicates to the observant forester the presence of injurious insects in the ground.

(*e*) The damage done by *Hares* consists in the nibbling of the buds of broad-leaved species, less frequently of conifers, and the gnawing of the bark of certain species, above all the Acacia, and then the Beech and fruit trees; but this gnawing of the bark usually only takes place in hard winters, when there is a decided want of other nourishment. Hares can be very troublesome by infesting nurseries and enclosures for raising seedlings.

(*f*) *Rabbits* do very much the same sort of injury as hares, by nibbling buds and young plants (even one-year-old Scots Pine), but occasionally cause somewhat greater damage by gnawing the bark, particularly of Beech, Hornbeam, Acacia, Oak, and Larch, whilst in young plantations they can cause a good deal of injury and annoyance by undermining the soil with their burrows. In consequence of their prolificness and rapid increase, and of their maintaining themselves permanently on one and the same area, the damage done is often very much felt, so that in falls and crops near rabbit-warrens there are often blanks which it is uncommonly difficult to fill up.

(49.) *Factors determining the Extent of the Damage done by Game.*

The extent of the damage that may be caused by game is dependent on many different circumstances. As has already been stated in the foregoing paragraph, it varies with the species of game, and still more according to the strength of the head maintained, the conditions relative to nourishment and fodder available for the game, and finally the species of trees and the sylvicultural treatment given to the crops.

A large head of game invariably leads to much greater damage proportionately, as may especially be noted in deer-parks, where also the greater frequency of stripping the bark cannot fail to be noted. So long as the deer have a sufficiency of green food in summer, whether supplied by succulent wild grasses, meadows, young field crops, or mast-bearing trees, and a suitable supply of fodder during winter, they will be much less likely to attack young woodland growth than under exactly the opposite circumstances.

But the extent to which the different species of trees are attacked by deer, and the amount of damage done by browsing on them, varies very considerably, as does also their recuperative power in healing the wounds inflicted. Amongst conifers, the

Silver Fir suffers most, but is at the same time the best endowed with recuperative capacity, whilst the Scots Pine, which is much less liable to be injured, is speedily interfered with in growth and development by being nibbled. Although in general more liable to be bitten and grazed on, the broad-leaved species of trees possess at the same time a superior reproductive power: Oak, Maple, Sycamore, Ash, and Beech are for the most part grazed on, whilst softwoods suffer more from rubbing with the antlers during early and late summer. Alder and Birch suffer least of all in either respect, as they are only exceptionally selected by deer for either purpose. Subordinate species of trees, merely sprinkled or interspersed among other ruling species, are most exposed to nibbling, as, for example, conifers, even including Scots Pine, scattered throughout seedling crops of Beech.

The succulent stoles and stool-shoots in coppice-hags are specially liable to be browsed on during the winter months; but, on the other hand, they grow beyond the reach of the deer much sooner than the seedling growth of young high-forest, so that any damage inflicted on the shoots hardly affects their quality as fuel, whereas high-forest is the method of treatment most likely to suffer permanently from any injuries received.

But in addition to the above-named direct results of injuries to the woods, there are also certain indirect consequences. Among these are the necessity for protecting the acorns and beech-mast by storing them throughout the winter, which cannot be done without some outlay,—the impossibility of reproducing the Oak by the dibbling in of acorns, which necessitates a heavier outlay for planting,—the hindrance occasioned by red-deer to the artificial interspersion of Silver Fir throughout crops of Spruce, owing to their being sought out for nibbling, &c. The extent, to which these dangers exist, varies so much with circumstances, that it is equally impossible either to estimate the indirect consequences or to express the direct results numerically.

(50.) *Preventive and Protective Measures.*

The means through which injuries to woodlands by the above-mentioned animals of the chase can be, so far as possible, hindered, or at any rate minimised, are partly of a preventive nature, having reference to adequate nourishment of the herds, or to keeping

down the head of game to reasonable limits by shooting off the periodic increment, and partly of a sylvicultural nature so far as regards the due protection of such trees, or species of trees, as are likely to be exposed to danger.

Among the *Preventive measures*, which fall to the duty of the gamekeeper, are to be reckoned the reduction of any excessive heads of game by shooting them down, the provision of a sufficient amount of nourishment for them, and adequate supplies of fodder during the winter months,—of hay, acorns, potatoes, turnips, Indian corn, and horse-chestnuts for red-deer, and by the felling of softwoods, especially Aspen and Silver Fir, for roe-deer, so that they can browse on the buds and the clusters of mistletoe that are often growing on the latter; whilst the formation of meadows and open spaces, the retention of a sprinkling of softwoods in young crops, and the planting out of chestnuts and horse-chestnuts, Mountain Ash, and other mast-bearing trees, should also not be lost sight of.

The Sylvicultural measures of utility in this respect include the avoidance of sowing out acorns and beech-nuts in autumn, especially along strips or bands of prepared soil, if there be any considerable head of red-deer or wild pigs, as they both, but particularly the latter, know very well how to find out the seed, and are almost certain to devour it completely during the winter months. Where blanks are to be filled up among young growth, quickly growing species should be selected, and sturdy transplants made use of; in some places, as on the Harz Mountains, for example, Spruce is planted out in wisps of seedlings for the protection of plantations, in the hope that one or other of the seedlings forming the wisp may escape being bitten. The introduction of subordinate species may also take place in small patches instead of merely singly or individually, when there is any likelihood of their being nibbled (Silver Fir) or barked (Larch) by the deer.

Among the direct *Protective measures* may be enumerated the enclosure or fencing in of all plantations, and areas being reproduced, until they have outgrown the danger of being browsed on, —a measure which cannot be avoided in deer-parks,—or less frequently the defilement of such areas by means of strongly smelling substances (crude pretroleum, assafœtida, &c.), into which linen cloths are dipped and then applied as convenient. Of late years, and particularly with regard to young woods of conifers,

and to the introduction of subordinate species (especially Silver Fir, which is greatly exposed to danger) interspersed throughout plantations, smearing with coal-tar has been adopted; it is applied either with a little wooden spud or else directly with the gloved hand to the leaves of the leading shoot, but due care must be taken not to injure the buds, as if they become coated with the tar they perish, in consequence of which the method is not applicable to the broad-leaved species of trees. The danger to which buds are thus exposed has led to the adoption of a less risky method;[1] a mixture being formed of 4 parts fresh cow-dung, 1 part coal-tar, and as much urine as brings it to the consistency of thick oil-paint when stirred; this is coated on the leading shoots with a wooden spud, and without any precautions being needed about the buds. Slacked lime has always been successfully used instead of the tar, as in spring the bud easily breaks through the protective and quite innocuous shell enclosing it. The operation must be repeated each autumn, but the costs are very small, and the success of the manipulation is complete.

Subordinate species that are interspersed only individually,—Larches, Weymouth Pine, and exotics planted experimentally,—can be protected against the brushing of roe-buck by binding brushwood round them, by fixing rugged branches near them in the ground, by tying on with a thread little pieces of newspaper,[2] about 4 inches square, that have been cut up at home, at a height of 20 to 24 inches above the ground, or by smearing the stem with any mixture having an objectionable smell, as, for example, lime mixed with bullock's blood and urine.

In order to prevent the treading and injuring of plants set out in horizontal lines on sloping ground, it has been found advantageous to insert pegs or short poles of about $4\frac{1}{2}$ feet in length slantingly into the ground every 20 or 30 paces apart; and as the deer dislike the inconvenience of always having to step aside for these obstructions, they usually change their run.

Where red-deer and wild-pig are plentiful, nurseries and seedling beds must be protected by fences of sufficient height and

[1] This method finds extensive application in Bavaria against both red-deer and roe.

[2] This method was first introduced at Grubenhagen (Hanover), more than twenty years ago, by Oberförster Niederstadt, under whom the Translator had the benefit of serving his apprenticeship at woodcraft during 1873–1874. The bits of paper were tied with rushes round the topmost buds of Silver Fir in autumn, and generally remained till the following autumn, like a collar at the base of the new shoot.—*Trans.*

strength; where the game consists only of roe-deer and hares, the seedling beds of broad-leaved species and Silver Fir will at any-rate need protection. But where the head of game of the latter kinds is comparatively small, poles laid across the beds, or feathers or rags hung on strings, are often all that is necessary to keep them off. For rabbits, a thick, close fence is necessary. Broad-leaved seedlings that have been gnawed round about by hares or rabbits should be cut back to the root; but fruit-trees and the more valuable species require to be protected against their attacks by binding thorns or rough brushwood round the stems.

51. *Damage done by Red-deer in Stripping the Bark.*

The peeling of the Rind of young smooth-barked species of broad-leaved and coniferous poles by red-deer,—as previously remarked, fallow-deer only do this exceptionally, in parks where a large head of game is maintained,—either takes place in winter in the shape of gnawing the bark at about the height of the animal's head, or higher when there is much snow on the ground, (in which case the marks of the teeth are plainly apparent on the damaged stems, with narrow lines of bark and cambium between the indentations), or else it occurs in spring and summer, when the sap is in flow. In this summer-stripping the deer bite through the bark at whatever height their head may happen to be, and then, holding it firmly between their teeth and moving back at the same time, tear or strip off huge portions of the rind, occasionally more than half the circumference of the stem in breadth, which, gradually becoming narrower and more wedge-shaped, at last parts from the stem, often at a considerable height, and is then completely devoured by the deer. Naturally, these injuries inflicted by barking the poles in summer do far more permanent damage than the comparatively slight injuries inflicted by gnawing during winter.

This fact was first mentioned in German forest literature about the middle of last century with reference to the Spruce forests of the Harz Mountains. But it has gradually gained in importance down to the present, and in many localities, especially in deer-parks, it has assumed such proportions as most materially to reduce the outturn from Spruce woods, which suffer most in this way. The reason for bark-peeling in winter is doubtless, for the most part,

want of a sufficiency of nourishment and satisfaction of the craving for fodder ; but with regard to the summer-stripping, it is probably due to the daintiness of the deer in quest of either the sugar or the tannic properties contained in the rind, although perhaps it may be merely a continuation of the method of nourishment practised during the winter, or arising simply from wantonness, and occasional stripping, developing into an easily acquired habit, imitated by the other animals forming the herd.

In his very thorough investigations into this matter, Reuss comes to the conclusion that the present modern method of Forestry in Germany, leading to the formation of densely canopied, equal-aged crops in deer-parks, throughout which the softwoods and shrubs become more and more suppressed, tends to an artificial and altogether unnatural method of rearing large game,—for bark-stripping seldom occurs unless the deer be confined within a ring fence,—that the usual monotonous feeding with hay is the principal cause of their stripping the bark, in order to provide themselves with the tannic acid necessary to stimulate the secretion of certain requisites (*e.g.*, for the formation of antlers and the process of digestion), and that from the feeding-trough to the peeling of bark has almost become a natural movement.

The consequences of the damage done, which often extends to the majority of the dominating poles throughout the crop, consist in the diminished increment of the damaged individual stems, and the rotting of the wood at the parts stripped. The rot often continues far up into the stem, and later on leads to breakage of the stems, whilst still young, from accumulations of snow or ice, or from violent winds after they have approached nearer to maturity. At the same time the lower and otherwise more valuable portion of the stem is rendered useless for technical purposes, often to the height of 15 to 20 feet, and this of course necessitates a considerable loss in the outturn from such woods.

The extent to which damage may take place, and the danger of incurring it, depend in the first instance on the species of trees forming the crop. The trees specially liable to be barked are Spruce, Beech, Silver Fir, Weymouth Pine, and Oak, whilst Larch, Ash, Elm, Maple, and Sycamore are less exposed to danger, and Scots Pine, Birch, and Alder least of all. The younger poles with smoother rind are invariably preferred for stripping, and the danger ends with the commencement of the formation of thick

rough bark. The danger begins when the thickets are clearing themselves, becomes imminent at the time of the first thinning of the crop, and especially so with regard to the dominating poles, whilst the backward growth, still rough with twigs, is threatened to a much less extent. Crops of inferior development are not so much attacked, owing to the presence of twigs and branches, and the consequent coarseness of the bark. Stripping does not take place everywhere; it occurs chiefly in deer-parks, or wherever the deer are hindered by fences from having access to fields. Where a large head of game is inadequately provided with natural grazing, and largely fed on hay and similar fodder, the damage assumes much larger proportions than when a moderate head of deer is maintained in the open. In mountainous tracts, where the game can roam about at will, and where there is richer and more varied grazing, damage from peeling the bark is seldom noticeable, even with large herds of deer.

Among the *Preventive measures* may be comprised the avoidance of giving hay exclusively as fodder during the winter months, and care generally in providing a moderate head of game with a sufficiency of suitable nourishment. In young Spruce plantations the putting out of seedlings in wisps of 3 to 5 has been found beneficial, as the middle plants have a certain amount of protection. Although, both from a financial and an æsthetic point of view, not suited for application on an extensive scale, the smearing of individual stems and patches or groups of valuable species with substances having a bad smell and taste is also efficacious. The formation of numerous salt-licks has also been recommended as a protective measure against stripping of the bark, and an admixture of Holfeld's feeding-powder for deer[1] was hoped to cure the tendency completely,—which has unfortunately not been the case.

Reuss has recently recommended a plan which he has found to yield good results, namely, binding twigs round the predominating stems most exposed to danger. The wealth of twigs littering the ground at the time of the first thinning-out taking place is made use of for this purpose: one labourer piles up a bundle of fairly long twigs by laying them one over the other round the stem, with

[1] According to Holfeld's receipt, it is composed as follows:—25 parts Turkish Gall apples, 25 parts Oak bark, 20 parts Aniseed or Feunel, 10 parts Smyrnium, 10 parts Violet root, 10 parts Fœnigrec (Fœnum graecum). To these add 40 parts salt and 10 parts of pure Bone-meal. The hundredweight comes to about 50s. in cost.

the tops pointing downwards, so that the thick ends come up to about 6 feet above the ground, whilst a second labourer binds on the twigs firmly with two thin but well-tempered wires. The outlay is said to be as low as 9s. to 11s. 6d. per 1000 poles, and the twig bundles last for eight to ten years, so that only one repetition of the process is necessary before the stems outgrow the chief danger of the bark being peeled off.

c. Small Rodentia.

52. *Damage done by Mice and Voles.*

Among the little, gnawing enemies of woodlands, by far the most important part is played by mice, occurring in two genera, *Mus* and *Arvicola*, which do damage.

The genus *Mus*, the true mouse, is characterised by its pointed head, large ears, and tail as long as the body. Of this genus only the *Wood mouse* (*Mus silvaticus*) commits damage by devouring seeds, whilst only occasionally causing injury otherwise by gnawing the bark.

The genus *Arvicola*, the vole, is characterised by a broad head, small ears hidden in fur, short legs, and a short tail. Many species of it are injurious in woodlands, viz. :—

The true Field-mouse (*A. arvalis*), which is fond of retreating into the woods in autumn, where it can make itself very injurious both by devouring seed and mast, and by gnawing the rind of saplings and poles, chiefly those near the ground, as it is an indifferent climber ;

The Common Field-vole, or short-tailed Field-mouse (*A. agrestis*), which does damage in a similar manner, but is a better climber ;

The Bank-vole (*A. glareolus*), which does less damage in devouring seed than by gnawing, often climbing to a considerable height in order to reach the soft bark ; and lastly,

The Water-rat (*A. amphibius*), the largest species, which always lives below the ground, and damages roots by gnawing them, but never occurs in large numbers.

Mice and voles are always to be found in larger or smaller numbers in woods and fields, migrating from these latter into the nearest woodlands in winter. Mild winters and dry springs and summers favour their increase (which, as is well known, is of

extraordinary rapidity), in a very considerable degree, whilst unfavourable weather, like violent downpours of rain, and a long-continued cold damp time in summer, hard frost without snow, or rain followed by frost in winter, not only interfere with their prolificness, but also often cause excessive swarms of them to disappear in a short time.

Mice always love a certain amount of protection, such as is afforded by scrub, dense seedling growth, a tangle of grasses, and thick layer of fallen leaves. Any sort of protective soil-covering tends greatly to increase their numbers and reproductive power. Young crops and plantations with strong growth of grass are their favourite place of abode, partly for the protection they afford, partly also because there they find rich supplies of reserve material stored up in the roots of perennial and biennial grasses and weeds ; but older woods are avoided when once the mast has been devoured, unless there is a thick mantle of fallen leaves on the soil. When a layer of twigs or dead foliage is spread over seed-beds to protect the seed, this is of itself enough to attract mice.

The damage done by mice in woodlands consists, as has above been briefly mentioned, in the destruction of mast and seed, and in gnawing of the bark and roots.

Of the seeds of forest trees, it is particularly acorns and beech-nuts, also chestnuts, lime, and hornbeam seed that chiefly attract mice, whilst the seed of other kinds of broad-leaved trees, and still more that of conifers, is less exposed to danger. Pine, Spruce, and Larch seed are occasionally, it is true, devoured, but Silver Fir seed appears to be protected by the turpentine which it contains. As might be expected, sowings made in autumn are most likely to suffer during the winter, especially when Oak or Beech mast has been sown in strips or lines. The damage done in seed-beds and nurseries is often very considerable, whilst the extent of the injury inflicted in natural reproductions of the Beech is less noticeable, although it can also often become somewhat serious.

So long as the bark is still young and tender it is eagerly devoured as nourishment by several species of mice; the plants that suffer most are Beech, Hornbeam, Oak, and Ash, and in a less degree the conifers, the Silver Fir indeed only exceptionally, then lastly Acacia and Sweet Chestnut. But in this respect

the various species of mice exhibit very different tastes; they also make their attacks at very different heights above the ground, some commencing quite close to the soil, others a little way above it, others again only after having climbed some way up the tree. On plants of fair size the gnawing often takes place on one side only, often also all the way round the bole, and increases in proportion as the size of the plant diminishes, until it attains the complete biting through of the stem; one and two year-old Spruce plants in seed-beds are often sheared off in whole rows. But as soon as the plants get larger, and the bark becomes thicker, the less is the latter likely to be nibbled and gnawed at.

In gnawing the roots, *Arvicola amphibius* is the chief offender, to whose attacks Oak and Ash are especially exposed. But in seed-beds, on which there is no loose protective covering of soil compelling the mice to a more underground existence, the other species of voles are also apt to commit injuries by gnawing the rootlets.

53. *Preventive and Protective Measures.*

Damage by mice may to a greater or less extent be prevented by measures hindering their numerical increase, as well as by protecting the objects of their attacks.

With a view to the first of these, all mice-devouring birds and animals, Owls, Buzzards, Crows, Hedgehogs, Weasels, Porcupines, Martens, Badgers, and Foxes should be protected, although at the same time it must be pointed out that the interests of sport will suffer by any great conservation of these birds and animals of prey.

Attempts should also be made to disturb the breeding-places of the mice by the removal of whatever growth of grass and scrub may be utilised as bedding material, and by maintaining density of canopy overhead so as to prevent the growth of grass. The herding of Swine is greatly to be recommended, as in wallowing, and breaking up the soil with their snouts, they disturb the nests and the runs of the mice, which they eagerly devour; even the grazing of cattle is of use in keeping down the growth of grass and disturbing the mice, whilst many runs and nests are destroyed under their heavy tread.

Other preventive measures also include the formation of seed-beds and nurseries, in which mice can be especially troublesome, only at some distance from fields and young woods whence they

are likely to migrate, and the encircling of such nurseries with sufficiently deep protective ditches, whose walls should be as nearly perpendicular as possible, and along whose bottom pots full of water should be let into the ground, at suitable distances apart. Even surrounding seed-beds in autumn with a girdle or band of asphalt-paper 4 to 8 inches in breadth, held upright in the ground by short wooden pegs, has proved of great use, whilst smearing the bark of the little stems of the more valuable species of trees with asphalt-tar has also proved a protection against gnawing. For this last-named purpose Altum recommends the use of the patent tar or glue employed against some kinds of caterpillars (*vide* note on page 126).

If mice are at all numerous, the sowing of acorns or beech-nuts should not be carried out until spring, the mast being stored throughout the winter in protected places. Covering the seed-beds with tanning bark and Spruce twigs, and besprinkling of the acorns with finely chopped Juniper twigs before they receive the soil-covering on the seed-beds, have also proved efficacious. The formation of ditches with steep walls along the edge of fields, whence immigration is to be feared in autumn, has likewise been tried with more or less successful results.

But finally, especially in young Beech woods apt to suffer severely from gnawing, the laying down upon the ground of young stoles, stool-shoots, and advance growth of soft-woods, or any other species of trees, and of brushwood from the parent standards when felled, is often a very good means of protecting the young seedling growth. For their own convenience, the mice prefer to gnaw material lying on the ground to what is still standing upright, whilst at the same time the buds of the Beech twigs afford them a very toothsome nourishment, in the enjoyment of which their likelihood of doing damage is materially diminished, and occasionally, indeed, entirely obviated. When such material is collected in heaps throughout young crops which are specially exposed to danger, the mice congregate in large numbers in their neighbourhood, enjoying both their shelter and the nourishment offered by them; an exceptionally good opportunity is thus also given for poisoning the mice with wheat soaked in a solution of strychnine or phosphorus, and laid in drain-pipes scattered loosely in the vicinity of the heaps. Great caution is, however, always necessary in the use of poison.

Any effort at annihilation of large swarms of mice can only take place in woodlands for the protection of nurseries, and are not feasible for the safeguarding of the whole of the young crops. Destructive measures are limited to poisoning, for the setting of traps of any sort would cause so much trouble as to be seldom applicable, and would at the same time not yield results commensurate with the labour and supervision requisite. The general method of poisoning consists in laying grains of wheat, meal, flour, or bread pills in the holes, or in drain-pipes to protect them from damp, after they have been soaked in, or specially prepared with, phosphorus, arsenic, or strychnine. But the great drawback of this method is, that the mice which have been poisoned with phosphorus or arsenic usually wander away from their holes in search of water, and in thus dying in the open, tend to spread death among useful birds and animals, like Owls and Weasels. Recently, therefore, the use of precipitated carbonated barium, kneaded together with meal or flour, and dropped into the holes in pieces the size of a bean, has been much recommended, as it produces an immediate paralysis of the animals poisoned.

In conclusion, it may also be remarked that saplings of broad-leaved species which have been much damaged by gnawing should be cut off close to the ground early in spring, so as to be stimulated at once to energetic reproduction from the stool; for if the operation be delayed, the reproductive power is prejudiced, in consequence of a certain portion of the reserve of nutrients being dissipated in the development of the stem above the injured part.

54. *Damage done by Squirrels and Tree-mice.*

Squirrels (*Sciurus vulgaris*), when numerous, can do no inconsiderable damage to woodland growth.

They are fond of devouring the seeds of many kinds of trees, especially acorns and beech-nuts, but also chestnuts, hornbeam seed, and the seeds of conifers, which they procure by picking the cones to pieces. Yet even the young seedlings of Beech and Oak are not safe from their attacks, as by devouring the cotyledons of the former, and by rooting up those of the latter from the ground, squirrels can be very troublesome.

When there is any scarcity of seeds, the terminal and the flowering buds of conifers also constitute a favourite food-supply

of squirrels. They eat out the former from seedlings in nursery-beds as well as from larger transplants, and even bite through the leading-shoots so as to get at the buds. In order to obtain the flowering buds,—and they are especially fond of the male buds of the Spruce,—they bite off the thin twigs on which the buds are situated, eat out the latter, and then let the sprays drop to the ground. Such bitten and nibbled twigs or cast sprays, of about a finger's length in size, are often to be found lying in large numbers under old Spruce trees. The male flowering buds of the Oak and Beech are also devoured in great numbers by squirrels, and perhaps also the female buds, but this has not been so authoritatively settled.

Squirrels also love to peel the soft, sappy bark from young conifers in spring, and to a less extent from broad-leaved species too, scaling it off in small patches from the upper parts of the stem, biting through the rind, and sucking or licking the sap, so that slender stems are injured to no slight extent by the damage done to the bark. In some places, indeed, the injuries thus done to Larch, Pine, and Spruce poles, and exceptionally even to the Oak, have been very considerable.

The robbing of nests by squirrels may be regarded as an indirect injury, for they steal the young brood from the nests, and thus destroy no small number of birds that would otherwise have been of use throughout the woodlands; and at the same time, any good they may do directly by feeding on various kinds of injurious insects (as, for example, the chrysalides of saw-flies), is but small.

Wherever there is any excess of squirrels they should be shot down energetically, which can easily be done by game-keepers and subordinate foresters without any practical difficulty.

Of the tree-mice, the common Dormouse (*Myoxus glis*) is commoner in warm southern lands, whilst the Hazel or Garden Dormouse (*Myoxus avellanarius*) is more frequent in cold northern tracts. In addition to devouring tree-seeds, they are characterised by generally gnawing the bark in a circular manner, particularly the rind of the Beech, but also that of the Silver Fir and the Larch; hence in years when the tree-mice are numerous, the damage done can be very perceptible. General protective measures are hardly applicable; they consist usually in catching the little animals in traps, for their nocturnal habits contribute

along with their small size to preclude the advisability of shooting them.[1]

B. Birds (*Aves*).

55. *Damage caused by Birds.*

The disadvantages which accrue to our woodlands through birds are on the whole slight, and are certainly much more than counterbalanced by the advantages gained through their destruction of insects injurious to the trees forming the timber crops. But, at the same time, the damage occasionally done is of such a nature as to render protective measures advisable.

Among the classes of birds that may be named as injurious are the following:—

The Capercaillie, Capercailzie,[2] *or Cock of the wood* (*Tetrao urogallus*), which obtains its chief nourishment during winter and spring from the buds and needles of conifers, does a good deal of damage in nurseries and seed-beds, although the results are otherwise hardly appreciable in the open forest. During the course of the winter months one single bird can injure a very large number of seedlings and young plants by pecking out the terminal buds, more especially as they usually keep more or less to one feeding-place. The Silver Fir seems most of all exposed to danger, for not only the buds, but also the needles, are eagerly devoured by this bird.

Black Grouse or Blackcock (*Tetrao tetrix*) and similar game birds do comparatively little damage to woodlands, as, although attacking the buds and the male catkins of Birch, Hazel, &c., they feed more on berries and seeds.

Culvers, Doves, or Pigeons, including *the Cushat, Ring-dove, or Wood-pigeon* (*Columba palumbus*), *the Stock-dove or Wood-dove* (*C. œnas*), *and the Turtle-dove* (*Turtur auritus*), consume a good many seeds of the coniferous species, and the two larger kinds even acorns and beech-nuts, so that when, during the migratory period, they assemble in large numbers at the time of sowing in spring, sowings made in the open run considerable risk; but this is less the case in nurseries, in which the seed-beds are generally somewhat protected in one way or another not applicable to extensive areas.

[1] Hess, *Forstschutz*, vol. i., 1887, page 144, states that in Carinthia, in good beech-mast years, as many as 800,000 tree-mice have been caught in one year.

[2] Now a rare bird even in Scotland.—*Trans.*

The Jay (*Garrulus glandarius*) is particularly partial to mast, in particular acorns, beech-nuts, and chestnuts, and, notwithstanding that these may be carefully hidden away in the soil, possesses considerable talent for finding them out. It also digs up young oak-seedlings in order to devour the cotyledons, and can consequently become very troublesome and injurious both in nursery-beds and on sowings in the open, where jays often collect in large numbers. They have also occasionally been observed feeding on the cotyledons of coniferous seedlings which have just germinated. They further do damage indirectly by robbing nests and destroying young birds of useful species, whilst the advantage which they are said to bring by hiding acorns and beech-nuts under moss, &c., where these find a germinating bed, is at best somewhat problematic, for in most cases such seedlings come up where there is no particular use for them.

The *Finches*, including the Chaffinch (*Fringilla cœlebs*), the Linnet (*F. cannabina*), the Bullfinch (*Pyrrhula rubricilla*), the Hawfinch (*Coccothraustes vulgaris*), &c., can be very destructive in nursery-beds by devouring the seeds of conifers, which they are particularly fond of. They not only feed on the seeds, but also devour the cotyledons when, after being formed, they are still capped with the shell of the seed; sometimes, when coming in large numbers, they destroy whole seed-beds.[1] They are also fond of beech-nuts and the cotyledons of young beech-seedlings.

And lastly, the *Crossbills* (*Loxiae*), which are exceedingly fond of Spruce and Pine seed, and can easily manage to extract them after having bitten off the cones, may be productive of considerable damage, owing to the enormous numbers in which they often occur, and to their voracity in devouring the seed.

Woodpeckers (*Pici*) have always been considered as on the whole rather useful in destroying insects in trees; but during the last decade not only has their utility been very much doubted, but their activity has even, in many directions, been held to be altogether injurious. Besides having to bear the blame of devouring coniferous seed, which they can pick out of the cones very cleverly, of picking off the rind of young smooth-barked stems, and of pecking breeding-holes in healthy boles, they are

[1] The Tits (*Paridæ*) can also do a good deal of similar damage when flocking to nurseries in large numbers—*Trans.*

charged with the fault of forming the very curious rings or girdles not infrequently seen round tree-stems, and especially noticeable on old Scots Pine, whilst at the same time their crusade against insects extends for the most part only to the seeking of the larger kinds of larvæ (*Cerambyx*, &c.) in trees that are already unsound. The *pros* and *cons* cannot be weighed here; but as the German Birds' Protection Act of 1888 has taken the woodpeckers under its wing, and as no forester shoots them, these facts rather testify to their utility on the whole.

56. *Preventive and Protective Measures.*

Where *Capercailzie* still occur, the seed-beds of coniferous species can easily be protected by laying a light wooden frame-work over the beds exposed to danger, or by putting down rough branching top-ends and branches on the ground, so as to interfere with the peregrinations and movings to and fro of the birds. Wire frame-work, and the stretching of wires along and across the beds, have also been tried with good results, but, of course, they come somewhat expensive.

Against *Pigeons and Doves*, which are more apt to attack the sowings in the open than the nursery-beds, measures can be taken by delaying the sowing of the seed till after the chief period of migration is over, by giving the seed a sufficient covering of soil, or, if necessary, by maintaining a watch over the sowings for a short time, and occasionally frightening away the birds; but on the whole, the best means that can be adopted is the use of red-lead, to be recommended below.

Jays can only be kept off the sowings by watching, and by shooting them now and again; whilst in nurseries, laying rugged branches and thorny scrub over the seed-beds, or else some sort of a frame-work, is useful, more especially if combined with shooting them down occasionally.

Against *Finches* the seed-beds can best be protected by frame-work, and absolute security may be obtained against them if it be made of wire netting. Excellent results can, however, at the same time be obtained by dipping the seed into red-lead, which gives the seed a red coating poisonous and distasteful to the birds, but innocuous so far as the germinating capacity is concerned. This method is, at the same time, extremely cheap, for

with 1 lb. of red-lead, costing about 6d., at least six pounds of seed can be prepared. Tying threads or twine across the beds, with white feathers knotted into them, is also serviceable, whereas scarecrows of different sorts are only of little temporary use. Watching of the seed-beds, which can only be carried out profitably in large nurseries, may be dispensed with by adopting one or other of the above methods recommended.

Against *Crossbills* there is no simple effective measure available, but fortunately such would only occasionally be required.

C. Insects (*Insecta*).

57. *General Remarks concerning Insects.*

Under *Forest Insects, or injurious Forest Insects,* are not comprised all insects that may be found living on woodland trees, but only such as, occurring more or less frequently in large numbers, damage and endanger the growth of timber crops.

The disadvantages that may accrue to woodlands through insects are as manifold as their consequences are frequently injurious. By their attacks, both young crops and trees are disturbed in growth, and even killed; loss of increment, the formation of blanks, and sometimes the total destruction of extensive crops are the results, whilst young seedling growth and plantations may be more or less damaged, thereby occasioning and necessitating labour and outlay in the re-filling of blanks, and in other works of improvement. Insects that are technically injurious eat into the stem and decrease the value of the timber by rendering it useless for technical purposes; and at the same time, the glutting of the market with timber of any one species, after extensive destruction of woods by insect enemies, not only reduces the prices obtainable, but frequently also precludes the possibility of finding a market for the smaller assortments, consisting of poles, top-ends, and the like. Preventive and annihilative measures may make very large direct demands on the purse of the woodland proprietor; and as it is often necessary to let the falls lie fallow for years, in order to get rid of the swarms of beetles that have taken possession of the soil, the loss of several years' growth of timber on such vacant land, and the possible deterioration of the soil, are also indirect consequences attributable to these insects. The struggle in suppressing these little enemies is, at the same time, very troublesome

and difficult; for under favourable circumstances, their rate of numerical increase is quite extraordinary, and when once they have gained the upper hand, their annihilation is, in the majority of cases, almost hopeless without the assistance of nature.

In view of the great danger to which forests, and in particular coniferous forests, are exposed, it is the duty of every Sylviculturist to make himself acquainted with the appearance and life-history of the more important forest insects, and to acquire a knowledge of the best means of obviating and combating their attacks: Forest Entomology, indeed, forms one of the most important branches of the Protection of Woodlands.

As a basis for the study of Forest Entomology in particular, some general acquaintance with the outlines of Zoology is requisite, so that at all Forest Academies, and all Universities where Forestry is taught in Germany, a course of lectures on Zoology precedes the special lectures on Entomology. But in order to make the following details intelligible to those who have not had the opportunity of benefiting by such a course of study, a few brief remarks may be permitted concerning the characteristics and life-history of insects in general, before proceeding to consider the more important species individually in greater detail. In order to avoid repetitions, mention may, by way of preface, be briefly made of the circumstances favouring, and also those militating against, the numerical increase of forest insects, and of their enemies, likewise of the methods of prevention and annihilation generally employed, together with the measures to be adopted after any unusually large swarms have finished feeding. The general classification of insects will also be referred to in a few words, previous to considering them individually.

58. *On the Life-history of Forest Insects in general.*

Most insects pass through four metamorphoses or different stages of development, each of which distinctly varies from that preceding it. These four different stages of the *complete metamorphosis* are: —1, *Ovum*, or egg; 2, *Larva*, the grub or caterpillar; 3, *Pupa*, or chrysalis; and 4, *Imago*, or perfect insect. But in the comparatively infrequent cases of *imperfect metamorphosis*, a distinct pupal stage is wanting, the transformation from *larva* to *imago*

taking place gradually and imperceptibly, so far as hard and fast lines of difference are concerned.

The *Ova*, or *eggs*, varying greatly in shape, size, and colour, are sometimes laid singly, sometimes in larger or smaller groups or nests on the most different portions of trees, and occasionally protected in some special way, as, for instance, with a covering of hairy filaments; but in the case of parasitic insects, the eggs are deposited on or in other species. The larva sometimes makes its appearance from the egg in the course of a few weeks, sometimes not until months afterwards; for when ova are deposited during autumn, they hibernate or pass the winter in that same condition or stage of development.

For the *Larva*, several appellations are made use of. Thus the usually 16-footed larvæ of butterflies and moths (only those of the so-called Spanners *Geometridæ*, have 10 feet, whilst a few mining-larvæ *Tineidæ* have none are named *caterpillars;* the 18 or 22-footed larvæ of saw-flies (*Tenthredinidæ*), with a tail-like extremity, are called *tailed caterpillars;* the larvæ of most beetles, partly without feet, partly 6-footed, are termed *larvæ*—those, however, of the cockchafer species (*Melolontha*), *grubs;* whilst the feetless larvæ of flies (*Diptera*), in which the complex structure of the head is wanting, are known as *maggots.*

During the larval stage several changes of skin take place. When full grown, the larva becomes transformed into the *pupa* or *chrysalis*, becoming either a free or sculpt chrysalis, with all the different portions of the complete insect visibly apparent externally, as in the case of beetles, or else a masked chrysalis, as in the case of butterflies and moths (*Lepidoptera*), in which the various segments and sections are not definitely apparent. The pupa either lies naked and unprotected on the soil, under moss, under the bark, or in its fissures, &c., or else it is woven into a *cocoon*, often of considerable toughness: in the case of the *Diptera*, instead of any cocoon, a sort of bladder or shell is formed by the last larval skin.

The period of rest during the pupal stage varies greatly, extending from two to three weeks (as in the case of the very destructive "Nun," *Liparis monacha*, for example) up to 6 or 8 months in the case of hibernating species (*e.g.*, *Gastropacha pini*), and occasionally even for years (*e.g.*, *Melolontha*); it is then terminated by the appearance of the *Imago* or *perfect Insect* in its complete form as

beetle, butterfly, wasp, fly, &c., according as it corresponds to one or other of the seven orders into which insects are classifiable. As soon as the imago has appeared from the chrysalis, the time of swarming commences, during which copulation and reproduction take place. In the case of most insects, the male dies soon after copulation, and the female after the ovi-deposition, so that, as a rule, the life-period of the perfect insects is comparatively very short. But at the same time, many insects, especially beetles and weevils, hibernate as imagines, and have, of course, a relatively long life-period during the complete stage of their existence.

The time intervening between the deposition of the ovum and the swarming and reproduction of the ova by imagines is termed the *generation* or *generative period* of the insect. The generation may be:—

Multiple or manifold, when several generations are produced within one year, as in the case of plant-lice (*Aphidæ*) and *Ichneumonidæ*.

Two-fold or double, when two generations are produced in every year, as in the case of bark-beetles (*Scolytidæ*) and saw-flies (*Tenthredinidæ*).

Single, simple, or annual, when one generation is produced each year, as in the case of most butterflies and moths (*Lepidoptera*).

Biennial, biannual, or two-yearly when the insect requires two complete years for its development, as in the case of wood-wasps (*Uroceridæ*), the Pine Resin-gall Tortrix (*Tortrix resinella*), and many long-horned beetles (*Cerambycidæ*).

Multannual or *polyannual*, when three or sometimes four years are necessary, as in the case of the cockchafer (*Melolontha vulgaris*).

Forest insects either do injury only as larvæ, as in the case of all butterflies and moths, and as regards a portion of the other insects, or only as imagines, as in the case of some beetles, or else during both stages of development as larvæ and imagines, although this is usually confined to the case of beetles, *e.g.*, cockchafer, Pine-beetle (*Hylesinus piniperda*), &c.

The distribution of injurious forest insects is very extensive, both horizontally and vertically, although the number of the species, and of the individuals in them, decreases in going north, or with elevation above the sea-level. Conifers are in a much

greater degree liable to be damaged by them than broad-leaved species; and woodlands formed of large, contiguous, pure crops of one or the other species, but particularly of Spruce or Scots Pine, are especially exposed to the frequent and serious attacks of insect enemies.

So far as the species of trees are concerned, insects are either *monophagous*, when the damage done is practically confined to one kind of tree, as is the case with many insects feeding on conifers, or else they are *polyphagous* when feeding more or less indiscriminately on a variety of trees, as with a large number of insects infecting broad-leaved species. But every kind of insect usually attacks certain definite portions of trees, whilst every part of a tree has its particular enemies, as we shall see in classifying the injurious insects. And in a similar manner, it will also be found that one insect principally attacks older crops, another poles chiefly, and a third for the most part young crops formed either by natural regeneration, or by sowing or planting (*vide* par. 63).

So far as *the damage done* is concerned, it may be said that in general, coniferous woods suffer far more than those of broad-leaved species, not only because the most numerous and the most destructive kinds of insects are to be found there, but also owing to the latter trees having a much greater recuperative power. The other factors of influence, however, include:—

The age of the crop; as, for obvious reasons, young seedlings and transplants suffer more than stems of older growth.

The Part of the Plant attacked; for destruction of the cambium, or of the roots, is most injurious, and usually leads to the death of the plant when the injury is at all extensive. Where the damage is confined to the foliage, it may pass away merely with the loss of a certain amount of increment, although in the case of conifers [1] even this may lead to death.

The Season at which the damage is done; for if the attacks on leaves and needles take place late in summer or in autumn, after the buds have been formed for the following year, the damage always causes less loss of increment than if it take place in spring.

The Nature of the damage; as for instance if, particularly in the case of the Pine, the needles are totally devoured along with the sheath encircling them, or if there be any possibility of the

[1] Especially in the case of Spruce.—*Trans.*

development of new buds from the sheath owing to the stumps of the spines being left capable of performing assimilative functions.

59. *Influences favourable and unfavourable to their Increase; Enemies.*

Many forest insects attack sickly seedlings, poles, or trees in the first instance, particularly insects feeding on conifers, which first of all seek out the suppressed or unhealthy individuals with a weakly flow of sap. Thus we may note that bark-beetles (*Bostrychini*) and cambial-beetles (*Hylesinini*) deposit their eggs on stems broken by wind, or on newly-felled wood, or on stems already damaged by the attacks of caterpillars,—that the large Pine-weevil (*Hylobius abietis*) selects, when available, sickly plantations, or overcrowded crops raised by sowing, for its feeding-ground, whilst choosing as its breeding-place the stools of recently felled trees,—and that moths not infrequently select for the deposition of their ova crops which are backward in growth owing, perhaps, to the inferiority of the soil.

Certain localities, as for example windfall areas, and falls of mature timber where the stumps have not been grubbed out, offer favourable conditions as breeding-places for such insects, whence they re-issue in vastly increased numbers. Crops backward in growth also form favourable breeding-places, as well as central points for their attacks when feeding. Save during great plagues of insects, attacks only exceptionally take place simultaneously over extensive areas; they are otherwise always found to proceed and spread from single detached centres.

All circumstances combining to form such breeding-places or feeding-grounds in large numbers, and especially windfall and breakage from accumulations of snow, favour the rapid increase of insects injurious to woodlands; hot, dry summers are also favourable to them, as long-continued drought always tends to reduce a number of stems to a sickly state, and warm weather at the time of caterpillars changing skin, or of imagines swarming, is for many kinds of insects (*e.g.*, moths, sawflies) decidedly favourable to their numerical increase. And not infrequently, one insect prepares the way for another, as for instance, after the Black Arches, "Nun," or Spruce Moth (*Liparis monacha*) has fed on the needles of Spruce and Pine, the sickly stems yield a

favourable breeding-place for bark-beetles (*Bostrichus lineatus*, &c.), whilst in the stumps of trees that have had to be felled in consequence of the injuries sustained by the destruction of the needles, the weevils or rostral-beetles (*Curculionidæ*) also deposit their ova for the rearing of their brood.

But fortunately there are also influences unfavourable to the numerical increase of insect enemies, as well as favourable conditions. Among the causes hindering their too prolific reproduction when once the attacks of any insect have attained calamitous proportions, and even in some cases bringing them to a natural close, may be mentioned the following :—

Ungenial weather, violent downpours of rain, and damp, cold, raw days, especially during the time of swarming, or at the time caterpillars are changing their skin, when many succumb to the cold. But on the other hand, species that hibernate as caterpillars or chrysalides are very little sensitive to wintry cold ; they get frozen and then thaw again without suffering any apparent injury.

Diseases and epidemics, which often kill off the caterpillars in a short time, and fungoid attacks, to which caterpillars and pupæ hibernating under moss are especially liable, often reduce large numbers quickly.

Natural enemies of the insects, finally, often appear in unusual numbers, and assist in the war that is being waged against these. The chief of these enemies are :—

1. *Among Mammalia.*

Bats (species of *Vesperugo*), which are especially inimical to cockchafers and moths.

Moles (*Talpa europæa*) destroy grubs and mole-crickets (*Gryllotalpa vulgaris*) ; shrew (*Sorex vulgaris*), hedgehog (*Erinaceus europæus*), squirrels (species of *Sciurus*), weasel (*Putorius vulgaris*), pole-cat (*P. fœtidus*), stoat (*P. erminеus*), badger (*Meles taxus*), and fox (*Vulpes vulgaris*), devour a large number of beetles and chrysalides, as has often been proved from investigations made of the contents of their stomachs, and from examination of their excreta.

Wild-boar and tame pigs are very fond of grubs, hairless caterpillars, and chrysalides, and love to hunt for them in the soil or under the moss.

2. *Among Birds.*

The birds that are most useful in devouring numerous insects at various stages of development include the cuckoo (*Cuculus canoris*), which feeds eagerly on hairy caterpillars like those of the Pine moth (*Gastropacha pini*), that are avoided by most other birds, the starling (*Sturnus vulgaris*), Tits or Titmice (*Paridæ*), tree-creepers (*Certhia familiaris*), swallows (*Hirundines*), and most singing-birds, then thrushes (*Turdidæ*), ravens (*Corvus frugilegus*), the stannel hawk (*Tinnunculus alaudarius*), and wasp-buzzards (*Pernis apivorus*); wood-peckers (*Picus, vide* par. 55). Sparrows and finches (*Fringillidæ*), crows (*Corvus*), rooks (*Monedula turrium*), and larks (*Alaudidæ*), are only of minor utility in this direction.

All the above-named animals and birds should be protected and preserved wherever the good they effect is likely to exceed the damage done (by wild-pigs, fox, marten, and crows). The increase of the useful birds should be assisted by Bird Protection Acts, and more directly by the hanging up of nesting-boxes throughout the woods.[1]

3. *Among Insects.*

The *useful forest insects*, or the enemies of forest insects to be found in the class of insects themselves, are perhaps of greater importance than those found among mammals and birds. They are either *predatory species* devouring as larvæ or imagines the ova, larvæ, pupæ, or imagines of other insects, or else they are *parasitic species* compassing the death of injurious insects by depositing their own eggs in the ova or larvæ, less frequently in the chrysalides or the imagines, of the others, on which the maggots proceed to feed when they come out of the egg.

Such species always occur in woodlands to a far greater extent than the casual observer might be inclined to believe; and as injurious insects increase in number, so do these predatory and

[1] Since the recent calamities in Bavaria caused by the "Nun" (*Liparis monacha*) from 1889–1892, thousands upon thousands of wooden nesting-boxes have been erected throughout the woods, particularly with a view to increase the number of starlings by protecting their nests and young against cuckoos, squirrels, and wild cats, &c.—*Trans.*

parasitic species, on account of the larger amount of natural nourishment and the greater opportunities of reproduction thus offered to them.

(*a*) *Predatory species of Insects* include the well-known predaceous land-beetles (*Carabidæ*), of which in particular the tree-climbing species *Calosoma sycophanta* and *C. inquisitor* are useful, the sand-beetles (*Cicindelidæ*), the dung-beetles (*Staphylinidæ*), the gold-beetles (*Cleridæ, vide* Plate I. fig. 2), the leaf-beetles (*Coccinellidae*), the wasps (*Vespidæ*), and predatory flies (*Asilidæ*). Ants (*Formicidæ*) also devour numerous caterpillars, and trees near ant-hills usually remain exempt from attacks of the latter. The mole-cricket (*Gryllotalpa vulgaris*) is also an enemy of all insects living in the soil, although, on the other hand, it often does considerable damage to the roots of plants (*vide* par. 91).

(*b*) *Parasitic species of Insects* include certain genera of flies (*Tachininæ* group of the *Muscidæ*), easily distinguishable from other ordinary flies by the rough, brush-like hairs on the abdomen (*vide* Plate I. fig. 3), and ichneumon-flies (*Ichneumonidæ, vide* Plate I. fig. 1), which rapidly increase whilst attacks of caterpillars are assuming calamitous proportions. Owing to their importance and general distribution, these latter deserve some little attention here.

The Ichneumon-flies, belonging to the order of the *Hymenoptera*, comprise very numerous genera,[1] which vary greatly in size By means of a long ovi-depositor the female lays her eggs, sometimes only singly, sometimes often in very considerable numbers in the case of the smaller genera (290 larvæ of *Microgaster globatus* have been found in a single caterpillar of the Pine moth, *Gastropacha pini*), in the ova or larvæ, less frequently in the chrysalides or imagines, of other insects. The minute larvæ, that soon make their appearance, subsist on the vital fluids of the host they occupy, and when fully grown, bore their way out to the surface; there they enter and pass through the pupal stage in small cocoons, with which the dying caterpillars are often completely covered. The generation of the Ichneumonidæ is partly simple, partly manifold, in which latter case, as also when the number of hosts is large, they are exceedingly prolific, and increase rapidly in numbers. The hosts perish under all circumstances, although sometimes the caterpillars attacked enter the

[1] Hess, *op. cit.*, vol. i. page 213, states that there are 5000 species, and that about 1000 of these are parasitic on injurious forest insects.—*Trans.*

pupal stage before succumbing from the effects of the attacks. Whether or not any caterpillar has become infected may, in the case of hairless and brightly-coloured caterpillars, be told by the appearance of dark punctures where the eggs have been deposited, but in other cases only by making sections to see if any larvæ have developed themselves.

The importance of the rôle played by ichneumon-flies during insect calamities has occasionally been over-estimated, occasionally under-estimated. It is perhaps correct to say that they of themselves will never be able to suppress totally any serious devastation of woodlands caused by the voracity of swarms of caterpillars, as the extent to which their reproduction can take place is dependent on the presence of a still larger number of caterpillars; but, at the same time, it is certain that they contribute very materially to reduce and shorten the calamity. If sections made prove that a large number of caterpillars have been infected with ichneumon parasites, it may be taken for granted that the calamity is approaching its end,[1] and any direct destruction of the caterpillars need no longer take place, as that would involve the killing of a much greater number of useful allies among the Ichneumonidæ.

60. *Preventive Measures in general.*

In view of the extreme difficulty, and sometimes almost the impossibility, of annihilating and exterminating injurious insects when once they have obtained a footing in large numbers, it should be the special care of the forester and the sylviculturist in the first instance to prevent their numerical increase taking place on any very considerable scale: PRINCIPIIS OBSTA must be a motto never lost sight of.

To begin with, he requires above all some knowledge of the appearance, habits, and life-history of injurious insects; and at the same time, he must from time to time make a careful examination of the woods, paying particular attention to all windfall areas, to recently felled coniferous timber lying stacked for sale or removal, and to all sickly plantations and backward crops, which may de-

[1] Experience of past calamities has shown that under such circumstances fungoid diseases also break out largely among the caterpillars, such as that occasioned by species of *Botrytis* (which also causes *Muscardine* in silkworms), *Isaria*, *Cordiceps*, *Micrococcus*, *Bacterium*, *Sacharomyces*, and *Torula*.—*Trans.*

velop into vast breeding-places for them. And in order to discover them in time, so as possibily to crush the evil in the bud, diligent revision of Pine and Spruce woods in particular is indispensable. Many different kinds of observations lead to their discovery; bore-holes or bore-dust yield indications on lying timber, whilst the exudation of white drops of resin, or bore-dust hanging on scales of the bark or on cobwebs, give evidence of their presence in standing trees; excreta and needles, that have been bitten through, are easily distinguishable along paths, or along the drives or open lanes between the compartments containing the different annual crops, especially in the ruts formed by carts; the gradual thinning of the foliage exhibits the destructive progress made by caterpillars; and even the presence of more insectivorous birds than usual (*e.g.*, cuckoos, starlings, &c.), conveys a plain hint to the thoughtful observer. Excessive breaking up of the surface-soil with their snouts, either by wild-pig or by domestic swine, points to the presence of an unusual number of chrysalides. During the time of swarming, and especially towards evening, the frequency of moths may be readily noted; whilst during winter the caterpillars, like those of the Pine moth (*Gastropacha pini*), which hibernate there, may be found by occasionally lifting up the soil-covering of moss.

Although, as far as moths are concerned, we must for the most part necessarily confine ourselves to the early discovery of their presence as one of the chief means of obviating damage on an extensive scale, yet, in respect to many kinds of beetles, more effective preventive measures are at our disposal. Thus the removal of all sickly stems and windfall timber from the crops, the early removal of coniferous timber, or peeling of the bark at once if it is to be left lying for some time, and grubbing out the stumps of trees utilised, prevent the most dangerous species (*Bostrichini, Hylesinini, Curculionidæ*) from finding the breeding-places most favourable to their increase. Decoy-stems may at the same time be laid down here and there in order to attract beetles and weevils occurring in small numbers; and by destroying the brood when these stems are examined later on, their increase in much larger numbers can thus be prevented. The use of these decoy-stems, to be considered more at length in par. 61, is the best means we have of combating the increase of bark-beetles (*Bostrichini*) and cambial-beetles (*Hylesinini*).

But a number of purely sylvicultural measures are also at our disposal to prevent the recurrence of calamitous danger from insects. It cannot be denied that the method, now usual in many parts of Germany, of having extensive successive annual clear falls of timber, which leads to a series of large annual falls or areas stocked with homogeneous pure forests of coniferous species of equal age, and altogether the more extensive cultivation of coniferous crops in comparison with broad-leaved species, has not inconsiderably increased the danger from insect enemies. More especially in young crops and plantations, weevils or rostral-beetles (*Curculionidae*) are not only much more numerous, but also vastly more destructive than formerly. The avoidance of large total clearances annually, so far as possible the reproduction or formation of mixed crops of various species of trees, which experience has shown to be much less exposed than pure forests to injurious attacks from insects, the proper sequence or location of the annual falls so as to afford the woods as much protection as possible against violent winds, the timely and regular carrying out of thinning operations, in which sickly poles and stems are removed, the abeyance of removal of leaf-mould, the want of which may affect the productive capacity of the soil, and the careful conduct of all cultural operations like sowing and planting in what appears to be a promising manner, all tend, whether individually or combined, to militate against the increase of destructive insects, and constitute the sylvicultural methods of obviating their attacks.

61. *Exterminative Measures in general.*

Annihilative measures must vary somewhat in each case according to the habits of the insect concerned. From the life-history of the latter it may be determined at what stage of development the easiest point of attack may be found, should it be possible to undertake destructive operations on a large scale for its extermination. From the study of its habits may be learned the best time for seeking it, whether at its work of destruction, or after it has withdrawn into its hiding-places, or if it may be advisable to offer it special material to feed upon, with a view to inducing it to use this as its hiding-places or breeding-centres, or if, finally, efforts ought to be made to entrap it on its way to the feeding-places. But whilst, in the case of each individual species of insect, the study of its peculiar habits and of its life-history

will recommend exterminative remedies being applied in one or other of these special directions, yet, at the same time, the more important and successful of these measures may be considered and criticised generally, in order to a have better overlook, and a more comprehensive idea of them, as well as to avoid the necessity for repetition and reiteration. As, however, such measures are in the case of beetles essentially different from those adopted in the case of moths, it appears advisable to consider them apart in relation to these two different orders of insects.

(*a.*) *Beetles* (*Coleopteræ*).

The chief means of annihilating many of the injurious bark-beetles (*Scolytidæ*) and weevils or rostral-beetles (*Curculionidæ*), breeding in conifers, consist first of all in the immediate felling and barking of all stems attacked, and in at once burning the bark, in the cambial layer of which are contained the ova, larvæ, pupæ, and often the recently developed imagines themselves. All stems that are infested should be found out by frequent revisions of the crops, either by the foresters or by woodmen specially trained to the work. Such inspections, however, are not of themselves sufficient, but should be supplemented by laying down decoy-stems here and there (*vide* par. 60), in as large a number as is convenient, in order to induce the insects to select these for ovi-deposition, and then destroying the brood,—a measure that is not only remedial, but also preventive.

The felling and preparation of such decoy-stems should be seen to early in the season, before the swarming of the insect takes place in threatened localities, for experience has shown that many genera of the above-named classes are most likely to select as their breeding-places coniferous stems with suspended flow of sap; they therefore seek first of all for recently felled timber, before proceeding to attack healthy trees, whose strong exudation of resin threatens the well-being of their brood. In localities where, or under circumstances in which, experience has previously shown that the appearance of such insects is to be feared, a suitable number of stems should be felled and formed into decoy breeding-places; at the proper time later on in the summer, the same operation should afterwards be repeated, in order to obviate the danger that may arise from a second generation within the

year. For such decoy-stems, dominated or suppressed, but still healthy, poles, or stems should be selected, and not half-dry ones, that are already nearly dead, as such lose their efficacy too soon. It is also a good thing to provide them with rests below, so that beetles and weevils may have access to every part of the stem, especially to the lower side which remains fresh and sappy longest; and, at the same time, the branches (which also form decoy breeding-places for many species) should be removed by lopping, in order to diminish the evaporation that otherwise takes places through the leaves. If timber from the winter's fall is still lying about in the woods, it can, in the same way, be utilised for decoy purposes. But care must in that case be taken to see that it is removed from the forest by about the middle of May, and that it is not merely taken to be stored at some saw-mill in the vicinity of woodlands, for it should be treated exactly in the same way as other decoy-stems, by being duly peeled and the bark being burned.

Decoy-stems must be examined carefully from time to time, in order to see if they have been utilised by insects for breeding purposes. This can be seen from exudation of resin at the punctures, or from small heaps of bore-dust lying on the bark; pieces of the latter should also be removed here and there to ascertain to what stage the young brood has developed. If development has proceeded so far that the largest larvæ are fully half-grown, the decoy-stems should be stripped of their bark; for if it be removed before then, there is always the danger of a good many females being still occupied in ovi-deposition throughout the stem, and these might still be able to go and breed elsewhere if the barking is carried out too soon. It is best to burn the bark containing the young brood, although the larvæ soon die if the pieces of bark be exposed to the sun with the sappy, cambial layer upwards on warm sunny days, provided always that the development of the insects has not gone so far as the pupal stage. Branches and twigs that have become infested had best be burned.

Collecting the larvæ, as may sometimes be done in the case of moths, is really only possible with regard to cockchafer grubs in nurseries, when the soil is being prepared for seed. But on the other hand, many kinds of the larger beetles, like cockchafers and Spanish flies (*Lytta vesicatoria*), may be collected and killed after shaking the crowns of young poles or trees, or by means of decoy bundles of twigs or bark to which the beetles are attracted, or

else by entrapping them, as in the case of the large rostral beetle (*Hylobius abietis*), in specially constructed ditches, and then killing them by treading on them, or pouring boiling-water over them.

(*b.*) *Moths*[1] (*Lepidoptera*).

Annihilative and exterminative measures against moths must chiefly be adopted during the prolonged larval stage as caterpillars, although in not a few cases something may at the same time be done towards their destruction during the pupal stage of rest, and to a slighter extent even whilst they are ova or imagines.

The caterpillars may sometimes be collected merely with the hand,[2] as in the case of those hibernating on the ground under moss, those brought to the ground by shaking the poles or knocking on the branches with the heavy flat head of an axe, or those caught in ditches; they are then thrown into wooden troughs, whose sides are smeared with fat so as to present the caterpillars crawling out again. Or again they may be crushed to death when clustered together in groups, like young schools of the newly developed caterpillars of the Spruce moth (*Liparis monacha*), or by burning or crushing the so-called nests of caterpillars of the Lackey moth (*Gastropacha neustria*), and the cocoon-like clusters of the caterpillars of the Processionary moth (*Cnethocampa processionea*).

By shaking the crowns through tapping on the stems with wooden mallets, or with the flat head of an axe, a method of course only applicable in pole-forests, the caterpillars of the Pine Owlet moth (*Trachea piniperda*), and the Pine Span-worm (*Fidonia piniaria*), may be brought to the ground for collection: two or three smart taps should be given with the axe or mallet, and the operation is all the more successful if carried out early in the morning or during cool weather, as the caterpillars do not then take such good hold on the foliage as during warm sunny days. In order to avoid injury to the stem, the mallet or axe-head should be padded, or care should be taken to select the snags of old

[1] Practically, true day-butterflies (*Papilionidæ*) are almost innocuous to woodlands, injurious qualities being bestowed on the families generally known as moths, and comprising Sphynges, Spinners, Spanners or Loopers, Leaf-rollers, &c.—*Trans.*

[2] Where hairy caterpillars are to be thus gathered, the collectors must be provided with old gloves or other protection for the hands, as the hairs of many species are poisonous and very irritant.—*Trans.*

broken branches as the points for rapping on. Where the soil is covered with a growth of heather, whortleberry, or similar weeds, it is advisable to spread out sheets below the crowns operated on, otherwise valuable time has to be spent, only more or less successfully, in searching after the fallen caterpillars.

Ditches for intercepting the migration of caterpillars are of special utility when the attacks of the insects are comparatively severe, but are concentrated within a small area. The ditches may either be for the express purpose of isolating the infested areas by preventing the caterpillars from wandering across into the neighbouring portions of the crop (when, of course, they can only be serviceable so long as the leaf canopy overhead is simultaneously interrupted), or else they may be dug throughout the infested area with the express view of catching the caterpillars when moving about from place to place. These find very considerable difficulty in ascending the smooth steep sides of the ditches, and in creeping about in search of an easy means of exit, they get caught in holes made for this purpose along the bottom of the ditch, when they can be killed by throwing earth over them. The depth to which the ditches must be dug depends on the size of the caterpillars; they are about two feet deep when operations are being conducted against the large Pine moth (*Gastropacha pini*). This method is especially recommendable when the caterpillars are naturally prone to migrate, and when small areas are totally denuded of their foliage.

Rings or girdles of tar were formerly considered to be means only applicable to areas of limited extent; but they now find application on the most extensive scale, particularly in combating the attacks of dangerous moths like the Pine and the Spruce moths, since it has been found possible to prepare a special kind of viscous tar or patent glue, which retains its stickiness, and other qualities obnoxious to the insect, sometimes for months, without becoming hard through exposure to the atmosphere. By means of these tar-girdles, the caterpillars of the Pine moth are prevented from ascending the stems in spring after their period of hibernation on the ground, and the ascent of young caterpillars of the Spruce moth is barred, when they come out from eggs deposited below the ring. It also hinders the re-ascent of all caterpillars, whether they have been shaken down from the crowns, or have spun themselves down to the ground on cobweb-like threads, as in the case

of the Spruce moth, of some *Tortricidæ*, and of the almost wingless female imago of the Winter moth (*Cheimatobia brumata*).

Good viscous tar or patent glue should remain sticky and active for at least 6 to 8 weeks, neither running in consequence of getting washed by rain or from the melting influence of a hot sun, nor oxidising or getting covered with a superficial skin. Although its composition is supposed to be a secret, it must be a rather open one, as it is extensively manufactured by over a dozen firms (Messrs Polborn in Berlin, Mützell in Stettin, &c.). A hundredweight costs about 7s. 6d., and on the average this quantity is about enough to do $2\frac{1}{2}$ acres, although this depends on the average girths of the stems, as young crops require a larger quantity per acre than older woods. Before the operation of ringing the stems with tar is carried out, the bark is cleaned, or "reddened" as it is called in the case of the Scots pine, with scrapers, so that a girdle at breast-height of about four inches in breadth is scraped clear of all rough bark, whilst, at the same time, care is exercised not to damage the tree by scraping too deep. By this scraping, the patent tar bites on to the bark much more easily, and at the same time a much less quantity is required per stem. This cleaning of the stems should take place during the course of the winter and the spring in all crops where inspection and revision have shown that many caterpillars are hibernating on the ground (Pine moth), or that deposits of eggs have been numerous (Spruce moth), and only later on, about the end of March and the beginning of April, should the formation of the rings of viscous tar be carried out, when the soil temperature ascends to about 40 to 45° Fahr., and the caterpillars begin to be impelled to ascend the trees. The gluey tar may be applied with hard brushes, but better results are obtained through the use of small wooden spuds about 1 to $1\frac{1}{2}$ inches broad, smoothing off being performed with a similar spud hollowed to a depth of about $\frac{1}{5}$th of an inch. With good patent tar one operation should remain active and effective, even although the period during which the caterpillars ascend the stems may, from one reason or another, be unduly prolonged.[1] Should it be convenient to undertake a

[1] In August 1892, during a summer of much more than the average heat and dryness, I found the rings of patent tar, that had been placed round Spruce in the Bavarian forests during April as a protection against the "Nun" or Spruce moth, still perfectly sticky and active, although this was quite a month after the necessary time.—*Trans.*

thinning operation previously, so as to remove all individuals not absolutely necessary for the wellbeing of the crop, this will contribute very materially to a saving in labour and in patent tar, as well as removing a class of stems favourable beyond all others for the propagation of the insects.

The action of good patent tar is repellent, owing either to its smell or its taste. The caterpillars either have not the courage to attempt to cross the rings, when they perish of hunger below them, or they remain caught in them, owing to their viscosity, or if they succeed in crossing, they soon die in consequence of their feet and mandibles being clogged with the gluey composition.

A measure that formerly found extensive application, consisted in the removal from the woods of the soil-covering of moss (for cattle-bedding, &c.), when many hibernating caterpillars (*e.g.*, Pine moth) were at the same time removed, and many others were killed by exposure to the cold; but experience has shown that it is not very effective. And as it is obviously most prejudicial to the well-being of the woods, and the productive capacity of the soil, it has now been given up wherever formerly practised.

The chrysalides can only be collected when situated low down on the stem in the fissures of the bark, or when attached to shrubs; but on the whole their collection is not generally practicable on any very large scale. In destructive measures against certain species, as for instance the Pine Owlet-moth (*Trachea piniperda*), and the Pine Span-worm (*Fidonia piniaria*), the driving in of swine into the woods is a much more effective way of getting rid of all smooth-skinned chrysalides lying under the moss; for these are eagerly devoured by swine, although they will not touch the hairy species like the Pine moth (*Gastropacha pini*), owing, most probably, to the irritant properties of the hairs.

Ova can only be collected when they have been deposited in large numbers on the lower portion of the stem, as in the case of the Spruce moth (*Liparis monacha*), and under any circumstances many eggs and clusters of eggs are apt to be overlooked, especially in Pine woods, owing to the deeper fissures in the bark than on Spruce or Silver Fir stems. The clusters of ova are more readily noticeable when they have cobweb-like filaments attached, as in the case of certain species feeding on the broad-leaved kinds of trees, and Altum recommends the coating over of such clusters of eggs with patent tar for the purpose of killing them; this may be done with

the Spruce moth, the Red-tailed Vapourer moth or Beech-spinner (*Dasychira pudibunda*), and the Gipsy moth (*Liparis dispar*).[1]

The collecting of the restless moths themselves is the most troublesome, and, at the same time, the least satisfactory method, although some species sit so low down on the leeward or protected side of the stem on cold, cloudy, damp days, that they can be collected without difficulty. Experiments have both formerly and recently (in the case of the Spruce moth or "Nun" in Bavaria in 1891) been tried with bonfires and electric lights to attract moths and night-swarming butterflies towards exhaustors, &c., where they could easily be killed *en masse;* but they have always proved almost useless, except only so far as to determine the actual presence of moths in the woods.

In regard to attacks from night butterflies and moths in general, it may be remarked that they seldom exceed more than three years in duration, during the first of which the butterflies are seen swarming singly, whilst, here and there, there is an unmistakable diminution of the foliage forming the crowns of the trees. During the second year the destruction assumes greater proportions, and in many parts develops into total denudation of the needles and leaves, whilst the healthiest and most vigorous crops also begin to be attacked by the voracious caterpillars; simultaneously, however, ichneumon-flies and other useful insects also make their appearance in greater numbers than usual. Throughout the third year these latter occur still more numerously; the caterpillars and moths get smaller and evidently degenerate; diseases and fungoid attacks supervene; and during the fourth year there is often hardly a caterpillar to be found.[2]

[1] It may be remarked here that Professor Altum recommends the use of patent tar for many different purposes, as, for example, protecting valuable saplings and seedlings against the gnawing of hares, rabbits, dormice, and squirrels; for preventing the ascent of *Curculionidæ*, and the exit of many saw-flies, weevils and bark-beetles. For very small enemies, like tree-lice (*Coccidae and Aphidae*), and tree-bugs (*Pentatomidæ*), he also strongly recommends the use of Nessler's solution, consisting of 5 parts black soap, 10 parts amyl alcohol, 20 parts spirits of wine, and 65 parts of rainwater.

[2] During the recent calamities occasioned in Bavaria by the Spruce-moth or "Nun" (*Liparis monacha*) from 1889–1891, the flight of starlings collected in one locality alone was credibly estimated at 10,000, all busy feeding on the caterpillars, chrysalides, and moths, not to mention enormous flights of titmice and finches similarly engaged. (*Vide* Pauly, "*Die Nonne*," 1891, p. 33.) The attraction of starlings to such centres became so great that market-gardeners felt their absence seriously in distant parts of the country.—*Trans.*

From the above it will be seen how important it is to make a timely discovery of the presence of lepidopterous enemies, so as to take immediate measures against their spread. We may thus avoid the necessity for resorting to exterminative measures on a large and costly scale during the third year, and, at the same time, obviate the loss attendant on any extensive calamities.

Of course, in estimating the measures that appear advisable in regard to checking the attacks of any kind of injurious insect, due consideration must be given as to the actual necessity for adopting special measures, and as to whether the object in view is likely to justify the necessary outlay; for only in the latter case can costly methods of annihilation be justified. The number of injurious insects present within the woods, a point by no means always easy to determine, the health and the vigour of the crops in resisting attacks from parasitic and fungoid growth, the value and general condition of the woods attacked or threatened, and, finally, the prospect of a more or less satisfactory and successful conduct of the preventive and remedial measures that seem advisable after due consideration of the probable extent of the danger, of the necessary outlay, and of the amount of labour standing at one's disposal, must in each special case determine which annihilative measure seems most desirable, and to what extent the war must be waged against the insect enemies.

62. *Treatment of damaged Timber Crops, and of Timber felled in consequence of Injuries.*

Only crops of Pine and Spruce are apt to be damaged to such an extent as to necessitate felling or clearance on an extensive scale. Silver Fir and Larch, as a rule, suffer to a much less degree, and mostly from less injurious insects, whilst broad-leaved species of trees, owing to their greater recuperative power, can withstand even total denudation of their foliage.

Whenever any extensive damage is being committed by insects, it is of great importance to note whether the trees are being fatally injured or not. In the former case, any delay in utilising and preparing them for sale injuriously affects the quality of the timber, whilst in the latter, by felling too precipitately, there is the danger of not only glutting the mart with one particular class of timber,

but also creating blanks in the canopy and the crops, that may be unnecessary, and must be undesirable.

In addition to these purely financial points of view, it must not be overlooked that, as previously mentioned, sickly stems afford only too attractive and favourable a breeding-place for many kinds of noxious insects, and that attacks of *Scolytidæ* are especially to be feared in crops which have already been much injured and weakened in vigour by the devastations of caterpillars among the foliage. Of course, where such may be feared to be the case,[1] the clearance of sickly stems must be allowed to be of more pressing necessity than the felling of trees that have already succumbed to their injuries.

Damage to, and disturbance of, the cambial layer by the larvæ of beetles and weevils generally results in the immediate death of the stem, which is soon recognisable through the foliage rapidly becoming brown and then falling off. It is more difficult to decide about the extent to which damage has been done by caterpillars, for the question virtually raised as regards denudation of the foliage to any great extent in conifers, is whether or not the needles still adhering are sufficient to maintain the life of the tree and if there is any reasonable hope of the terminal and axial buds attaining development in the following spring.[2]

Among the signs which betoken the approaching death of stems may be included the appearance of all sorts of insects under the bark; flabby, soft, drooping, withered-like buds; needles of the Pine devoured down into the sheaths; scaling off of the bark; and brownish or bluish patches showing on the inner bark and sapwood. It will be advisable to retard felling operations when it happens that the damage takes place in autumn, so that the buds have a chance of developing, or when no total denudation of the foliage has taken place, or when the crops damaged are youngand growing on soil of good quality, where there is always a much better hope of their recovery than on inferior soils and situations

[1] In the Ebersbeger Park, near Munich, the chief beetles which followed the Spruce-moth in 1891 were the Harz rostral beetle (*Pissodes hercyniæ*), the four-eyed bark-beetle (*Hylesinus polygraphus*), and the Spruce cervicorn (*Callidium luridum*). (*Vide* Pauly, *op. cit.*, p. 78).—*Trans.*

[2] With regard to this point, it must be remarked that the recuperative power of the Scots pine is much greater than that of the Spruce fir, the former being ultimately able to recover although over 50 per cent. of its foliage be devoured.—*Trans.*

As regards the clearance of timber crops that are already nearly mature, there will, of course, be less hesitation or delay than in the case of younger crops; hence all the older falls of timber that have been essentially injured in annual increment may be cleared. But when the devastation has been committed over extensive areas, so that the utilisation of the trees is likely to affect the market price of the timber very prejudicially, endeavours will naturally be made to perform the operation of clearance as gradually as possible; in this matter, however, prudence must dictate in regard to the previously-mentioned dangers of sickly crops from other enemies among the *Scolytidæ* and *Curculionidæ*.

But whatever timber it is considered necessary to fell should be prepared for sale as speedily as possible. Both long timber and fuel should be barked in order to let it dry quickly, and all fuel should be well split; and finally, all the wood, of whatever class or assortment, should be stored or stacked in airy places, and well raised from the ground on suitable rests.

63. *Classification of the injurious Forest Insects.*

The injurious forest insects may be grouped together in many different ways, either according to the parts of the tree they damage, or according to the manner in which they injure the vital power and the value of the tree, or according to the age of the woodland crops chiefly attacked by them, or according to the degree and extent to which they do injury. Again, they may, of course, also be classified according to the species of tree on which they chiefly occur, or simply in accordance with their natural entomological classes.

According to the portions of the tree attacked by them, they are grouped into—

1. *Wood-boring or Timber-destroying insects*, which either bore into and riddle the wood with holes (*e.g.*, some *Scolytidæ*, *Cerambycidæ*, *Siricidæ*), or destroy the cambial layer of the bark and the sapwood (*e.g.*, *Bostrichini* and several *Curculionidæ*), or eat out the pith from the tender shoots (*e.g.*, some *Hylesinini* and *Tortricidæ*).
2. *Leaf-destroyers*, including the caterpillars of most *Lepidoptera* and of *Tenthredinidæ*, cockchafers (*Melolontha*), leaf-beetles (*Chrysomelidæ*), and Spanish fly (*Lytta vesicatoria*).

3. *Root-destroyers*, including the caterpillars of the Seed Owlet-moth (*Agrotis*), the grubs of the cockchafer, and the mole-cricket (*Gryllotalpa vulgaris*).
4. *Bud-destroyers*, including a number of *Tortricidæ* and *Curculionidæ*.
5. *Mast or Seed destroyers*, as for instance the Acorn-borer (*Balaninus*) and the Spruce Cone-twister (*Grapholitha strobilella*).
6. *Producers of Deformities or Malformation*, including Gall-wasps (*Cynipidæ*), Gall-midges (*Cecidomyidæ*), Plant-lice (*Aphidæ*), &c.

Insects are also classified as *physiologically* or *technically injurious* according to the injuries inflicted. These may on the one hand occur on important organs, and disturb the plants in their growth, or even cause their death; and on the other hand they may be connected with the riddling of the stems with holes, whereby the timber is rendered, to a greater or less extent, useless for technical purposes. Those comprised among the former are by far the more numerous, including all such as destroy the cambial layer, foliage, buds, and roots; whilst among the latter class are included the genera already named as timber-destroying insects (some *Scolytidæ*, *Cerambycidæ*, *Siricidæ*).

According to the age of the timber crops which are most liable to their attacks, insects may be either classed as destroyers of young plantations and seedling growths, or else as, for the most part, and sometimes exclusively, enemies of crops which have already passed through the sapling and thicket stages of development, and have entered upon the pole-forest or the tree-forest stage of growth. Amongst the former are found most of the *Curculionidæ*, some *Tortricidæ*, and the grubs of the cockchafer (*Melolontha*) genus of the *Scarabæidæ;* whilst the latter include the majority of the *Lepidoptera*, although many species at first exhibit a decided amount of choice between pole-forests and tree-forests when they commence their destructive operations. Thus, for example, experience shows that the Pine Span-worm or Bordered White Moth (*Fidonia piniaria*), and the Pine Owlet-moth or Pine Beauty (*Trachea piniperda*), always attack pole-forest first, and then only later migrate to tree-forest if their numbers be allowed to increase; whilst the reverse holds good regarding the Pine Moth (*Gastropacha pini*), and the Black Arches, "Nun," or

Spruce Moth (*Liparis monacha*), which first attack older woods, and then in their voracity proceed to denude younger woods of their foliage.

With reference to the extent of the injury each species does on the average, attempts have been made to divide them into *very injurious, noticeably injurious,* and *slightly injurious,* according as they occur more or less frequently, and usually in more or less numerical strength. Such a classification has, however, little to recommend it; it is apt to be extremely elastic, and under any circumstances indefinite.

But at the same time there are numerous insects, which, on account of the extensive and often calamitous injuries they have from time to time done in woodlands, must undoubtedly be considered as *very injurious species.* These include in particular the large 8-toothed or Spruce bark-beetle (*Bostrichus typographus*),[1] the large brown rostral-beetle or Pine weevil (*Hylobius abietis*), the cockchafer (*Melolontha vulgaris*), the large Pine Moth (*Gastropacha pini*), and the Black Arches, "Nun," or Spruce Moth (*Liparis monacha*). And along with these there are also others which have in certain localities committed such devastations in woodlands, as might justify their being included among the very injurious species; these include the Pine Owlet-moth or Pine Beauty (*Trachea piniperda*), the Pine Span-worm or Bordered White Moth (*Fidonia piniaria*), the Pine Sawfly (*Lophyrus pini*), the small, brown, white-spotted rostral-beetle (*Pissodes notatus*), and others, which, under ordinary circumstances, are reckoned as *noticeably injurious species.* Between this latter class and the *slightly injurious species,* the borderland is still more indefinite. It has, therefore, seemed best on the whole to adopt a different classification below, to consider the chief insect enemies in two main groups—namely, *Insects on coniferous trees* and *Insects on broad-leaved species of trees,*—and to treat of them within these groups under the special headings of *Beetles, Moths,* and *other kinds of Insects.*

[1] In the Highland and Agricultural Society of Scotland's *Transactions* for 1887, Fourth Series, vol. xix. p. 186, footnote, it is remarked by one of the Prize Committee on Forest Reports that *B. typographus* is "*not in any of the entomological lists for Scotland,*"—a fortunate thing for the Pine and Fir forests of the North.—*Trans.*

(*a.*) Insects on Coniferous Trees.

I. Beetles or Chafers (*Coleoptera*).

A. Bark-beetles (*Scolytidæ*).

64. *Bark-beetles* (*Scolytidæ*) *in General.*

The bark-beetles include some of the most destructive insect enemies of our coniferous woodlands, and although a few species are also to be found on broad-leaved species of trees, yet as they mostly live in the sapwood, they are less injurious as well as less numerous. Their number is very large, but in the following only the most important species can be treated of. As the habits and the life-history of the various genera and species have much that is common to all of them, a short general description thereof may be given before proceeding to consider the species in detail.

The bark-beetles are small, often very small, insects, almost cylindrical in shape, and of quiet, indefinite colour, which spend all their life, with the exception of the short time of swarming and reproduction, in the inside of woody fibrous plants, within which they develop from the ovum. For the most part they hibernate as perfect insects; but some of them are very early afoot in spring, and swarm during the first warm days of March, or even in February, whilst others only make their appearance again in April or May, so that they may be divided in this respect into early swarmers and late swarmers.

For the purpose of ovi-deposition they select, in the first instance, the class of timber most suitable, preferring neither wood that is dead or that has already grown too dry, nor sound, healthy trees, whose strong flow of resin would destroy the beetles and larvæ of most of the species; stems in any way damaged, and sickly, windfall trees, or those injured and broken by wind or by accumulations of snow and ice, newly felled timber, the stumps left in the ground from recent clearances, and crops of backward growth constitute the most favourable breeding-places. The beetles bore as quickly as possible into the sapwood of the stems selected, choosing for convenience the fissures on thick-barked Pine trees. In the case of species which only enter *in copulâ* within the stem, there is generally a comparatively large hollow cavity under the bark, the copulating chamber or *camera*

copulatrix. Here the act of fructification of the female takes place, and hence proceed the main galleries of equal breadth, which are characteristic of the *Scolytidæ*, (the breadth being in each instance dependent on the size of the beetle), and along which the female deposits her eggs alternately right and left in small holes bitten out for the purpose. It less frequently happens that the ova are deposited in clusters.

The *Main galleries* occur partly in the cambial layer between the wood and the bark, being now more in the former, or again more in the latter (bark-galleries), and partly in the sapwood itself (wood-galleries); they constitute the main difference between the beetles which breed in the bark and those which breed in the wood, and are distinguishable, according to the direction they take, into:—

1. *Vertical or longitudinal galleries*, running in the axial direction of the stem.
2. *Horizontal or latitudinal galleries*, when spreading peripherally round the stem.
3. *Radiating or star-shaped galleries*, when radiating in considerable numbers from the *camera copulatrix* forming the central point.

The two first-named species of galleries have either one or two branches, according as they go only to one or to both sides from the entrance-hole bored into the stem.

From the ova, whose number is often very considerable, (sometimes up to 100), and all of which are deposited within about 3 to 4 weeks, the larvæ, (developed in about 14 days and issuing feetless, curled in at the ends towards the belly, dirty-white in colour with a brown head), begin to eat *larval galleries* almost at right angles from the main gallery. These are small and narrow at first but gradually enlarge in breadth and depth as the larvæ develop in size; at the termination of each a *pupal chamber* is scooped out for the inhabitation of the chrysalis. Whilst growing broader, the larval galleries always spread out further from one another, and deviate more and more from their original direction perpendicular to the main gallery, so that the longest of them sometimes at last run almost parallel to the latter. As a rule, every larva has its own gallery, and in boring, the larvæ instinctively know very well how to keep clear of the galleries formed by their neighbours on each side.

In the few species whose ova are deposited in clusters, the larvæ form *family galleries* or *galleries in common*, whilst (according to Eichhoff, an authority on the *Scolytidæ*) in the case of the timber-borers true larval galleries are not formed, as the larvæ live in the main galleries, and only hollow out short cone-like galleries, at right angles to the main gallery, for their pupal chambers, the whole being specifically known as *ladder galleries*.

The main galleries, and the larval galleries connected with them, usually form very characteristic designs that in most cases very materially simplify the recognition of the species of insect to which the damage is due ; whereas the determination of the species by a mere examination of the larvæ only would not be possible.

The period elapsing between the deposition of the ova and the development of the mature imago, varies not only according to the species, but also according to the general kind of weather, and in particular according to the temperature of the breeding-place. Thus the period of generation is of longer duration in the hills and mountains than on the warmer plains ; but on the average it lasts only from 8 to 10 weeks. The chrysalides lying in the pupal chamber already exhibit all the different sections of the perfect beetle, from which they are mainly distinguished by their lighter colour and their softness of structure. After a pupal rest of about 8 days they undergo the metamorphosis into the fully developed beetle, but usually, especially when the weather is raw and cold, spend a few days feeding on the succulent cambial layer surrounding the pupal chamber, which then rather interferes with the characteristic appearance of the larval galleries. When, however, the weather is fine, the beetle bores a small circular *exit-hole* in the bark, and generally at once begins to swarm and to reproduce itself in a new brood. This attains its complete development in the same season, but as a rule does not swarm until the following year ; the beetles hibernate in the meantime under the bark, in fissures and cracks, in roots, stumps of trees, &c. Most bark-beetles have such a double generation, although, in regard to a few species, this has not yet been proved beyond doubt ; but local circumstances have always more or less of influence in this respect, for one and the same species may have a double generation in warm localities, whilst only having a single or annual generation in less favourable situations.

The presence of bark-beetles in stems lying on the ground is

betrayed by the bore-dust collecting at the entrance-hole, and by the entrance-holes themselves, and the air-holes communicating every now and again with the main gallery, which are apparent without difficulty when the bark is not too rough and scaly. On standing timber their presence is indicated by the exudation of white drops of resin, as well as by the bore-dust, which, falling down from above, chances to get caught in the rough scales of bark, and on cobwebs near the foot of the tree. When exit-holes are numerous and irregularly distributed over the stem, this plainly shows that the beetles have already begun to swarm, and that annihilative and exterminative remedies are too late for application in reference to these.

As already remarked, most bark-beetles exhibit a decided preference for sickly crops of backward growth, and timber in which the natural flow of resin has become stagnant; hence by frequent thinning and clearing of the woods from such material, by removing all windfall stems and broken trees, and such as have been prejudicially influenced in growth by wind, snow, ice, or any other natural cause, by clearing the falls as soon as possible of recently felled timber, by grubbing up the stumps of such trees, and utilising their roots and branches, or if that cannot be done by at any rate barking the stems felled, the best measures are adopted for preventing the reproduction of these insect enemies on any large scale. When the breeding-places naturally more convenient to them are wanting, the beetles also attack sound stems, and for the most part perish in consequence of the resinous outflow that follows; but when thousands of such small punctures or wounds have been inflicted, the tree grows sickly (*wilts*), and then offers a normally suitable breeding-place for the remaining beetles, as may only too often be seen when attacks of bark-beetles take place to any calamitous extent. All such sylvicultural operations as are recommendable against injuries of every sort,—against storms, ice and snow accumulations, stripping of the bark by deer, &c.,—are also distinctly favourable to the prevention of serious attacks from bark-beetles, the chief protection against which, as against injurious insects of all kinds, must undoubtedly be looked for in the formation and reproduction of mixed woods in place of pure forests; for in the former, not only are the conditions less favourable for the reproduction of insects, but there is at the same time a greater abundance of insectivorous birds.

The best annihilative measures consist in the laying down of decoy-stems here and there (*vide* par. 61), and in duly peeling and burning the bark from these after all the ova of one swarming-time have been deposited, but before any of the first beetles have had time to make their exit. Burning of the bark is best, though, where this is inconvenient, it is sufficient to expose it inside upwards to the sun, if the brood is still in the larval stage. But if the bark be thrown together in large heaps, as must occur when the attacks of the insects are on any very large scale, burning is absolutely necessary in order to destroy them.

It is of particular importance that, in order to carry on exterminative operations with fully successful results, another supply of decoy-stems should be prepared against the second time of swarming of the insects in summer, to induce them to deposit the ova there. As a general rule, it may be said that fresh decoy-stems should be felled every 4 to 5 weeks throughout the summer and well into autumn, wherever experience has shown that bark-beetles are likely to occur in any large number.

What has been said above concerning injuries inflicted, protective or preventive measures, and annihilative or exterminative remedies, refers especially to the bark-boring beetles. The much less numerous genera of wood-boring beetles, occurring in conifers as well as broad-leaved trees (*e.g.*, Oak), belong to the technically injurious class of insects; the trees attacked by these, especially the broad-leaved species, often continue to live and flourish for decades afterwards, although early utilisation of such stems is certainly advisable in view of the constantly increasing depreciation in the value of the trees attacked. For such cases the felling of decoy-stems is of no avail, and other measures require to be adopted in order to counteract the damage threatened, and to reduce it to a minimum (*vide* par. 71).

The bark-beetles are subdivided into three main groups, comprising about thirty species of sylvicultural importance:—

1. *True Bark-beetles* (*Bostrichini*) having the elytra often contracted and toothed at the lower end. They live chiefly on conifers, but also on broad-leaved species, partly under the bark and partly in the wood, but never breed in the roots, like many *Hylesinini*.
2. *Cambial-beetles* (*Hylesinini*) having the elytra or outer

wings extending beyond the termination of the abdomen. They chiefly occur in conifers and then always bore in the bark or but slightly into the sapwood, but never live in the wood or timber.

3. *Sapwood-beetles* (*Scolytini*), with obliquely shortened abdomen. They chiefly occur on broad-leaved species, and are of but slight sylvicultural importance.

(*a.*) True Bark-Beetles (*Bostrichini*).

65. *The 8-toothed Spruce Bark-beetle, Bostrichus* (*Tomicus*) *typographus.*

(*Vide* Plate I. figs. 5 and 15.)

This beetle varies from 0·16 to 0·24 inches in length, is cylindrical in form, black in colour, with brownish-yellow hairs attached to the thorax and elytra, and with reddish-yellow feelers and legs. The elytra or outer pair of wings have deep longitudinal notched stripes, and at the obliquely truncated termination there are four equidistant tooth-like projections on each side (whence the name 8-toothed). Next to *B. stenographus* it is the largest of the bark-beetles, but although fortunately apparently unknown in the extensive coniferous forests of Scotland,[1] it is about the most widely distributed, and at the same time the most injurious, of the true bark-beetles on the continent, having at various times occasioned enormous destruction throughout the Spruce forests of Germany.[2]

It is comparatively late in swarming, making its exit usually during the second half of April, or the beginning of May, or even towards the end of May in the mountainous tracts, where it finds its true natural home. It swarms for the most part on warm, sunny afternoons, and soon proceeds to attack first of all recently

[1] *Vide* footnote at page 90.—*Trans.*

[2] Hess, *op. cit.*, vol. i. p. 284, states that in the Böhmerwald between Austria and Bavaria, during 1872-1874, the devastation caused by *Bostrichus typographus* (principally) together with *B. chalcographus*, *B. pityographus*, *B. autographus*, *Hylesinus palliatus* and others, necessitated the clearance of 130,753,800 cubic feet of timber from 22,500 acres, besides, at the same time, causing the felling of 25,200,000 cubic feet of timber in the Bayerischer Wald. The beetles were present in such enormous swarms as to obscure the sunlight. In one forest alone in the latter locality 1000 woodmen were employed in felling and barking the trees.—*Trans.*

Thanks to our mixed forests, such calamities are impossible, even on a very much smaller scale proportionate to the lesser area (approx. $\frac{1}{11}$th) of our woodlands.—*Trans.*

felled stems or windfall trees; but, failing such, it also attacks standing timber at a considerable height above the ground, invariably selecting stems of large girth, and in these the portions having thick bark. The sunny edges of compartments, and the warm sides of trees surrounding small blank areas, are therefore its favourite breeding-places,—a fact which should be kept in mind when felling and placing decoy-stems. From the copulating chamber, which is somewhat large, a vertical gallery is hollowed out to a length of up to 6 inches, mostly either proceeding up or down the stem parallel to its axis, though it less frequently also occurs that there are two such longitudinal galleries running closely parallel to each other; these main galleries have 2 to 5 air-holes as well as the entrance-hole, and hardly touch the sapwood.

In small indentations made alternately on the right and left sides, and somewhat close to each other, the female, within a few weeks, deposits from 30 to 50 eggs, and sometimes many more (to about 100 it has been asserted), fixing them into position in the dents with glucose substance. About fourteen days later the larvæ creep out of the shells, and begin to eat their way sidewards from the main gallery, forming sinuous larval galleries at right-angles to it at first, which gradually get broader and bite deeper into the cambial layer till they attain from 2 to 4 inches in length, each terminating with the pupal chamber, in which the chrysalis stage is passed. After a pupal rest of 8 days, the chrysalis develops into the beetle, at first of a bright yellow colour, but quickly becoming darker in appearance, which sooner or later, according to the state of the weather, makes its exit from the stem by a circular hole. The whole of the metamorphoses from Ovum to Imago occupies 8 weeks on the average, but can take about 12 weeks under less favourable circumstances.

The first generation of beetles swarms from the middle of June till July, and at once reproduces itself in a new brood, which is also fully developed by autumn, either hibernating as beetles before reproducing themselves, or else under particularly favourable circumstances, (as, for instance, if they swarm as early as August), proceeding at once to reproduce a third generation within the year. From this it will be seen how enormously this insect can multiply under favourable circumstances; but fortunately, in the rawer mountainous tracts, where it naturally occurs most fre-

quently, the generation is frequently only a simple annual one, or else three generations require two years for their development, in which case the second generation hibernates as larvæ.

It must, however, be specially mentioned that any special time of swarming is only noticeable in spring, for during summer the beetles only gradually make their appearance in consequence of the ovi-deposition in the first instance being protracted throughout several weeks.

Trees that are attacked by any considerable number of beetles soon begin to show signs of the stagnation of the sap, and die rapidly in consequence of the interference with the flow of the latter occasioned by the larval galleries; but the beetles always make their exit from the stems before they are quite dead, so that the felling of such does not enable the forester to stay the current of reproduction.

This bark-beetle is almost always to be found here and there within Spruce woods; but under favourable circumstances, and when numerous suitable breeding-places are offered to it in consequence of extensive damage by storms or snow, it increases at a calamitous rate, and has several times committed enormous destruction in Spruce forests. It is only exceptionally that it attacks other species of trees.

As one of the cases of calamitous devastation of forests may be mentioned the enormous damage caused by bark-beetles, and principally *B. typographus*, in the Spruce forests of the Böhmischer and the Bayerischer Wald, which immediately followed, and was due to, the very extensive injuries occasioned by a great hurricane in 1870; it necessitated the felling of many millions of cubic feet of timber (see note to page 137).

Similar extensive devastations also occurred in the Spruce forests of the Harz Mountains towards the end of last century.

The speedy removal of felled timber, the barking of stems that must remain lying in the woods for some time, and diligent inspection of all windfall areas to see that they do not develop into breeding-places for insects, are the best preventive and protective measures; whilst the felling and barking of stems that have been attacked, the laying down of a sufficient number of decoy-stems in suitable places, and the peeling and burning of the bark from these, constitute the most effective annihilative and exterminative remedies against this dangerous enemy.

B. amitinus is also an 8-toothed bark-beetle, so very closely resembling *B. typographus* in outward appearance, and in its habits and life-history, that it is very frequently mistaken for the latter. It is, however, found on the Scots Pine and the Larch as well as on the Spruce; and the often-reported finding of the Spruce bark-beetle on the Larch is probably in reality the occurrence of *B. amitinus*, which also appears to be very common. Similar preventive measures and exterminative remedies must be adopted against it as have been described for *B. typographus*.

66. *The 6-toothed Spruce Bark-beetle, Bostrichus (Tomicus) chalcographus.*

(*Vide* Plate I. fig. 15.)

This is one of the smallest of the bark-beetles. It is only about 0·06 to 0·08 inches in length, almost hairless, with a fatty kind of gloss; it has a dark thorax, but is otherwise reddish-brown, and its elytra, though dotted near their base with fine rows of punctures, are smooth towards the ends, and carry on both sides 3 dark coloured, tooth-like protections near the end (hence the name 6-toothed).

It is chiefly to be met with on Spruce trees, but has also been found on all other conifers. It is an almost constant attendant on *B. typographus*, but is then usually to be met with principally in the upper portions of the stem, and on the main branches, in places where the bark is thinnest; it also occurs in pole-forests that are sickly or backward in growth. The main galleries formed by it are quite characteristic, as 4 or 5 of them radiate, star-like, from the copulating chamber; they are of course, as also the larval galleries, much smaller than the corresponding galleries formed by *B. typographus* (*vide* Plate I. fig. 15). Its habits and life-history resemble those of the last-named species, *B. chalcographus* having undoubtedly also a double generation within the year. It swarms a little earlier than *B. typographus*, and by making its attacks always in the upper portions of the stem, it soon brings the tree into a sickly sort of condition, thereby rendering it a favourable breeding-place for that more dangerous species.

The preventive measures and exterminative remedies are practi-

cally the same as with regard to *B. typographus*, but with this difference only, that more careful attention must be given to the younger classes of woods.

67. *The large* 12-*toothed Pine Bark-beetle, Bostrichus stenographus* (*Tomicus sexdentatus*).

(*Vide* Plate I. fig. 6.)

This is the largest of the bark-beetles; it varies from 0·22 to 0·32 inches in length. It is of a glossy black or deep brown colour, with yellow hairs, and narrows towards its lower end. The elytra are deeply grooved and punctured, and pinched in where they curve downwards; they have 6 tooth-like projections (*i.e.*, 12 in all) on each side, of which the fourth is the longest.

Notwithstanding its size, it is one of the less injurious species of bark-beetles, for it almost always deposits its ova in felled timber only, in windfall stems, or the ordinary falls prepared for sale as timber or fuel, and confines itself almost entirely to old and thick barked Scots Pines or the species closely allied thereto; it is found only exceptionally on the Spruce. When, however, such timber cannot be found, it also, driven by necessity, attacks standing timber. Such devastations as have been committed by the Spruce bark-beetle have never yet been chargeable to this insect, which is even comparatively rare in some parts of the vast Pine forests of northern Germany.

In habits and life-history it resembles the Spruce bark-beetle in many respects. It swarms in April and May. The main galleries are vertical, and attain a length up to 8 inches and more on each side of the entrance-hole, hardly, if at all, penetrating into the sapwood. Its generation was formerly considered to be merely simple, but recent observations seem to prove that it is also double.

Special measures will seldom require to be adopted against this insect, as the barking of any timber that may have been attacked usually suffices to confine its occurrence within non-injurious limits.

68. *The 2-toothed Pine Bark-beetle, Bostrichus bidens (Tomicus bidentatus).*

This little beetle, from 0·08 to 0·092 inches in length, is black, glossy, and covered with fine hairs. The elytra are frequently dark brown, with fine rows of punctures; towards their termination on the male there is a broad flat indentation, on the upper edge of which a large curved tooth-like projection protrudes on both elytra (hence *bidens*), that is wanting on the female.

This insect is chiefly to be found on the Scots Pine, and on the various species of Pine generally, although it also attacks Spruce and even Larch when it cannot find suitable breeding-places on the former.

It principally attacks young crops about 10 to 12 years of age, or else the crowns and branches of poles and trees where the bark is thinnest, avoiding as far as possible the portions where the bark is thicker. It must be included amongst the very injurious class of insects, for it has often been the cause of the ruination of very extensive plantations and young seedling growth, as well as of thinning and interrupting the canopy of old Pine woods to an injurious extent.

Swarming in April or May, it also has a double generation. The main galleries radiate in a star-shaped manner, but are easily distinguishable from those of *B. chalcographus* by their greater irregularity, whilst both the main and the larval galleries bite into the sapwood to a certain extent, and the pupal chamber is embedded within it to a very considerable degree.

The first generation is usually fully developed by the end of July, when it proceeds to reproduce itself in a second generation. Under favourable circumstances this can also reproduce itself in a third generation that hibernates in the larval state; but under normal circumstances, the beetles of the second generation as a rule hibernate before reproducing themselves.

The best means of operating against *B. bidens* is by keeping the woods clean and well-thinned, removing all sickly poles during the thinnings, and by laying down small wood, the branches and twigs of decoy-stems set for other kinds of bark-beetles, for the purpose of attracting the beetles thereto, and then burning it or removing it from the woods as soon as the ovi-deposition is at an end. Young seedlings or saplings that have been attacked should

be pulled out by the roots and burned, whilst poles should be felled and barked, and the bark burned.

69. *The crooked-toothed Silver Fir Bark-beetle, Bostrichus (Tomicus) curvidens.*

This beetle, which is 0·10 to 0·128 inches in length, is deep-brown to black in colour, with long brownish-yellow hairs, whilst the female in particular is characterised by a close, golden yellow, frontal tuft of hair. The elytra have very deep longitudinal stripes with rows of fine punctures, and their edges at the somewhat abrupt termination have 5 to 7 teeth on each side on the male insect, of which 3 are much curved, whilst only 3 to 4 projections are noticeable on the female.

B. curvidens is to be found almost exclusively on the Silver Fir, and only exceptionally on any other conifer. It principally attacks stems in tree-forest, beginning its attacks in the crown and gradually working its way down the bole; it has also, however, been known to attack pole-forest at times, but has not yet been proved to be destructive to younger crops.

Swarming as early as the end of March and the beginning of April, it undoubtedly has a two-fold generation within the year. The main galleries are mostly two-armed and horizontal, although there are many deviations from their normal characteristic form, including galleries at many different angles, but never approaching the vertical like *B. typographus*. Both the main and the larval galleries eat a little way into the sapwood, whilst the pupal chambers are often formed for the most part in it, and are consequently filled up with bore-dust.

Its attacks are chiefly confined to trees near the edges of compartments, or to standards in the more or less full enjoyment of light and warmth; but under favourable circumstances the insect can reproduce and multiply itself so quickly as to cause very serious damage in Silver Fir woods,—hence sylviculturists have every reason to keep a careful look-out for the commencement of any attacks.

The same general protective and annihilative measures may be adopted as in the case of the other bark-beetles; but when barking fallen trees, it must be borne in mind that on stems, or portions of stems, which have thin bark, the chrysalides often

lie so deeply embedded in the sapwood as not to be removed along with the bark. This therefore necessitates the peeling of the bark before the larvæ proceed to form the pupal chambers, or involves the crushing of the pupæ within them.

70. *The many-toothed or Larch Bark-beetle, Bostrichus (Tomicus) laricis.*

This beetle is 0·14 to 0·16 inches long, mostly dark in colour, but occasionally a light brown, with a sprinkling of grey hairs, and with rusty-brown feelers and legs. The elytra are densely punctured, terminate abruptly almost at right angles, and with a circular indentation, the edges of which have 3 projections or teeth on each side.[1]

This insect is chiefly to be found on Pines, but also occurs on Spruce, and less frequently on Larch and Silver Fir; it is found principally in fuel stacked for sale, in poles, and in the upper portions of trees.

It is somewhat late in swarming, coming out for the most part in the month of May, the ovi-deposition by the second generation of beetles taking place, however, about the end of July or the beginning of August; these latter ova attain their full development in October, and the insects hibernate as beetles.

The main galleries are irregularly vertical, frequently twisting about, and often provided with short supplementary galleries or off-shoots; they generally begin with a boot-shaped chamber, and at the end of a gallery, often only about 1 to 2 inches in length, the female deposits her 30 to 40 ova in one or two clusters in a prolongation of the main gallery. The larvæ feed in common in irregular, confused *family galleries*, and in different directions, so that distinct larval galleries are not traceable as in the case of other *Bostrichini*.

This bark-beetle is of frequent occurrence in many localities, but its first brood is usually deposited in fuel stacked for sale, as this is frequently still in the woods at the time of swarming. Hence if this be barked at the proper time, or removed from the forest before the second brood has time to swarm, during July and August, special measures will not require to be taken against it.

Otherwise the preventive and remedial measures previously

[1] Hess, *op. cit.*, vol. i. page 290 gives 3 to 6 projections on each side.—*Trans.*

indicated for the other bark-beetles, will require to be applied in order to prevent its increase at the usual rapid rate.

71. *The Three-striped or Wood-boring Bark-beetle, Bostrichus (Xyloterus) lineatus.*

This timber-destroying bark-beetle, from 0·112 to 0·12 inches in length, has dull yellow-brown elytra, antennæ, and legs, with three dark longitudinal stripes (at inner edge, middle, and outer edge) on the outer pair of wings, whence the name *lineatus* is derived. It has none of the tooth-like projections at the termination of the elytra which have been noted in the other bark-beetles already described.

This beetle only attacks conifers, but may be found on all species of them. It is chiefly attracted towards recently-felled timber, and only exceptionally attacks standing timber of sickly growth; it differs essentially from the *Bostrichini* already described in detail, not only in its habits and life-history, but also in being one of the insects classifiable as being technically injurious to timber.

It swarms very early, in March and the beginning of April, and at once proceeds to attack the timber then usually lying here and there throughout the woods, the female boring an entrance-hole, at right angles to the axis of the stem, into the sapwood and the timber for about 1·6 to 2·0 inches, and then proceeding to form a horizontal main gallery, or, not seldom, two on each side, (following the periphery in the direction of an annual ring or zone of wood), on the upper and lower sides of which the ova are alternately deposited in small pockets or indentations. On coming out of the shell the larvæ nourish themselves mainly from the sap which oozes out from the walls of the main gallery, and only bore, at right angles to the latter, quite a short larval gallery about 0·20 of an inch in length, which remains constant throughout in diameter in place of increasing with the age of the larva, and in which the pupal metamorphosis proceeds. The whole figure represented by the borings is called a *ladder gallery*, from the fancied resemblance of the main gallery and the short larval galleries to a single-pole ladder and its rungs. There are no special exit-holes, as the beetles, when full-grown, make their way out from their place of abode by the entrance-hole.

Its generation is also twofold during one year.

The damage which can be done to valuable timber by this wood-boring beetle is somewhat considerable; but as, fortunately, the galleries do not go very deep into the wood, they are for the most part confined to the less valuable sapwood.

Besides laying down decoy-stems as breeding-places in summer, and then removing or charring these, the best means of preventing extensive reproduction of, and consequent damage by, this insect consist in the carting away of valuable timber that has been felled during winter, before the first swarming takes place in spring; or if too late for that, then timely removal of stems in which ova have been deposited, and barking of the stems, or splitting up of fuel sections are recommended, in order that the young brood may perish owing to the dryness of the timber.

(*b.*) Cambial Beetles (*Hylesinini*).

72. *The large Pine Shoot-boring Beetle or Scots Pine Cambial Beetle, Hylesinus* (*Hylurgus*) *piniperda.*[1]

(*Vide* Plate I. figs. 4 and 14.)

This beetle is from 0·16 to 0·18 inches in length, almost cylindrical, mostly glossy black, or at anyrate dark brown in colour, with a black thorax, and bright brown antennæ and legs. The elytra have rows of very fine punctures, the spaces between which are wrinkled with punctures and small knobs, and have a row of little excrescences bearing tufts of thick hair, like brushes. The second space on each front wing, however, has no excrescence at its termination, and thus appears somewhat indented or slightly pressed in,—thereby differing characteristically from *H. minor*.

Flattening and tooth-like processes at the end of the outer wings, as in the case of all the bark-beetles, are wanting, so that a distinction can easily be made between the *Hylesinini* and the *Bostrichini;* but, on the other hand, the distinctions between the cambial beetles themselves are made much more difficult owing to the absence of such marks.

The Pine beetle swarms very early, as early as March in good

[1] For a detailed account of this beetle, *vide* Transactions of the Highland and Agricultural Society for 1891, Fifth Series, vol. iii. pp. 31–43.—*Trans.*

weather, or in April if it be less favourable, and deposits its eggs under the bark of newly-felled stems or fuel-stacks arranged for sale, or failing these attacks also standing trees of sickly growth, selecting so far as possible only the portions of the tree where the bark is thick. It also visits recently-formed Pine stumps for ovi-deposition, and so long as such material is available it selects the Scots Pine, or at anyrate the genus *Pinus*,[1] for the purpose, although it may also occasionally be found on Spruce.

The female insect generally effects an entrance at one of the fissures of the bark, bores under the latter, and deposits the ova along a vertical main gallery, which commences with a curve before proceeding for a length of about 3·2 to 5·6 inches parallel to the axis of the stem. Ovi-deposition is continued for about 3 to 4 weeks, up to 100 eggs being laid fairly close to each other in niches or indentations along the edges of the main gallery. The bore-holes, by means of which the insects effect an entrance, are not infrequently noticeable from the yellowish outflow of resin on the bark.

The larvæ eat sinuous galleries in the cambial layer of the bark on each side of the main gallery, without boring into the sapwood, and pass through the stage of chrysalides in pupal chambers formed in the bark. The imago, of a brighter colour at first than afterwards, appears as a rule in June, 11 to 12 weeks after the laying of the eggs, or later if the spring weather has been backward and unfavourable; it bores its way out through the bark for the purpose of at once proceeding to produce a second generation. That a second generation could be produced during the year, was formerly doubted by many; but recent observations have proved that in mild situations such is the rule, whilst in rawer and more unfavourable localities, where the swarming in spring is usually a good deal later, only a single or simple generation obtains.

The beetles belonging to the second generation,—often, too, stragglers belonging to the first generation, that have been late of developing,—bore their way into the tops of the youngest shoots just below the buds, and after eating the pith, either turn and leave again by the entrance-hole or else from a special exit-hole. The entrance-hole is generally noticeable by the formation of a shell of resin round about it. Shoots, that have thus been

[1] Weymouth Pines are often attacked and badly injured by this beetle.

hollowed out, break as soon as any strong wind comes, and may often be found covering the ground in great numbers, whilst the trees themselves look as if they had been artificially trimmed by cropping: this is particularly the case when the injury has been repeated frequently, as from the constant loss of the side-shoots the crowns assume a pointed, cypress-like shape. The insect is, from this peculiarity, generally known as the *Waldgärtner* or woodland-gardener throughout Germany. The beetle itself hibernates in fissures of the bark, or under moss, and more frequently still inside the thick bark of the lower portion of the bole into which it bores its way.

This insect does less damage during the larval stage than is occasioned by the fully developed beetle. Owing to the strong exudation of resin from the healthier stems, its attacks are principally confined to felled timber, or to sickly and unhealthy crops; healthy trees are only attacked when the swarms have become excessive. But the imago does very considerable injury in the portions of the growing-stock attacked, especially along the edge of compartments and in pole-forests, where it is chiefly to be found, by annually repeating its interference with the normal development of the crown; it often completely cripples the crops in growth. Thus woods in the vicinity of timber depots, saw-mills, &c., often show exceedingly bad development, in consequence of the attacks of this beetle.

The protective and exterminative measures available against it are similar to those adoptable against the Spruce bark-beetle. These include keeping the woods as clean as possible, the removal of all sickly trees, or of individual stems which the bore-dust lying at their base, the white shells of resin, and the entrance-holes in the thick bark indicate to have been already infested, and the placing of decoy-stems here and there in spring and during summer, combined with the peeling and burning of the bark at the proper times. The timber and fuel obtained from the winter fall acts very beneficially in this way; but if not removed from the woods before the end of May, it should certainly be barked then.

Sweeping together the hollowed shoots and twigs, which lie scattered on the ground, is of little avail, as they have usually been quitted by the beetles before they break off.

73. *The small Pine Shoot-boring or Cambial Beetle, Hylesinus (Hylurgus) minor.*

In appearance this beetle may easily be mistaken for *H. piniperda*, than which it is about 0·02 inches less in length (*i.e.*, 0·14 to 0·16 inches). It can only be distinguished from that species by not having any interruption of the process-like excrescences at the extremities of the elytra, and also in being more of a brown, or even reddish-brown colour than deep brown or black.

But it is much more easy to distinguish between them in their habits, for whilst *H. piniperda* forms vertical main galleries, this species forms two horizontal galleries branching one on each side of the entrance-hole; these are chiefly to be found in the thin-barked upper portions of the trees, and only exceptionally in the parts where the bark is thicker. In consequence of this, both the main and the larval galleries are always partially formed in the sapwood, whilst the pupal chambers are entirely within it.

It prefers to attack sickly standing trees rather than timber lying on the ground, as in the parts thinly covered with bark this latter is apt to dry soon. It is not infrequently the forerunner of *H. piniperda.*

In other respects its life-history closely resembles that of its near relative; it is probable that it also has a double generation within the year. It likewise becomes injurious in the same way to young shoots when a beetle, and this *H. minor* is perhaps in one way the more noxious of the two species, owing to ovideposition taking place more frequently in standing trees than in felled stems, thereby leading to interruption of the canopy in Pine woods.

It appears to be less widely distributed than *H. piniperda*, which has a very extensive distribution; but whilst remaining unknown im many localities, it often occurs in very large numbers in other places.

Preventive and annihilative measures are practically the same as for *H. piniperda;* but owing to the rapidity with which the thin-barked parts of the stem and of poles dry, it is more difficult to operate against it by means of decoy-stems. The latter, too, must be stripped of their bark early, in order to prevent the formation of the pupal chambers in the sapwood.

74. *Other Cambial Beetles, Hylesinini.*

Among these may be mentioned the following, on account of their occasionally occurring as very injurious insects :—

The large Spruce cambial beetle, *Hylesinus* (*Dendroctonus*) *micans*, characterised by its size, 0·32 to 0·36 inches, and also by the fact of the larvæ living and feeding in family or common galleries under the bark as in the case of *Bostrichus laricis*. They chiefly attack standing timber, and frequently bore into Spruce trees that are perfectly sound, for the outflow of resin seems to inconvenience them much less than it does other species of bark and cambial beetles. At the same time the beetle usually bores into stems and poles immediately above the ground, where its presence is betrayed by the resinous exudations. Protection and prevention are difficult, being confined to the felling and barking of stems that have been attacked.

The black Pine Cambial Beetle, Hylesinus (*Hylastes*) *ater, and the black Spruce Cambial Beetle, Hylesinus* (*Hylastes*) *cunicularis*, exhibit many points of resemblance in their habits and life-history. Both belong to the root-boring class, and, along with a number of other less frequent cambial-beetles (*Hyl. angustatus, attenuatus*, &c.) deposit their ova somewhat early in spring within the fresh stumps and roots of recently-felled conifers,—the former principally on Pine stumps, the latter mostly on Spruce,—where the larvæ soon begin to feed throughout the cambial layer, but without forming any distinct sort of galleries, as the whole substance between the wood and the bark becomes transformed by them into a brownish kind of bore-dust. But towards the end of June the beetles make their appearance, and migrate to young Pine and Spruce thickets, where they attack the tender bark near the neck or upper part of the roots, and also gnaw it near the base of the stem. In the latter case they also at the same time bore under the bark, and often make tunnels in the cambium right round the bole, so that plants only slightly injured sicken in growth (*wilt*), whilst those badly injured soon die off.

The grubbing up of stumps, and, as far as practicable, of all the roots, especially during May and early in June, after ovideposition has taken place, the burying of decoy-sticks in the ground as breeding-places for the second generation, the pulling out and burning of saplings or young transplants that are of

sickly growth and weakly development, and, finally, waiting with the re-wooding of areas recently cleared of timber until the stumps and roots left in the ground have become too dry to serve as congenial breeding-places, are the best protective and remedial measures to be adopted against the above-named species of noxious root-boring insects, which too often fail to receive the attention they really demand.

B. Weevils, Rostral or Proboscid Beetles (*Curculionidæ*).

75. *The large brown Rostral Beetle or Pine Weevil, Hylobius Abietis.*

(*Vide* Plate I. fig. 10.)

This beetle (weevil), from 0·32 to 0·52 inches in length, and 0·16 to 0·24 inches in breadth, with a moderately long and thick rostrum or proboscis, is dark brown to deep red in colour. Yellow marks occur between the eyes, on the sides of the thorax and abdomen, and on the elytra; these are formed by clusters of diminutive yellow hairy scales, which look like transverse bands on the outer wings, and are very prominent on the beetle when it issues from the chrysalis, but which gradually get more or less obliterated by rubbing later on.

Until quite recently, the opinions held by the most eminent authorities concerning the life-history of this most important, most injurious, and prolific devastator of young timber crops, which is annually collected and destroyed in millions in the coniferous forests of Germany, were, strange to say, characterised by great indefiniteness and want of unanimity. After observations extending over many years, Altum asserted that one generation took two years for its complete development, whilst Eichhoff denied this altogether, and maintained that a double generation during the year was much more probable. These diametrically opposed opinions, and the whole uncertainty about the matter, arose from the fact that recently-developed beetles, as well as beetles that had (to judge from the faint markings on their elytra) been swarming for some considerable time, and also larvæ in every stage of development, might all be found at one and the same time. But a series of observations made by Von Oppen, in a very careful manner, with beetles confined under circumstances ap-

proximating as closely as possible to natural conditions, led to very interesting results throwing light on the above-mentioned phenomena. He not only proved that the beetle is endowed with a very long vital period (extending up to two years), but also that the same individual beetles are endowed with the power of re-copulation and repeated ovi-deposition,—facts which explain in the simplest manner the simultaneous appearance of recently-developed and of older beetles, as well as of ova, larvæ, and chrysalides.

According to Altum's observations, made throughout many years in the vicinity of Eberswalde,[1] the main time of swarming falls during the warm months of spring, from April till the beginning of June, when the beetles, attracted by the resinous scent, crawl and fly towards the recently cleared falls of coniferous crops for the purpose of depositing their ova in the stumps and roots after they have entered *in copulâ;* reproduction is continued throughout the summer as long as there are suitable breeding-places available for receiving the ova. The eggs are deposited on roots of 0·4 inches or above in diameter that lie on the surface of or below the soil, and when the larvæ make their appearance they at first bore only in the cambium, but in developing also attack the sapwood, forming long sinuous larval galleries, trending downwards, and sometimes over three feet in total length. The larvæ are yellowish-white, with a large brown head, curved or bent ventrally by contraction on the lower side, and sometimes attain a length of about 0·7 of an inch. By autumn they are fully grown, and then hollow out a pupal chamber for themselves in the sapwood, which they seal up with the bore-dust formed, and in which they rest as larvæ till the June of the following year; there they become transformed into chrysalides in continuation of their previous rest in the same chamber, and after a pupal rest of about three weeks the imago makes its appearance, the whole of the metamorphoses occupying about fifteen months, reckoned from the time of ovi-deposition,—a period which corresponds with the results of Von Oppen's observations.

But after the beetles, appearing in July, have only partly reproduced themselves, and have only partially deposited their ova, they continue alive till the chief time of swarming comes

[1] About 20 miles from Berlin, where one of the two great Forest Academies of Prussia, (Münden and Neustadt-Eberswalde), is situated.—*Trans.*

round in the following spring. They then have a wealth of material suitable for breeding-places offered to them on the falls of the mature timber cleared during autumn and winter. The generation may therefore perfectly well be said to occupy two years, without in any way excluding the possibility and probability of a simple annual generation of a portion of the beetles in consequence of the ovi-deposition being continued throughout the whole year, and of the more rapid development on warm situations and during hot summers.

The damage done by the beetles which come out in summer is not very considerable, as they very soon take to their winter quarters—according to Altum, indeed, as early as the end of August. They hibernate on areas with a thick soil-covering of grass or weeds, preferring the edges of the crops bordering the last falls of timber, where their breeding-places lie, so as to be near at hand to commence their feeding and reproduction in spring, as above described.

Comparatively innocuous as is the boring of the larvæ, the damage done by the long-lived beetles is often enormous, for they gnaw off patches of the young and tender bark from the stems and branches of young Pine and Spruce plants, as well as of other conifers, though only to a less extent, and in case of necessity even attack different kinds of broad-leaved species, especially Oaks, that may be interspersed among the conifers. In addition to the bark, the beetle also devours the cambial layer above the sap-wood; the patches gnawed, in size and shape often resembling a lentil, get coated over with resin, and thus give the plants a scabby appearance. When attacked to any great extent, the young plants often die off in very large numbers, so that extensive plantations may either be totally ruined, or at best a considerable amount of re-planting may be necessitated.

The damage inflicted throughout the vast coniferous forests of Germany by this beetle have often been very considerable during the last few decades, necessitating the outlay of large sums without the attainment of satisfactory results in all cases. The present method in Germany of making clear falls of mature timber annually over extensive areas stocked with Spruce and Scots Pine, which in many localities forms the rule, and the location of large clearance areas side by side with the young plantations formed for the reproduction of the woods that have been utilised, together with

the neglect of grubbing up the stumps and roots in places where it does not pay to utilise them as fuel, have all contributed to favour in a great degree the numerical increase of this most dangerous insect. Other calamities, too, to which the forests have from time to time been exposed, as, for instance, extensive throwing of timber by storms and breakage from heavy snowfall, have had an injurious influence; for it is often impossible to get rid of the enormous masses of stumps and root-timber, despite the fact that they offer the most favourable breeding-places for the reproduction of this insect.

But in face of such possible danger, it is all the more the duty of the forester and the sylviculturist to do everything that lies in their power to hinder and prevent the reproduction of the rostral beetle. The safest of all means lies, of course, in the careful grubbing up and disposal of all stumps and roots as fuel, for where this can be carried out there is little danger of complaints being heard about its prevalence. Felling of the timber in the pan—that is, felling it by cutting through the main roots with the axe, and not in such manner with axe and saw as will leave a stump protruding above the soil—is not of itself sufficient, as even then too many thick roots remain in the ground.

Where only small numbers of these beetles are still noticeable, the time at which the grubbing up of the stumps and roots may take place is a matter of comparative indifference; but when they already occur in large numbers, the stumps can be utilised as decoy places, and grubbing out had best be seen to during the later half of summer, after the bulk of the ova have been deposited, or, if more convenient, can be arranged for early in the following spring. Where it can conveniently take place, the utilisation of the land for agricultural purposes for a year or two is an excellent means of obviating attacks from this beetle, for it necessitates the clearance of the stumps; but unfortunately it is impracticable on any extensive scale.

In order to obviate danger to young plantations, it is better to let the soil lie fallow for one, or still better for two years after a clear fall of mature timber has been made; for if the fall be at once planted up, both breeding-places and feeding-grounds are conveniently afforded to the beetle on the same area, whilst the injurious effects are all the more marked if it has not been possible to grub up the stumps in anything like a complete manner.

With the same object in view, an alternation of the fall in different localities, in place of having the annual crops following each other contiguously, is also highly recommendable; and the longer the period elapsing between the planting up of each two contiguous falls, so much the better. And, at the same time, it must be pointed out that, by natural reproduction under present standards, or by the formation of mixed crops, instead of total clearance with artificial regeneration, chiefly by means of planting, we have the means of obviating attacks to a considerable degree, or at any rate of very materially diminishing their severity.

In the conduct of annihilative or exterminative measures, the main object must be to get hold of the beetle if possible in its breeding-places,—that is to say, in the fresh clearances of the previous year. This can best be arranged for by digging narrow trenches round the recent falls in early spring, in order to intercept the beetles coming crawling from their winter quarters to lay their ova in the new stumps. For this purpose the trenches should be about one foot deep, and with smoothly cut perpendicular walls, with holes also a foot in depth dug here and there along the base, to serve as pitfalls or traps. But as, at the same time, many beetles can reach the area in flight, these trenches are even more useful during the summer of the second year, by hindering the newly-developed beetles from crawling away from the area: the trenches should be examined every day, the beetles being collected together and destroyed.

And on the newly-cleared areas themselves, and places already infested with the insects, endeavours should also be made to attract the beetles to decoy-objects. Such include pieces of bark recently stripped from Spruce or Pine stems, laid so as to have the cambial layer next to the ground, and held down in position by being weighted with a stone, and also faggots about 3 or $3\frac{1}{2}$ feet long, cut from recently-felled Spruce or Pine poles, from which a strip of bark about $1\frac{1}{2}$ to 2 inches broad has been peeled off lengthways, and which are then laid on the ground with the barked part lowermost and touching the soil. Attracted by the fresh resinous odour, the beetles come to these decoys, attack the cambial layer, and as they take a fairly good hold of it, they can easily be collected daily. By spreading bundles of fresh Pine branches on the areas cleared, the beetles can also be induced to feed on them, and can then be collected by being shaken or tapped out on to sheets spread on

the ground to receive them when falling. The best way of destroying the beetles is by pouring boiling water over them when collected.

And finally, the beetles can also be induced to deposit their ova in specially prepared breeding-faggots,—thin coniferous sticks, of 3 to 3½ feet in length, which are buried near the surface of the soil, several of them being set close to each other, and the places marked with a peg so as to find them easily again. The brood is annihilated by pealing off the bark from the sticks. This method is usually of considerable success during the second year, during which neither the beetle coming out of its winter quarters, nor the newly-developed beetle, can find other suitable sappy breeding-places on the fall of the previous year, with its dried-up stumps.

It should be distinctly borne in mind that endeavours must always be made to destroy the beetles in the places where they are developed, and that operations for exterminating the insect must not be delayed, as was so often the case until comparatively recently, until they attack the young seedling crops.

76. *The small Brown or White-spotted Weevil or Rostral Beetle, Pissodes notatus.*

(*Vide* Plate I. figs. 8 and 13.)

This cambial beetle, from 0·24 to 0·32 inches in length, and of a dark red brown colour, is irregularly covered with small scales having a covering of greyish-white hairs, with a number of plainly visible small white dots on the thorax; on the elytra two rusty red transverse bands are noticeable, which bear white and yellow scales, and of which the upper is interrupted at the junction of the wings. The rostrum or proboscis is rather long and thin.

The beetle swarms about May, and then deposits its ova for the most part under the whorls of 5 to 10-year-old Pines (Scots, Weymouth, and Black or Austrian), and also in the bark of dominated or suppressed poles. When the larvæ, which are yellowish-white in colour with a brown head, appear, they penetrate downwards, eating sinuous galleries in the cambial layer, and at the end of these hollow out a pupal chamber in the sapwood. Here they plaster up the vacant space with the bore-dust, and then enter

the chrysalid stage. The fully-developed beetle makes its exit from the pupal chamber by boring a circular exit-hole, in the month of August or sometimes later, and hibernates under moss, or in the fissures of the bark of trees. The generation is consequently simple or annual, although Eichhoff has recently asserted that it is double, which seems hardly likely to be the case.

As a beetle, this insect damages plants by boring into them for nourishment, and young growth often shows a great number of such small wounds or punctures; but the injuiry done by the larvæ is of a much more serious nature, frequently leading to the sickening of large numbers of plants, and killing them outright when the borings are numerous or the plants small. In many districts this beetle is considered one of the most injurious insect enemies of young seedling crops and plantations, but fortunately its distribution is not nearly so general as that of its near relative, *Hylobius abietis*, already described in the preceding paragraph.

The uprooting of plants infested by the larvæ, whose presence may be betrayed by the young shoots drooping and losing their colour, about the month of July, and then burning them, is the only really practical way of fighting against this enemy; but at the same time it is a fairly successful remedy, and, if persevered in consistently for several years in succession, ends by almost completely annihilating the pest. Poles that are attacked by them should also be felled and barked; but it is much more difficult to detect the infested poles than to discover the younger plants attacked.

77. *Other Weevils, or Rynchophorous, Rostral, or Proboscid Beetles, Curculionidæ.*

Although amongst the numerous rostral beetles there are many which are often decidedly injurious to coniferous woods, mention will be confined to the three following species only.

The Harz Weevil, or Rostral Beetle of the Harz, Pissodes hercyniæ, is a thin beetle about 0·24 inches in length, and almost black in colour, with two narrow whitish-yellow stripes across the elytra, which has frequently committed great devastations on the Harz mountains and the Erz Gebirge. It only attacks Spruce, and principally crops between 60 to 100 years of age. Whilst the

beetles swarm and fly about in May and June, the female deposits her ova in small clusters in holes bored with the rostrum or proboscis into the upper parts of the trees still retaining their smooth bark. From this breeding-place as a centre, the larvæ bore sinuous and irregular radiating galleries in the cambial layer, which increase in breadth as the larva increases in size, and terminate in pupal chambers formed exclusively in the sapwood, and filled up with bore-dust, within which the chrysalides rest. Whether the generation occupies one year or two is not yet fully determined.[1] The trees attacked soon fall into a sickly and unhealthy state, and if much injured die off, whilst at the same time these sickly stems offer considerable attraction as suitable and favourable breeding-places for other noxious insects, bark-beetles in particular. The white drops of resin, which exude from the punctures made by the rostrum for the deposition of the ova, betray to the practised eye the trees that have become attacked, and when the beetle occurs in any great numbers, such stems should be marked, felled, and barked—an operation which must be repeated from time to time throughout the summer.

The Pine-pole Weevil or Rostral Beetle, Pissodes piniphilus.—This beetle very much resembles, but is a little smaller than, *P. notatus*. It is of a rusty-brown colour, with one characteristic rusty-yellow patch on each of the elytra, and lives in the thin-barked upper portions of Pine poles, although also to be found on stems of older growth, where the female deposits her ova singly in holes bored for the purpose. When the larvæ come out, they eat sinuous and very irregular galleries in the cambial layer, which gradually increase in breadth, and at length terminate in small pupal chambers formed in the sapwood, where the chrysalides rest. The time of swarming is in June, so that the generation is either annual or extends over exactly two years, a point not yet determined.[2] This insect has hitherto not received very much attention, although it sometimes occurs rather frequently. Poles and stems that have been attacked sicken if at all badly injured, and ulti-

[1] Hess, *op. cit.*, vol. i. page 267, states that it is annual as a rule, but that there are exceptions and deviations from the rule. Altum says the generation occupies two years, whilst Eichhoff assigns to it also a double generation. No Von Oppen has as yet thrown the light of his observations on the subject.—*Trans.*

[2] Here, again, Altum says it takes two years, and Eichhoff asserts that a double generation takes place within the year. Hess (page 264) thinks an annual generation is most probable.—*Trans.*

mately die off, so that the canopy overhead is apt to become gradually interrupted, and finally broken. Here, too, the best preventive and remedial measure consists in the felling of stems and poles attacked, which may be known by the resin which has oozed out of the punctures made for ovi-deposition, and which, glittering in the sunlight, are easily seen when the stems are bathed in strong sunshine. Peeling the bark of the stems felled is not necessary, as the larvæ soon die when the bark begins to dry.

The Silver-fir Weevil or Rostral Beetle, Pissodes piceæ, also attacks Silver fir in much the same way, but occurs less frequently and in much smaller numbers.

C. Lamellicorn or Platycorn Beetles (*Scarabæidæ*).

78. *The Cockchafer, May-beetle, or May-bug, Melolontha vulgaris.*

As a beetle, this insect's attacks are almost exclusively confined to broad-leaved species of trees; but as the larvæ or grubs damage conifers principally, it is included here among the insect enemies of coniferous trees.

It is perhaps unnecessary to describe the well-known appearance of this beetle,[1] but it may be remarked in passing, that the male can easily be distinguished from the female by means of its beautifully feathered antennæ. The larva, specifically called a *grub,* is from 1·6 to 2 inches in length when full grown, with a thick, yellowish-brown head, six long feet attached to the thorax, yellowish-white in colour, and thickening somewhat towards the end; the latter part is generally bluish, owing to the excrement showing through. The chrysalis is of a brownish-yellow colour, with a double-pointed termination. The ova are egg-shaped, yellowish-white, and about the size of hemp-seed.

The beetle swarms in May, or somewhat later in raw localities.

[1] The beetle is from 1 to 1·2 inches in length; the thorax is black or, less frequently, reddish-brown; the elytra or outer wings and legs are ruddy-brown, each of the former having five longitudinal ribs, the depressions between which are covered with fine hairs. The belly is black, with five triangular white spots on the sides. The abdomen gradually terminates in a somewhat broad, elongated, and pointed anus. The feelers have ten joints or sections, the laminæ being seven-fold and feathery on the male, but smaller, narrower, and only six-fold on the female.—*Trans.*

The female, after impregnation, seeks free open spaces as far as possible for ovi-deposition, selecting light unoccupied soil, if available, into which it burrows for a depth of 2 to 4 inches, and then lays up to about thirty eggs in a cluster. Similar ovi-deposition takes place in several places, one female being capable of laying up to about seventy eggs in all; whenever this reproductive function is complete the female dies.

About four weeks later the larvæ or grubs come out from the shell. During the first year they do not wander far from their place of birth, but seem to nourish themselves from humus or decomposing substances in the soil. When winter approaches they go deeper into the soil in order to avoid the frost, but with the return of spring ascend again nearer the surface, and now commence feeding on the roots of plants throughout the whole of the spring, summer, and autumn, after which they again hibernate as grubs. In the third spring, summer, and autumn, they once more repeat the process of gnawing and feeding on the roots of growing plants; and as during this third year the grubs are large and full-grown, it is then that their voracity and the damage they do are greatest. For the third time they hibernate as grubs, burrowing deep into the soil, and when they re-ascend to the surface once more in spring, they resume feeding for a short time; but about June, three years after their issue from the egg, they descend deep into the soil, in order to pass through their stage of pupal rest. The chrysalid metamorphosis takes place in a hollow scooped out in the soil, and after a few months of pupal rest the complete beetle emerges from it, being at first soft and white, but gradually hardening and deepening in colour. The beetle hibernates in the soil without once coming to the surface, and does not emerge till the following spring (May), when it makes its exit by means of a hole resembling such an one as would be made by thrusting the point of a walking-stick into the ground.

This beetle therefore requires four years for its full normal development and generation, but in southern countries, in consequence of the greater warmth, the generation takes place in three years only, so that in cold northern tracts the beetles usually swarm every fourth year, whilst in the warmer south they may be anticipated every third year. In the intervening years there are always some of these beetles to be seen flying about, but only in comparatively moderate numbers.

As a beetle, this insect feeds on the leaves and flowers of most trees of the broad-leaved species, particularly on the foliage of Oak, Beech, Maple, Sycamore, Horse Chestnut, Willows and Poplars, whilst among conifers it confines its attention mainly to the soft tufts of needles of the Larch, and to the male flowers of the Pine. During years in which it swarms in large numbers, whole woods of broad-leaved trees may often be seen almost or even entirely denuded of foliage, but as these are able to replace, although perhaps only partially, their leafy crowns by means of the midsummer-shoots or summer flush of leaves, the damage is practically confined merely to loss of increment for the time being.[1]

Commencing from the second year, as a grub, it devours the tender rootlets of all kinds of plants, especially the roots of perennial grasses and weeds containing rich stores of reserves, and also the roots of young coniferous seedlings, so that young plants of the latter species quickly die off, whilst older plants are at least interfered with in the vigour of their development. In seed-beds, which from their light porous soil offer special attractions to the female beetle when laying her eggs, and on extensive falls of Scots Pine on soils of a class also favourable to the most suitable conditions of ovi-deposition, grubs have been known to occasion an extraordinary amount of damage. Hence the cockchafer may well be reckoned as decidedly belonging to the most dangerous class of injurious forest insects.

The devastations which have been, and are still, caused by the grubs in some of the extensive Scots Pine plantations, in Northern Germany in particular, are on a vast scale; so much so, indeed, that in some localities sylvicultural operations have had to be suspended, whilst in other parts, instead of having well-grown thickets in full canopy, the best results of infinite trouble and patient labour are patchy crops of branching and badly-developed pole-forest.

Endeavours can be made to obviate such disasters by not

[1] That is to say, the damage is *apparently* confined to temporary loss of increment only. But as a matter of fact, after total destruction of the spring flush of leaves, a summer flush can only replace them by means of the utilisation of the reserve supplies of nutriment so much more richly stored up in broad-leaved trees than in the evergreen conifers (the deciduous Larch is better endowed in this respect than Pines, Spruce, or Silver Fir). Until, therefore, these starchy reserves have been replaced by a surplus of nutrient matter over the actual requirements of each tree for structural and functional purposes, the original *status quo ante* cannot possibly be attained as regards either general vigour in growth or wood-producing capacity.—*Trans.*

allowing the female beetles to have the favourable opportunity of reproduction offered by large vacant areas with loose soil during years in which large swarms of beetles may be anticipated, or in other words, by not undertaking extensive cultural operations which necessitate any extensive soil-preparation; it is better to adopt the process of notching-in seedlings into the ground during such years as far as possible. Where the Scots Pine woods have been most badly attacked in Northern Germany, a return has been made to the reproduction of the mature crops under parent standards; but the results are only partially successful, for even with light fellings and partial clearances, and often in fairly well-stocked mature crops, the grubs are frequently to be found in large numbers.

In forming nurseries, the vicinity of young Oak crops, and of areas stocked with broad-leaved species generally, should be avoided, as a flight of beetles almost always comes from these. The nurseries, whether temporary or permanent, should always be protected from the entry of grubs by being surrounded by a trench, whilst the spreading of a frame-work over each bed may prevent the female from laying her eggs in it. But the best protection consists in hanging up wooden nesting-boxes for starlings round about the nursery; for these birds take very kindly to such protection, and well repay the cost and trouble by the effective war they wage against the grubs.

In undertaking annihilative measures against the beetles we are assisted by many of their enemies, such as the hedgehog, badger, fox, marten, &c., which devour them whilst still in the ground; bats, starlings, crows, rooks, jackdaws, stannel-hawks, sparrows, &c., also destroy them in great numbers whilst swarming and laying their eggs.

But all these co-operative remedies are practically unavailing when large swarms occur; hence endeavours should be made to keep down the numbers of the insects by collecting the beetles from trees along the edges of compartments and open spaces, particularly from the lower branches, and from any oak-coppices in the vicinity. Especially in the early morning, when the beetles sit loosely on the foliage, they can easily be brought to the ground by shaking young poles with the hand, or by tapping or knocking young stems with the padded back of a heavy axe, or by shaking the branches of larger trees by means of

a pole with a hook at the end, when the beetles can be picked up off the ground by children. They can best be killed by pouring boiling water over them, or by dipping into hot water the sacks in which they have been put when collected.

As measures for exterminating the grubs have for the most part hitherto proved unavailing, more attention has of late years been given to the collecting of the beetles, for each of the latter killed represents, or is equivalent to, the practical destruction of a large number of grubs during any of the following three years. But to be effective, it can only take place successfully in woods where broad-leaved trees occur sparsely scattered throughout a matrix of conifers, as then the chafers become attracted towards them and congregate there; Oaks, Birches, &c., are therefore often planted among conifers for the express purpose of thus acting as decoy-trees in tracts with light friable soil, where this insect is likely to swarm. Such exterminative measures should not be confined to the efforts of sylviculturists, as agriculturists are equally concerned in getting rid of the pest, and should therefore co-operate heartily in annihilating all chafers that can be found on fruit-trees in their orchards, or on timber-trees standing isolated along the fields or in hedgerows.

The annihilation and extermination of the grubs is of course accompanied by many difficulties; this can only successfully be carried out in nurseries, where the presence of the enemy is soon betrayed by the drooping and sickening of the tender seedlings, and the grub itself can usually be collected with the hand or with a spade on one of the immediately adjacent plants. Specially constructed grubbing-irons, and numerous other things recommended, have not shown themselves really effective in practice.

Where a certain amount of soil-preparation is requisite previous to the carrying out of sowing or planting operations, the grubs should be collected whilst the soil is being broken up, and they can often be attracted together for easier collection by laying down sods of turf on the ground with the grassy side downwards, as the grubs come and lie under them. Although swine eagerly devour the grubs, the herding of pigs is hardly a practical method of remedying the matter, for the grubs are too deep in the soil to be got at without the swine breaking up the surface a good deal with their snouts, and to allow this is out of the question in young plantations.

Moles are particularly keen in hunting after the grubs, whilst such as are turned up to the surface by the ploughshare are eagerly devoured by crows and starlings.

The Horse-chestnut Cockchafer, Melolontha hippocastani, on the whole closely resembles the May-beetle in appearance, habits, and life-history, but is of less frequent occurrence, and can easily be distinguished from this by its red thorax.

The Fuller or Garden Beetle, *Polyphylla fullo,* the largest of the cockchafer genera, also occurs rather frequently here and there throughout sandy tracts, being easily recognisable by its brown outer wings, marbled with white.

II. Moths (*Lepidoptera*).

A. Spinners (*Bombycidæ*).

79. *The Pine Moth, Bombyx* (*Gastropacha*) *pini.*

This moth has a span of 2·4 to 3·2 inches when the wings are fully extended, but that of the female is considerably greater than that of the male. The body is thick, the head small and nearly hidden under the thorax. The eyes are large and prominent. The antennæ are shortly plumose in the female, but long and double-feathered in the male. The upper pair of wings is indistinctly toothed along the lower edge. There is a thick covering of hairy growth at the base of the wings, on the legs, and on the abdomen. The front wings and the body are greyish-brown in colour, and the former have a reddish-brown horizontal band or belt across them bisecting the wings, which have a dark fringe along the lower edge; about the middle of the upper half of each of these wings, that next to the body, there is a white half-moon-shaped spot standing out prominently from its dark surroundings. The back pair of wings and the abdomen are of a monotonous brown colour, whilst the whole of the under side is of a light greyish-brown throughout. In colour the male butterfly is usually much brighter than the female; but with regard to the colouring, sports of all kinds, melanic and the opposite, are comparatively frequent. When the moths are sitting at rest, the outer wings lie over the under ones like shingles, or slates on a roof.

When full-grown, the caterpillar is about 2·8 inches in length, and also shows great variations in colour, from ashy grey to ruddy brown, and even blackish brown, with longitudinal stripes halfway along the upper side, or white patches on the side, dark patches or pencillings on the back, and strong growth of bushy hairs. Characteristic marks for the easy recognition of this caterpillar consist in the dark-blue tufts of hair in the incisions or joints between the first and second, and the second and third (thoracic) sections of the caterpillar's body, which look like blue transverse bands across its back,—also in the blackish-blue tufts of hair occurring between the other hairy growth,—and in a particularly strong tuft of such hair on the 11th ring of the body.

The chrysalis, which is dark in colour near the head, but of a lighter brown in the lower portion, and only slightly hairy, reposes in a large, elliptical, dirty-whitish or grey cocoon. The ova, about half the size of hemp-seed, are roundly elliptical in shape, but somewhat compressed at the sides; though at first bluish-grey in colour, they ultimately change to a more pearly grey.

The chief time of the swarming of the moths is in the month of July, usually about the middle of it. Like the majority of other moths, their flight is most active towards evening. The copulation takes place on the stems at no great height above the ground. After impregnation the female lays her eggs in clusters of 30 to 50, and to a total of from 100 to 150, on the bark of the stem and its branches, and about three weeks later, about the middle of August on the average, or somewhat later if the weather has been unfavourable, the tiny caterpillars make their appearance, first of all consuming the shells of the eggs from which they have just issued, and then proceeding to attack the needles forming the foliage of the trees. In October, or early in November, when frost begins to make itself felt, they descend from the trees in search of winter quarters. By this time the caterpillars are as a rule about half-grown. Throughout the winter they hibernate under dead foliage and moss, mostly under cover of the crown of trees on which they have been feeding, until awakened again to life and action by the gradual increase in the soil temperature which takes place about the end of March or the beginning of April. Thereupon they at once re-ascend the trees, commence attacking the foliage, and continue feeding on it till about the end of June, the caterpillars devouring the whole of

the needles down to the sheaths enclosing them, and in bad years, when the foliage becomes totally denuded, destroying even the young buds, in which latter case the crop is naturally killed. So long, however, as they can still get food elsewhere, the voracious caterpillars, whose requirements in the way of forage are indeed very considerable, spare the young shoots.

The pupal rest is entered into about the end of June, the chrysalides occupying the fissures in the bark, where the flakes of dead rind stand out prominently from the stem, or else the cocoons are formed up among the branches in the crown. The fully-developed moths make their appearance after a pupal rest of about three weeks. This moth lives only on Pines, chiefly Scots Pine, and principally attacks crops of older growth on soils of inferior quantity, as these are especially favourable to the hibernation of the caterpillars; but when reproduced in large numbers it also naturally attacks younger crops, such as pole-forests, and even young thickets and new plantations. It belongs to the most injurious class of forest insects, and has at various times committed enormous devastations in the Scots Pine forests that cover such a great extent of country throughout the North German Plain, as also in the large Pine forests of the same species which occur here and there in Southern Germany, absolutely ruining vast stretches of woodlands by totally denuding them of foliage. In such localities the forester and the sylviculturist have every reason to bestow very careful attention on this insect wherever it makes its appearance.

The formation of mixed woods has been recommended as a preventive measure, for it is well known from experience that the individual species are then least exposed to attacks, and suffer far less from insect enemies than when grown in pure forests; but on the poor classes of sandy soil to which the Scots Pine is so often assigned, there are such difficulties in the way of getting other species to thrive as to render this measure often quite impracticable.

A constant and careful revision of the whole of the growing stock, and not merely of a few of the annual crops, is a most important protective measure, so that wherever any considerable increase of the insect is to be feared, prompt action may be taken to obviate the otherwise certain results. In addition to keeping a look-out at the usual time of the swarming of the moths, and to

noting any fall of excrement on the ground during the time whilst caterpillars may be feeding among the foliage, examinations of the soil should also be made here and there about November, after the caterpillars have descended from the trees for the purpose of hibernating under the moss, especially in such localities as sandy ridges, or in crops of sickly and backward growth, which are most likely to develop into hot-beds of reproduction. An experimental area should be selected and marked off, and the dead foliage and moss should be removed in order to see how many caterpillars can be collected. Should about 10 to 20 per stem, according to the age of the crop and the size of the trees, be found, one may take it for granted that there are really 4 or 5 times as many actually present, and, in view of the rapid and prolific reproduction of the moth, it will be advisable to take measures for preventing its numerical increase.

One of the best methods of annihilating this enemy consists in the formation of a ring of tar round each of the stems. This measure was not formerly held in any great repute, as the ordinary tar applied dried up too soon, and it was found practically impossible to go on re-forming girdles to maintain them effective. But, now that it has been found easy to produce a kind of patent viscous tar or caterpillar-glue, at a fairly cheap rate, which will remain sticky and effective for eight weeks and longer, this method of forming narrow rings or girdles of patent tar round each of the stems has recently, although somewhat costly, become almost the sole preventive measure adopted, as it has achieved brilliant results in preventing the continued excessive reproduction of this insect. As the method of carrying out the operation has already been described (*vide* par. 61), it is unnecessary to repeat the information here.

The collection of the caterpillars in their winter quarters, formerly held in considerable estimation, has at all times been productive only of unsatisfactory results, as even with the most careful search on the experimental areas themselves, and still more throughout extensive portions of crops, many of the caterpillars, especially of the smaller ones, are apt to get overlooked. Their collection during summer, by knocking or rapping on poles and young trees, so as to throw them down to the ground, is only possible in pole-forest, and even there it is dear, as well as being a very troublesome and ineffective measure.

The collection of ova and pupæ is also at best only a very disappointing and ineffective sort of measure, as also the killing of the moths during bad weather whilst they are seated at rest low down on the sheltered side of the stem during the time of their swarming.

Trenches, either for isolating a crop infested, or for intercepting the migration of the caterpillars from place to place within the area attacked, can only be of use when the latter are either confined within small areas, or occur in such numbers as to denude the trees of foliage, and are thus forced to wander about, or migrate to neighbouring areas in search of food. Where young timber crops especially are anything like contiguous to older crops likely to be totally defoliated, they certainly require to be protected by trenches against the migratory caterpillars. For the large caterpillar of this species of moth the trenches require to be depth up to about two feet, and with walls as clean cut and perpendicular as possible. Along the sole of the trenches holes are again dug as traps for the caterpillars; those caught in them should be crushed or killed by having earth heaped on them.

The mere removal of moss, or of the layer of dead foliage with which the ground is covered, is of almost no avail so far as any probable removal of the caterpillars along with it is concerned.

The numbers of the enemies of this insect which destroy the caterpillars or chrysalides is very small among birds, on account of the hairy growth of the former, and the large protective cocoons in the case of the latter: the cuckoo is the most useful of all the birds in devouring the caterpillars. Mammals, too, even including swine, disdain on this account the caterpillars hibernating on the ground, though, on the other hand, a considerable number of the ova are annihilated by tomtits and other small birds; but then, unfortunately, the period of life spent in the ovum only lasts for a few weeks.

It is due in a far higher degree to the so-called useful forest insects, especially ichneumon-flies (*Ichneumonidæ*), that a large number of caterpillars, and even of eggs, is naturally destroyed; for, particularly when attacks have lasted for any length of time on any very extensive scale, a disproportionately larger number of caterpillars than usual become infested with ichneumon-larvæ,[1]

[1] The dead caterpillars, thickly covered with the small white cocoons of *Microgaster globatus*, are often visible on the trees from some little distance.

although this does not usually take place until after the devastations have passed their culminating point.

The hairy caterpillars are by no means sensitive to either wet or cold. But nature sometimes comes to the assistance of the sylviculturist with parasitic fungoid diseases, to which the caterpillars often succumb in large numbers, especially in soft, damp, humose soil, so that sometimes all of them observed in their winter quarters are found to be dead.

80. *The Black Arches, "Nun," or Spruce Moth, Bombyx (Liparis) monacha.*[1]

(*Vide* Plate II. fig. 16.)

When extended, the wings of the female moth have a span of 1·6 to 2·4 inches; the male is smaller, and also easily distinguishable by its beautiful double-feathered antennæ. The outer wings and upper part of the body are in both genders white, with numerous deeply-arched zigzag stripes, varying from brownish-black to black in colour; the lower pair of wings are brownish-grey, with bright black-dotted edges; the abdomen is mostly of a beautiful rose-colour, with black horizontal or transverse bands, but is also at times more of a blackish tinge.

The caterpillar, which is about 1·6 inches in length when full-grown, is of a dirty-green colour on the lower side, and whitish-grey to reddish-grey on the upper; along the back there is a broad grey stripe, which commences with a heart-shaped black patch on the second ring or section of the body, but narrows, and is interrupted by a broad light patch on the seventh and eighth rings. On each section of the body there are six small knob-like hairy warts, of which the two first, on the first ring, tower above the others, whilst those to the right and left of the back stripe are blue, and constitute a characteristic sign for the recognition of this caterpillar, which often varies exceedingly in colour.[2]

The densely-haired chrysalis, at first of a greenish colour, but

[1] For an exhaustive account of this insect, and of the ravages committed by it in the Spruce Forests of Bavaria during 1889–91, see the Translator's Report in the *Transactions of the Highland and Agricultural Society of Scotland* for 1893.—*Trans.*

[2] Melanic sports are particularly frequent, occurring mostly in Scots Pine woods. This is supposed to be a natural effort of adaptation to the darker stems of the Pine trees, in order to protect the insects from enemies.—*Trans.*

afterwards changing into brown with a bronzy shimmer, lies within a very flimsy cocoon, consisting of merely a few dirty yellow threads spun between the fissures of the bark on the lower portion of the stem, or among the needles on the branches and twigs, or on underwood or brushwood.

The time of the swarming of the moths is about the end of July or the beginning of August, or perhaps somewhat earlier during dry years. During the day, and especially when the weather is dull, they usually cluster about the lower portion of the boles, whilst in bright sunshine the males in particular keep fluttering about and revelling in the enjoyment of the brightness and warmth. But, like most moths, their normal time of lively motion is towards dusk, when they either flit about, or run up and down the stems, seated upon which they enter *in copulâ*.[1]

After the course of a few days the ovi-deposition takes place, the eggs being at first of a rose colour with bronzy shimmer, but afterwards changing to a greyish brown with mother-of-pearl lustre. The female moth lays her eggs beneath the scales of the bark, and always under some sort of protection. When the insect does not swarm in large numbers, the ova are mostly deposited on the lower portion of the stem, usually within about fifteen feet from the ground; but when there are enormous flights of moths, as during the calamitous devastations of the Spruce tracts of Bavaria and Western Austria in 1889–1891, they cover the whole of the stems from top to bottom.[2] One female can deposit as many as 150 to 170 ova, which are mostly laid in clusters of 20 to 50, though sometimes all are deposited in one patch or nest.

Although in four weeks the larva becomes fully formed within the ovum, the tiny caterpillars hibernate within the shell, and only make their appearance in the next spring during April, or not until May should the weather be unfavourable. After issuing from the ova the young caterpillars remain for several days collected together in clusters or schools on spots varying in size from what might be covered by a penny to what the hand could

[1] It is worthy of note that the numerical relation of sexes has been found during the recent immense swarms in South Germany to be 70 % male and 30 % female, evidently a provision of nature to make the impregnation of the latter a matter of almost absolute certainty.—*Trans.*

[2] "In 1890, on large individual stems, 30,090, 50,000, and even 90,000 eggs were found in the Ebersberg Park, and recently as many as 200,000 were found on one stem in the Perlacher Park." Nitsche, "*Die Nonne*," 1892, page 8.—*Trans.*

cover. These schools or colonies,—a characteristic of this insect, often plainly discernible by the contrast of the blackish caterpillars against the brown bark of the Spruce, often hardly distinguishable against either Spruce or Pine,—are broken up after about 4 to 6 days, when the tiny caterpillars ascend the stems to commence feeding on the foliage. They attack the lower portions first, and gradually work up towards the summit of the crown, denuding the branches and twigs of needles as they proceed upwards. Their manner of feeding is very wasteful, for only in the case of the Spruce do they entirely devour the spines, whilst in regard to the Pine they bite the needles through about the middle, and eat only the lower portion remaining; the foliage of broad-leaved species is in the same way only partially devoured, the mid-rib being gnawed through, so that the larger part of the leaf falls down to the ground, which is often littered with the fragments of needles and leaves when the caterpillars are very numerous.

During the process of their development, the caterpillars change their skins four times, and until about half-grown they are endowed with the power of spinning gossamer threads, by means of which they let themselves down to the ground, or from which they depend if blown or shaken down from the foliage.

Their feeding-time lasts till about the end of June or the beginning of July, when the caterpillars descend from the stems in troops in order to enter the pupal state of rest under the scales of the bark, or on the undergrowth, &c.

The Black Arches moth or "Nun" (so called in Germany from its plain black-and-white colouring) belongs to the most injurious class of forest insects, and the devastations in Spruce and Pine woods have at times been so enormous as to have totally denuded very extensive areas of their foliage, and thus killed the crops. Such calamitous attacks usually commence within the older crops, but during high winds the young caterpillars are blown away on their gossamer threads, and wafted over into pole-forests and young seedling growth that may happen to be contiguous, where they at once begin to feed.[1]

[1] When the moths swarm in great numbers, they often migrate from one place to another. Thus, it was proved beyond doubt that in the recent enormous swarms in Bavaria, the moths, attracted by the brilliant lights, used to accompany the railway trains for considerable distances, travelling, of course, at night.—*Trans.*

As already remarked, this Spruce moth also attacks broad-leaved species of trees, Beeches, Birches, and fruit-trees, and even feeds on the leaves of whortleberry bushes occurring as undergrowth under trees that have already been denuded of their foliage by the voracious caterpillars; but the damage done is, thanks to the greater reserve-supplies of nourishment stored up in the broad-leaved deciduous species, never of a fatal nature, as is not unfrequently the case with the conifers.[1] And in Spruce woods particularly, bark-beetles follow soon after the attacks of this caterpillar, for the sickly stems afford the most favourable breeding-places for these other most dangerous insect enemies (*vide* note on page 128).

True preventive measures can hardly be said to exist for hindering attacks of this dangerous moth, but the early discovery of its presence and the immediate adoption of annihilative measures may promptly exterminate the brood, and easily obviate disastrous calamity on an extensive scale. If the woods are as carefully and constantly inspected as they should be, then the presence of the characteristic fragments of bitten leaves and needles scattered about the ground, the gradual thinning of the crown of foliage, and later on the light-coloured and easily distinguishable moths seen during the time of swarming in summer, ought to leave no doubt as to the advisability of taking measures to prevent their rapid increase in numbers.

Exterminative remedies of various kinds are applied. First of all, the ova may be collected at any time during August till April, but this is of course only effective so long as the insects have confined themselves to ovi-deposition near the base of the stem, the clusters of eggs being scraped off with a knife into a bag held below them. Although great numbers of ova can thus be collected, yet at the same time many clusters of eggs get overlooked, especially on the thick-barked Scots Pine; and the larger the number of moths previously, the more likelihood there is of the clusters being in great part deposited too high up the stem to be within reach, so that on the whole the results of this method are at best only partial and somewhat unsatisfactory.

The crushing of the little schools or colonies of tiny caterpillars, whilst they are collected together for a few days just after coming out of the shell, is somewhat more practical and satisfactory; still

[1] And more especially so with regard to the Spruce.—*Trans.*

it is at best only a sort of half-measure. They are easily killed near the base of the stem by the use of a leather flap tied to the end of a rod or stick, whilst a long thin pole with a thick knob of cloth at the end is the best way of getting at them if seen at some height above the ground, and beyond the ordinary reach with the flapper. Altum recommends the smearing or soaking of the latter with a solution of patent viscous tar. The principal drawback of this method is, that the whole of the clusters of ova are not all hatched at the same time, so that some schools or colonies appear earlier, and others only later, whilst a constant repetition of the process of destroying them is practically out of the question.

The destruction of the larger caterpillars, as well as of chrysalides and of moths, is always accompanied with difficulties, and on the whole not particularly satisfactory, although at the same time the somewhat lazy female seated quietly on the stem is easily discernible and approachable, and can easily be killed or collected during the daytime throughout the period of swarming.

The number of the natural enemies of this insect, and especially of the hairy caterpillar, is comparatively small, as also in the case of the Pine-moth; but during the winter very large numbers of the ova are devoured by many kinds of birds, particularly by tomtits, whilst predatory species of insects, principally *Ichneumonidæ* and *Tachininæ*, also annihilate many caterpillars. Like the Pine-moth, this Spruce-moth is comparatively insensible to changes in the weather and to climatic influences generally. But, at the same time, it is usual for its ravages to cease also after the third year, when the caterpillars, somewhat degenerate by that time, and less both in size and vigour, die off in large numbers; and recently the opinion has been strongly expressed, that as annihilative measures seem to be practically of little effect, it is perhaps better not to spend money and time on them, but to leave the matter for nature to assert its proper balance again.

Note.—As the work of which this is a translation was published in 1889, before the recent calamitous devastations throughout Bavaria and Western Austria, begun in 1888, had anything like reached their culminating point in 1891, it may be permitted to me to briefly indicate the exterminative measures which the experience then won has proved to be most effectual. After the remedies previously held in repute and above referred to had all been tried during 1889–1890, (including collection of ova, crushing of young caterpillars whilst still in schools or colonies, and later on collection of the full-grown caterpillars and chrysalides, and cutting and burning all undergrowth covered with pupæ), after experiments made with exhaustors worked close

behind strong electric lights, and after endeavours made to isolate the crops attacked by surrounding them with poles thickly coated with patent tar on the upper side, had all been found only partially successful, it occurred to a young forest-officer named Mayer to try the effect of putting rings of the patent tar round all the stems of a young 12 to 15-year-old Spruce plantation, which was first of all cleared of the lower branches for the purpose. This experiment was found to answer so well that it was carried out on a much larger scale in 1891 ; and as the damage done in that year was still greater than it had previously been in 1889 or 1890, it was again resorted to in the present year, no less than £75,000 being spent in the Bavarian State Forests alone on ringing with patent tar all the stems from the thickness of a finger upwards, in whatever areas it was known that the moth had gained a footing. Millions of stems may now be seen with these blackish rings at breast-height, which experience has shown to be much less expensive than, and practically quite as effective as, ringing at about 15 to 18 feet above the ground. By forming them at the latter height, it was thought to intercept the tiny caterpillars from all the ova deposited between breast-height and that elevation, but the happy efficacy of this remedial measure rests on the fact that practically all the caterpillars spin down on gossamer threads from the crowns of the trees to the ground before they have developed so far as to lose this power of spinning, and that when they wish to re-ascend the stems, their progress is barred by the viscous band of tar, whose smell, or taste, or touch they absolutely abhor ; and being unable to pass over them, they die of hunger in hundreds, and on large boles often in thousands, below the rings.

In 1892 the plague of moths has been completely stayed. Abnormally warm weather early in spring induced the tiny larvæ to come out of the shell earlier than usual, but the cold snap which followed it prevented the Spruce and Pine from throwing out young foliage, so that whilst caterpillars already below the tarry rings could not ascend the stems, those above them could find no food in the shape of the new flush of needles, and were physically unable to attack the older and harder needles of last year, and so both sets died of hunger. But in addition to this, fungoid diseases broke out amongst them, and it seems undoubted that after about three years of devastation, when they occur absolutely in millions, the caterpillars become constitutionally debilitated, and are extremely apt to die off even much more suddenly than they increased and multiplied.

Thousands of acres of coniferous woods, mostly Spruce, have been totally defoliated, or so badly injured that millions of cubic feet of timber have had to be felled and thrown on the timber-market at extremely low prices. But it is still too early to add up the account and state the full extent of the calamity due by this Spruce-moth, for the subsequent destruction among the remaining woods by *Pissodes hercyniæ*, *Hylesinus poligraphus*, *Callidium luridum*, and in a lesser but still considerable degree, by *Anthaxia quadripunctata*, *Bostrichus chaleographus*, *micrographus*, *autographus*, and *lineatus*, *Hylesinus pilosus*, *palliatus*, *piniperda*, and *minor*, and *Pissodes pini*, is indirectly due solely to the ravages of the Spruce-moth, and will very considerably swell the total extent of the damage done.—*Trans.*

B. Owlet-Moths (*Noctuidæ*).

81. *The Pine Owlet-moth or Pine Beauty, Noctua* (*Trachea*) *piniperda.*

(*Vide* Plate III. fig 20.)

Both male and female moths are about the same size, having a span of 1·28 to 1·4 inches across the front wings, and are somewhat similarly marked; but they are distinguishable by means of the more ciliated or feathered feelers of the male, and the somewhat fuller abdomen of the female.

The front wings and the upper part of the body are brownish-red spotted with white, and the larger lower spots on the wings form a crescent pointing downwards when the moth is at rest; the hind wings and abdomen are of a dark brownish-grey colour, the former having a lighter edge. The lower side is bluish-red, becoming blackish-grey towards the bases of the front wings, but merging into a black point on the lower pair. Melanic and other sports in colour are not infrequent.

When full-grown, the caterpillar attains a length up to 1·6 inches. It is yellowish-green in colour, with 3 to 5 white longitudinal markings, and a yellow or orange-coloured stripe on each side running just above the spiracles and the legs, has a dark head, and is only very slightly hairy. In consequence of the malformation of the two first abdominal legs, it has a motion somewhat resembling that of a span-worm; whilst in the younger caterpillar stage, it is also endowed with the capacity of spinning gossamer threads.

The chrysalis is about 0·64 inches in length, and more of a green colour at first, but afterwards turns dark brown, with a two-pointed termination at the lower extremity.

The moth swarms as early as the end of March or the beginning of April, and enters *in copulâ* in the evening and during the night, high up in the stems. After impregnation, the female deposits her ova for the most part singly on the needles of the trees, selecting pole-forest in preference to other crops. When the tiny caterpillars make their appearance in May, they at once commence feeding, gnawing first of all the sides of the needles, but later on, after gaining strength, devouring the whole of the

spines right down to the sheath. In July, when fully grown, the caterpillars descend from their feeding-ground on the tree-foliage for the purpose of entering into the pupal state of rest under the moss with which the ground is usually covered. When this is wanting, they hibernate as chrysalides in the soil itself, scattering themselves over the whole of the area attacked until the following spring again calls them into active life as imagines. The period of pupal rest is therefore of exceptional length, extending over eight months.

The Pine Owlet-moth or Pine Beauty lives only on Pines, and especially in pole-forests; but when its reproduction is favoured by warm dry weather it becomes very prolific, and has at various times done very considerable damage over extensive areas, sometimes totally destroying pole-forests of Pine amounting to 2000 acres in one block (*e.g.*, Bunzlau town forest in Silesia, 1884).

Among birds and animals this insect has a great many natural enemies, which either feed on the almost naked caterpillar, or else on the chrysalides lying unprotected on the soil for about eight months. Such enemies include birds of all descriptions, predatory insects (*Carabidæ*), flies (*Tachininæ*), and ichneumon-flies (*Ichneumonidæ*), then swine, badger, hedgehog, and mice. The caterpillars are also extremely sensitive to damp, cold, raw weather, which often kills them off with great rapidity,[1] so that this sensitiveness, coupled with the action of their natural enemies, often effectually suppresses their tendency to numerical increase.

The herding of swine in the woods is a good practical annihilative measure, as they are particularly fond of the chrysalides, and know very well how to find them out; where any wild-pigs are still maintained, the presence of the insect may often be betrayed by examining the vicinity of patches where they have broken up the soil with their snouts when in quest of the pupæ.

In pole-forests that have been attacked, the caterpillars can easily be brought down to the ground by shaking the young poles or tapping older ones with a padded mallet or axe-head (*vide* par. 61); and they can often be killed off in heaps when they have

[1] In some of the Pine woods of Northern Bavaria the year 1889 threatened to bring a plague of these owlet-moths, but suddenly, about the middle of June, nearly all the caterpillars, which were nearly full-grown by that time, died off, without any apparent reason being deducible from changes in temperature and weather, parasites, or similar intelligible reason.

completed their feeding on the foliage, and descended from the trees in order to enter the pupal state, as they frequently collect in large clusters at the foot of the stems before betaking themselves to their winter (chrysalid) quarters.

As the caterpillars exhibit no migratory tendencies, the formation of trenches within and around the crops attacked would be of little practical avail as an exterminative measure.

C. Spanworms or Loopers (*Geometridæ*).

82. *The Geometrical Moth, Bordered White Moth, or Pine Spanworm, Geometra (Fidonia) piniaria.*

(*Vide* Plate IV. fig. 25.)

The male and female moths differ very little in size, but vary essentially in colour; the wings, when extended, have a span of about 1·28 inches.

The female has simple comb-like feelers and ruddy-brown wings with a broad dark edge. Two dark-brown transverse stripes run across the lower pair of wings, and one similar stripe passes across the upper pair. The lower edges of the wings have a row of alternating light and dark spots.

The male, however, has large feathery antennæ, and is brownish-yellow in colour instead of ruddy-brown, with broad dark-brown edging and transverse stripes, whilst the lower edges of the wings are tipped with brown and yellow spots.

The lower side of the insect is similar in both genders, being of a brownish colour, with dark transverse lines, a broad yellowish-white longitudinal stripe, and numerous small brown and white spots.

When the moths are at rest the wings are borne upright.

The caterpillar is about 1·4 inches in length when full-grown. It is of a yellowish-green colour, with three white longitudinal stripes, which are also continued on the head; close below the spiracles there is a yellow line along each side, whilst three yellowish longitudinal stripes are also noticeable on the lower side or belly of the spanworm or looper.

The chrysalis is about 0·48 inches in length, and very much resembles that of the Pine Beauty, being greenish at first, and then gradually changing into dark-brown; but it is easily dis-

tinguishable by having only one point at the lower extremity, and by being somewhat less in size.

The time of the swarming of the moths is during May and June, when the males may be noticed flitting about during the daytime, although like other moths their natural time of activity is towards night. After impregnation, the female deposits her bright-green ova on the needles of the Pine, near the summit of the crown, and on the foliage at the extreme end of the side-shoots. The tiny caterpillars make their appearance about the beginning of July, and at once begin to feed, commencing by only gnawing the needles slightly, but afterwards biting them through about the middle, so that the upper half falls to the ground, whilst they devour the lower portion remaining. Thus, directly the opposite takes place here of what occurs in the case of the Spruce-moth, for whilst the "Nun" carries on its destructive work from below upwards (*i.e.* centrifugally), the Pine spanworm devours the foliage from above downwards (*i.e.* centripetally). The spanworms or caterpillars have the power of spinning themselves down to the ground on gossamer threads, and often let themselves down to the ground in this way before entering the pupal state of rest.

The chrysalid metamorphosis takes place about October, either under moss or on the surface of the soil, the caterpillars often lying extended on the ground for some time awaiting the final change of skin, during which they enter the pupal state. The chrysalides lie scattered about the whole of the area that has been infested with the spanworms, and do not necessarily confine themselves merely to the extent overshadowed by the crowns on which they have been feeding.

The Pine spanworm or Bordered white moth has often been known to commit extensive devastation in certain localities; and here again, although it may also be occasionally found on other species of trees, it is young pole-forests of Scots Pine which most of all suffer from its attacks. Its power of inflicting injury on an extensive scale is diminished by the facts that, in the first place, it does not commence feeding till the new spines or needles are completely developed, and the young buds for the following year's foliage are already actually formed,—and that, in the second place, experience has hitherto shown that two bad years of spanworms occur only very exceptionally in succession.

The spanworm is, like the caterpillar of the Pine Beauty, very sensitive to atmospheric influences and changes in temperature, whilst both caterpillars and chrysalides have also numerous enemies that render material assistance in keeping down any tendency towards too prolific increase. But when, despite these checking influences, large swarms actually occur to anything like a calamitous extent, epidemics due to fungoid infection usually soon break out among the caterpillars, and with such virulence as practically to kill them all off very rapidly.

As a protective or an exterminative measure, swine may be driven into the woods during autumn and winter, to rout out the pupæ; or the shaking and tapping of poles may be resorted to during summer in woods where the presence of the spanworms has been observed. For crops that are badly infested, Altum strongly recommends the raking together of the dead foliage in heaps or lines late in autumn, as the caterpillars and chrysalides thus laid bare on the strips cleared of foliage are more accessible to birds, and perish from the cold during winter, whilst those lying under the heaps of dead needles never attain development during the following spring. But this measure is only applicable when the plague of insects is concentrated within a comparatively small area. On poor soils it is essential, for the maintenance of their productive capacity, that the dead foliage should be replaced in its normal position during the following spring; and even on the better classes of soil this will also be certainly advisable, though not so absolutely necessary.

D. Leaf-rollers (*Tortricidæ*).

83. *The Pine-shoot Tortrix or Pine Twig-twister, Tortrix (Retinia) buoliana.*

(*Vide* Plate IV. fig. 23.)

Though small, this can under certain circumstances become a very dangerous insect in woodlands. This butterfly, or rather moth, has a span of about 0·8 inches. The narrow upper wings and the front part of the body are yellowish-red in colour, with silvery-white, sinuous, transverse bands across them, having a bluish tinge about the middle, and with greyish-white edging; the lower pair of wings are of a glossy, silky grey, also tipped

with greyish-white fringes. The lower side is of a glossy, silk-like dark-grey, and spotted with yellowish-red and white near the upper edges.

The caterpillar, attaining a length of about 0·56 inches, is light-brown in colour, with glossy black head and thorax.

The chrysalis is of a dirty yellowish-brown colour, and about 0·32 inches in length.

The moth swarms during the evenings about the beginning of July, whilst during the daytime it remains quietly seated on the needles and shoots of young Pines, with the wings ranged over each other like the tiles on a roof.

The female deposits her eggs singly on the buds of the young shoots, almost unexceptionally of young Scots Pine between 5 and 12 years of age, into which the tiny caterpillars proceed to bore, when they make their appearance from the shell in August; but owing to the diminutive size of the caterpillar, the havoc it is beginning to commit is hardly noticeable during the first autumn. During the following spring the caterpillar becomes more energetic and active, and the damage done is greater; still the bud is able to develop itself partially, before the shoot dies off through being hollowed out. As a rule, the terminal bud gets hollowed out first, and then later on the side-buds forming the whorl. Should one of these remain uninjured, it takes over the function of the leading-shoot. But in doing so, it not infrequently happens that a shoot thus damaged makes a downward bend before commencing its upward growth; it recovers itself when the injury inflicted has only been moderate, though even then the bend at the damaged place is still recognisable many years afterwards, and sometimes even when the tree approaches maturity.

In June the caterpillar enters the pupal stage of metamorphosis at the base of the hollow it has scooped out inside the shoot.

Where this insect occurs in any large numbers, the young Pines are apt to be attacked every year, when they of course become sickly in growth and crippled in development, so that the total damage done may be somewhat considerable.

The only means of preventing its attacks is to break off all the shoots attacked, which are easily recognisable, during May and till the middle of June, so as thus to destroy both caterpillars and chrysalides; but in respect to the latter, care must be taken

to look for them below the place at which the twig breaks, as they often lie somewhat lower down than that.

84. *The Pine-bud Tortrix or Bud-hollower, Tortrix (Retinia) turionana.*

The Pine-bud Tortrix is very much like the Pine-shoot Tortrix, but somewhat smaller. The upper wings are a mixture of bluish-grey and ruddy-brown, the former colour being shot through the latter in the shape of patches and bands, whilst the fringes round the edge are of a dark bluish-grey; the hind wings are grey, with greyish-white fringed edges. The lower side of the upper wings is of a blackish-grey colour, with patches of red towards the tip, and of greyish-white towards the upper edge; that of the lower wings is greyish-white, but somewhat darker towards the upper edge.

The caterpillar is about 0·4 inches long, and both caterpillar and chrysalis strongly resemble those of *Tortrix buoliana*. The attacks of this insect are also practically confined to young Scots Pine woods of from 6 to 15 years of age. The moths swarm about the end of May, and deposit their ova singly on the terminal buds of the young shoots, into which the young caterpillars bore their way when they issue from the shell; during the autumn and the following spring they hollow it out, so that it either dies, or can only develop very slightly before dying. About the end of April the caterpillar enters into the pupal state of rest within the hollowed-out bud, which it fills with the fine threads of its cocoon.

This insect seldom occurs in such large numbers as the Pine-shoot Tortrix; and as it does not often happen that all the side-buds forming the whorl are injured, one of these generally assumes the rôle of leading-shoot, thus materially minimising the actual damage done.

When the occurrence of damage is at all frequent, or in any way considerable, annihilative measures should be adopted. The only good remedies are a careful revision of the thickets during April and May, like that adopted simultaneously or a little later in the case of the Pine-shoot Tortrix, and the breaking off of buds that are seen to be infested with the worm.

85. *The Pine Resin-gall Tortrix, Tortrix (Retinia) resinella.*

The wings of this moth have a span of only about 0·64 inches. Head, body, and front wings are brownish-black or slate-coloured with a copperish sheen. The upper wings have silvery-grey transverse stripes, with a blackish feathery fringe, and the lower wings are of a dark brownish-grey with soft light-grey edging, whilst in both the under side is of a dark brownish-grey colour.

The caterpillar is about 0·4 inches long, and of a yellowish-brown colour. The chrysalis is 0·32 inches long, and dark in colour, almost black.

The life-history of this insect is remarkable, being distinguished on account of its biennial generation, which is seldom among *Lepidoptera*.

The moths swarm in May, the female depositing her ova singly beneath the whorl-buds of young Pines, principally on the side branches. When the young caterpillar comes out of the egg a few weeks afterwards, it bores its way through the rind into the soft shoot, and the resin which exudes from the wound thus made forms a small soft gall about the size of a pea during the first year; this serves the tiny, worm-like caterpillar as a place of residence when hibernating during the following winter. In the second year, on account of the continuation of the feeding of the caterpillar, this gall increases to about the size of a cherry, and is formed of thick walls of resin, but exhibits internally a distinct partition formed by the gall of the former year. The shoot itself is hollowed out to the very pith, and is enclosed within the resin-gall. In April of the second year the caterpillar enters into the pupal state within the gall, and in the following month the moth emerges from the chrysalis, coming head first out of the gall when ready for swarming.

The damage done by this insect is on the whole not very considerable, for, as above remarked, the side-shoots are principally attacked, and the leading-shoots only exceptionally, whilst they do not always perish in consequence. But when the insects are allowed to increase to any great extent, or when the young woods are growing on soils of only inferior quality, the damage done to the crops may frequently be quite considerable enough to make remedial measures advisable, and these can best take place by breaking off or crushing the galls of resin during the winter, whilst the caterpillar is reposing within them.

86. *The Spruce-shoot Tortrix or Shoot-twister, Tortrix (Grapholitha) pactolana.*

This is a small moth, having olive-brown upper wings with white markings, and dark-grey hind wings with a light-coloured edge. The caterpillar is of a pale-reddish colour, with a light-brown head.

The moths swarm about the end of May or the beginning of June, the female laying her eggs in little clusters on the whorl-shoots of young Spruce about 10 to 25 years of age. After about 14 days the caterpillars make their appearance, and bore through the soft rind into the cambial layer, in which they form a broad, irregular gallery; within this they shelter themselves against the resinous outflow by means of spinning a cocoon-like tube. Towards the end of April or the beginning of May, they enter into the pupal state of rest under the bark.

The presence of this insect is always betrayed by the excrement, which is visible mixed up with the resinous exudation from the wound made by the caterpillar. When several caterpillars are feeding about the same locality, all the portion of the plant lying above the part attacked usually dies off, so that when attacks take place from a large number of caterpillars, the damage inflicted can be by no means inconsiderable.

The only method of preventing numerical increase of this little enemy is to cut out and burn the young Spruce infested, a measure which is rendered all the easier by the fact that it is principally the plants near the edges of the thickets that are largely attacked. Altum also recommends the smearing of patent viscous tar over the places attacked, in order to prevent the moths from making their exit from the pupal chamber.

The curious observation recorded by Professor R. Hartig may be noted here, that the fungus *Nectria curcubitula*, which occasions a cankerous disease of the bark on Spruce growth of 5 to 15 feet in height, frequently effects its entrance by means of the places where the bark has been injured by this caterpillar.

The dark Spruce-shoot Tortrix, Grapholitha duplicana, is in colour, life-history, and sylvicultural importance very much like *G. pactolana;* but it makes its appearance about four weeks later, and is of less frequent occurrence.

E. Leaf-moths (*Tincidæ*).

87. *The Larch Mining-moth, Tinea (Coleophora) laricella.*

This very small, greyish-black moth swarms about the end of May or the beginning of June, the female laying her eggs singly on the needles of Larches from about the pole-forest stage of growth onwards, whilst saplings and plants of younger growth are only exceptionally attacked after the insect has increased greatly in numbers.

When the tiny caterpillar makes its appearance after being about 3 to 4 weeks in the ovum, it bores its way into the needle, eats out the contents of the spine, makes use of the empty shell as a protective covering, and then hibernates in this little, yellowish-brown sack, which is firmly attached to the twig. In the following spring it resumes feeding on the soft fresh needles, but still drags its original sack about with it, and finally enters the chrysalid stage in this. The new flush of foliage attacked becomes yellow and withered at once, and the injuries inflicted often assume such dimensions, especially on young Larch trees near the edges of the compartment, that hardly a sound tuft can be seen, the foliage looking as if it had been nipped and damaged by late frost. They gradually, however, recover, as new tufts of needles are formed in the centre of the damaged rosettes, and numerous short shoots develop, which assume the functions of the original long shoots that have been destroyed.

These injuries are often inflicted year after year on young Larch trees growing near the edge of compartments, and of course then do a great deal of damage, not only retarding them materially in their development, but also killing them off finally. Borggreve considers this mining-moth one of the chief primary causes of the cankerous disease so frequently noticeable on young Larch stems.[1]

Annihilative measures can hardly be applied against this tiny little insect. Large numbers of the caterpillars are devoured by tomtits, and destroyed by *Ichneumonidæ*, whilst heavy showers of

[1] The generally accepted opinion among sylviculturists throughout Germany is distinctly that the primary cause of the Larch canker is the fungus *Peziza Willkommii*, R. Hrtg., although of course there are several predisposing influences. Careful selection of soils and situation suitable to the Larch, and the formation of mixed rather than of pure crops, are the sylvicultural means of decreasing the dangers with which this tree is threatened in Britain.—*Trans.*

rain during the time of swarming often kill off a good many of the little moths.

The Larch-bark Tortrix, Grapholitha Zebeana, may also be mentioned. The little caterpillars live in the cambium and in the outer layer of the sapwood of small stems and branches of young Larch, on the bark of which they form conspicuous blisters and excrescences.

III. Other Injurious Insects.

A. Saw-flies (*Tenthredinidæ*).

88. *The Pine Saw-fly, Tenthredo* (*Lophyrus*) *pini.*

(*Vide* Plate IV. fig. 26.)

The wings of the female fly have a span of 0·64 to 0·72 inches. Its feelers are short and delicately toothed; its head is black in colour, whilst the body is yellowish with black patches on the back, and with three black rings or sections on the abdomen. The male insect is essentially smaller, but has beautifully double-feathered antennæ, and is of a darker colour generally, with yellowish legs.

The tailed-caterpillars, which have 22 legs, are of a dirty yellowish-green colour with a brown head, and black markings over the abdominal feet; when touched, they suddenly rear or raise their heads like a sphynx, or in a cobra-like manner.

In the chrysalis all the parts of the fully-developed saw-fly are already recognisable. It passes the pupal state in a leathern cocoon, mostly of a dark-brown colour, formed in the fissures of the bark, on the needles of the tree, or on the ground under moss. When effecting its exit from the cocoon as imago, this saw-fly makes a characteristic circular section.

The Pine saw-fly has a double generation. During the latter part of April and the beginning of May the first swarming takes place, when the female lays 120 or more eggs on the edges of the spines, which it wounds for the purpose with a saw-like ovi-depositor, whence it derives its English name. From 10 to 20 eggs are deposited inside each needle, and then the wound is closed up with a kind of frothy slime.

The larvæ or caterpillars make their appearance in May and June, and hang in clusters on the whorls of young Scots Pine, especially of those near the edge of compartments, or on such

as are badly grown and somewhat sickly from being suppressed or dominated, and thus cut off from normal supplies of light and air requisite for the due satisfaction of their requirements for healthy development. So long as they are still small, the caterpillars generally feed in twos on each spine, and leave the midrib standing; but when they are stronger and nearer the attainment of their full growth, they devour the whole needle, just leaving a little bit of stump, whilst the young spines remain untouched.

During the month of July they enter into the pupal state of rest, the cocoons being formed between the scales of the bark and on the branches of the foliage. In about 2 or 3 weeks the fully-developed saw-fly makes its appearance and swarms, when reproduction is accomplished, and the second ovi-deposition takes place.

The caterpillars of this second generation come out of the shell during August, and often continue feeding until well into autumn, when they descend from the stems, form their cocoons under the moss covering the soil, and hibernate within these as larvæ, for the metamorphosis into chrysalides only takes place during the following spring.

The above-sketched normal development is not always carried out in full regularity or entirety, for it sometimes happens that single broods, or even whole generations, remain for a whole year, or even for two years, in the cocoon before at length developing into the imago or perfect insect.

The Pine Saw-fly, which sometimes occurs in very large numbers, decidedly belongs to the more injurious class of forest insects. Although, as above remarked, it in the first instance attacks crops of sickly growth and backward development, yet, when increasing rapidly in numbers, it also extends its ravages to healthy crops of normal growth; by interfering then with their development, it very soon brings them into an unhealthy condition, and thus directly paves the way for other noxious insects finding in them only too favourable a breeding-place. The immediate damage which the saw-flies themselves commit is checked or minimised, owing to the fact that the shoots of the last year usually remain intact, so that the formation of buds for the next year is not rendered impossible.

Numerous animals render valuable assistance towards the annihilation of the Pine Saw-fly,—above all, the insectivorous

birds; squirrels and mice devour the contents of the cocoons, whilst swine eat the caterpillars, but do not touch the cocoons. Ichneumon-flies, predatory flies (*Asilidæ*) and beetles (*Carabidæ*), considerably diminish the number of the caterpillars, which are also particularly sensitive to frost and cold, damp, unseasonable weather, and consequently often die off in large numbers during autumn.

The annihilative or exterminative remedies, that have from time to time been found necessary, include the collection of the caterpillars when they are crowded together in clusters, although it is by no means always easy to detect their dirty yellowish-green colour against the foliage and twigs. They may either be crushed by pulling the gloved hand firmly along the twigs in the direction of the leading shoots, so as not to injure the foliage, or may be shaken down from the crown when the poles have outgrown the young thicket stage: for crushing the clusters of caterpillars on trees from which they cannot be easily dislodged, nippers have been specially constructed with broad wooden tongues.

The collection of the cocoons lying on the ground below moss is hardly practicable, as they are so small as to be very easily overlooked.

The herding of swine in the woods can only be of utility, so far as this insect is concerned, during the short time between the descent of the caterpillar from the stems and the formation of its cocoon-like winter-quarters in autumn, for, as has already been remarked, the pigs will not eat the cocoons.

Although it will only seldom be of actual occurrence, yet should there be any necessity for felling a crop of young Pine, that may have been totally defoliated by the caterpillars of this insect, a complete and deep overturn of the surface-soil will be advisable, in order to ensure the destruction of the caterpillars and chrysalides lying on and in the ground.

But in most cases direct and special measures for the extermination of this saw-fly will seldom be within the limits of practical adoption.

89. *Cocoon Saw-flies or Foliage-wasps, Lydæ.*

The Cocoon Saw-flies are particularly distinguished from the ordinary saw-flies of the genus *Lophyrus*, by the fact that the

larvæ or caterpillars, which have only three pairs of thoracic legs, and one pair of feet on the last section of the abdomen for purposes of propulsion, live in a cocoon which moves forward with them along the twig; this cocoon is partly transparent, but most of it is so obscured by pieces of needles, and especially by excrement, that it has been termed the "dung-bag." As these saw-flies only seldom occur in large swarms, and are not under ordinary circumstances particularly injurious in coniferous woodlands, it will only be necessary to mention the following principal species briefly:—

The Yellow Cocoon Saw-fly, Tenthredo (*Lyda*) *campestris,* whose tiny larvæ or caterpillars live singly on the young shoots of 3 to 6-year-old Scots and Weymouth Pines, and are covered with a thick dung-bag. The chief exterminative remedy applied, when young plantations or transplants in nurseries appear to be attacked, is pulling the shoots firmly through the gloved hand, so as to crush the larvæ. Young Weymouth Pine transplants are apt to suffer a good deal from them, but the presence of the caterpillar is easily noticeable.

The Large or Variegated Cocoon Saw-fly, Tenthredo (*Lyda*) *pratensis,* whose larvæ live singly in sacks that are usually less defiled with excrement than in the other species. It is more frequently to be found on 15 to 40-year-old pole-forests of Pine than on younger growth, so that practical remedies by crushing the sacks containing the small caterpillars are hardly applicable.

The Red-headed Cocoon Saw-fly, Tenthredo (*Lyda*) *erythrocephala,* lives in colonies of 3 or 4 in sacks plastered over inside with bits of needles and excrement. It occurs principally on young Scots and Weymouth Pines, and as it makes its appearance early in May, its attacks are confined to the older foliage.

The Spruce Cocoon Saw-fly, Tenthredo (*Lyda*) *hypotrophica,* has now and again occurred in Spruce pole-forests in such large numbers as to have cleared them of all the older needles, and in some cases even to have totally denuded them of foliage. Against this species also there is no direct practical annihilative measure applicable.

B. Wood-wasps (*Siricidæ or Uroceridæ*).

90. *Wood-wasps, Siricidæ.*

The wood-wasps belong to the class of technically injurious insects, as their large larvæ often render timber unfit for many technical purposes by boring deeply into the wood. They only attack coniferous timber.

By means of a long ovi-depositor the female wasp lays her eggs singly in the wood of the stem, principally selecting trees that have become sickly in growth in consequence of overtapping for resin, stripping of the bark by red-deer, injury by lightning, or other external injuries, whilst decidedly avoiding rotten wood. The larva bores first of all in the softer sapwood, but gradually, with growing strength, works deeper into the stem, and in the spring following the second winter again bores its way towards the surface of the trunk for the purpose of forming a pupal chamber in the sapwood. About the middle of summer the fully-developed wasp bores a round hole straight through to the surface, and issues for the purpose of swarming and reproduction. The galleries bored in the wood by the white, cylindrical, thick larvæ, which have a short terminal borer pointing upwards, are also circular.

Their generation is always biennial at least, and sometimes longer, for occasionally the wasps make their appearance from beams and scantlings that have been prepared and worked up for some length of time.

The three chief species are:—

The Pine Wood-wasp, Sirex juvencus, which occurs almost entirely in Pine timber. The female has a steel-blue body, whilst the male is usually much smaller in size, and of a yellowish-red colour from the third to the seventh sections of the abdomen.

The Giant or Yellow Spruce Wood-wasp, Sirex gigas (*Vide* Plate IV. fig. 22), which inhabits Spruce and Silver Fir. It is of a blackish colour, with a yellow patch behind the eyes. In the female the two first and the three last sections of the abdomen are yellow, whilst in the male all the rings are reddish-yellow, with the exception of the first and the last, which are black.

The Black Spruce Wood-wasp, Sirex spectrum, also inhabiting Spruce and Silver Fir, and of a bluish-black colour, with yellow-

ish longitudinal lines along the sides of the front rings of the thorax, and a yellowish dot on each side of the back of the head, is a species of less frequent occurrence.

The only preventive or annihilative measure of any practical use against wood-wasps is to cut out without delay any sickly or injured stems, and thus keep the woods as clean as possible by thinning and proper supervision.

C. Crickets (*Gryllidæ*).

91. *The Mole-cricket, Gryllus gryllotalpa* (*Gryllotalpa vulgaris*).

(*Vide* Plate IV. fig. 24.)

This well-known insect, easily distinguishable through its strongly developed claw-like legs, formed like a mole's for digging, belongs to the order of *Orthoptera*, and has only an imperfect metamorphosis.

The wingless larva already resembles the fully developed insect, whilst this is still more the case with regard to the chrysalis, which only differs from the imago by having merely rudimentary in place of completely developed wings, and crawls about and feeds like both larva and imago.

The pairing-time is in June, when both sexes entice the other by means of a chirping underground. After impregnation the female deposits her ova, up to the number of about 200, and in size about as large as a grain of hempseed, inside a nest formed by a hollow clump of earth about the size of a fist, cemented with a kind of slime, and lying about 3 to 4 inches below the surface of the soil.

After about 2 or 3 weeks the larvæ make their appearance in July, being at first of a whitish colour, but becoming darker later on, and soon wander throughout the soil in search of food. After hibernating under the surface of the soil, and making several changes of skin, they develop into imagines during the following spring. It is well worthy of note that the female cricket watches carefully over the opening of the nest containing her young, but at the same time also actually devours a large number of her progeny.

The food of the mole-cricket is for the most part animal, and in this way it may to a certain extent be useful. But in its search

for cockchafer grubs, worms, &c., it certainly destroys many seedlings in nurseries, in the formation of its runs underground; these at last become as large as could be formed by inserting a finger, for it bites through all roots that oppose its passage, and thus causes seedlings and transplants to wither and die off. This damage may at times become very considerable, especially in Pine and Spruce seed-beds.

The methods of endeavouring to exterminate the mole-cricket comprise the following:—

The seeking out of nests, which may be tracked by the confluence or converging of the runs, that dip down lower into the ground when they approach the nest. Although the runs are marked by air-holes in the soil, which look as if they had been made by sticking one's finger into the ground, and by the withering and dying off of the seedlings, yet it is by no means altogether an easy matter to find out the nests.

The planting-out of ordinary flower-pots, the holes in the bottom of which have been plugged up with cork, about six feet apart, and the stretching of pieces of wood, like laths, across from pot to pot, so that when the crickets are wandering about after nightfall during the pairing-time they cannot pass, but are forced to go along the edge of the lath, and finally tumble into the pots.

The killing of the mole-crickets when they are calling to each other during the pairing-time. This can be done by cautiously approaching the place where the chirping is noted, and then suddenly dislodging the insect in a clod by means of a hoe.

The pouring of a tea-spoonful of petroleum, oil, or tar into the freshly-formed runs, which are easily distinguishable after rain, and then pouring in water until the runs are full. As soon as the cricket gets touched by any of the oil, it at once ascends for fresh air, and then can be easily destroyed.

(*b.*) Insects on Broad-leaved Trees.

I. Beetles or Chafers (*Coleoptera*).

Bark-beetles (*Scolytidæ*).

92. The broad-leaved species are much less exposed than conifers to injuries from bark-beetles, and when the former are

attacked at all, it occurs to a far greater extent in avenues and clumps of ornamental trees in parks and gardens, than in the close canopy of woodlands. But at the same time they do not escape injury entirely.

The broad-leaved species of forest trees that are most frequently attacked, or rather that are least exempt from danger, are the Elm, Ash, Birch, and in a less degree the Oak and Beech; it is also quite worthy of note that on the broad-leaved trees most kinds of beetles are polyphagous, now attacking this, now the other species. Here too, however, as among conifers, it is usually the older stems of sickly growth that are most apt to be attacked.

It is only young growth like seedlings, saplings, or poles and older stems that have been badly damaged, which are apt to succumb soon to the injuries received; for in tree-forest the boring of the larvæ may often be carried on for years before the trees gradually show signs of dying off. Thanks to their strong recuperative power, broad-leaved species of trees are altogether less sensitive than conifers to wounds and injuries inflicted, whilst at the same time a number of the bark-beetles that infest the former class of trees live more in the wood than in the cambium, and consequently threaten in a much less degree the vital energy of the tree.

The following include the more injurious species which are of somewhat frequent occurrence :—

The Oak-beetle, Bostrichus (Xyleborus) dispar. This insect chiefly attacks old Oak and Beech, that have been somewhat damaged or interfered with in one way or another, and also bores into their stools. Sturdy Oak saplings and transplants are often quickly killed off in large numbers by reason of the galleries [1] formed by the larvæ within the slender stems. The cutting back of such young growth, and the burning of the stems infested, are the only way of annihilating this insect enemy.

The variegated Ash-beetle, Hylesinus fraxini, and *the black Ash-beetle, Hylesinus crenatus*, both live principally on the Ash. The main gallery of the former consists of two horizontal arms or branches, but that of the latter has only one. Here and there these beetles occasion no inconsiderable amount of damage, as poles and young stems of backward growth are often killed off

[1] They somewhat resemble the short galleries formed by *Bostrichus (Xyleborus) lineatus* in Spruce, but are very considerably longer (*vide* par. 71).—*Trans.*

quickly owing to the main and larval galleries being bored in large numbers throughout the cambium.

The large Elm-beetle, Scolytus destructor (*Eccoptogaster Geoffroyi*), and *the small Elm-beetle, Scolytus* (*Eccoptogaster*) *multistriatus*, both principally to be found infesting the Elm, do a good deal of damage to the trees they attack, owing to the larval galleries permeating the cambium, and only slightly entering the sapwood. Avenue trees seem especially liable to attacks from this insect. The main galleries, which are vertical, bite somewhat deeper into the sapwood.

93. *Cockchafers* (*Melolonthidæ*).

Although the fully developed chafers feed almost entirely on the foliage of the broad-leaved species of trees, yet it is especially during their larval or grub stage that these insects do by far the most injury; and as they are usually more injurious to young coniferous seedlings and plants than to broad-leaved growth, they have already been dealt with amongst the insects injurious to conifers (*vide* par. 78). They are only mentioned here in passing, and for the sake of completeness in detailing the insects that actually damage plants or trees of broad-leaved species.

94. *Long-horned or Cervicorn Beetles* (*Cerambycidæ*).

The very numerous class of long-horned beetles is distinguished in some instances by their size, or by their elongated powerful bodies and long legs, or by the fact that in many species the feelers are often several times the length of the body.

The larvæ are soft, whitish or whitish-yellow, with a large head and strong horny upper jaws; they are mostly feetless, being provided with small warty projections only in place of legs, and live in the wood, whereas the beetles feed innocuously on leaves and flowers.

The beetles swarm in summer, and lay their eggs on the bark, or in some instances in it by means of an ovi-depositor. When the larvæ make their appearance they first of all feed superficially, but bore deeper into the wood later on. The galleries formed are, as might be expected from the shape of the larvæ, broad and shallow, but gradually increase in size with the growth of the larvæ, and are full of the mealy dust formed by the latter.

The generation of the cervicorn beetles varies, being simple or annual in many species, biennial with most of them, and multannual in some cases. The imago bores its way out to the surface by an oblique passage having an elliptical exit-hole.

The larvæ of the cervicorn beetles live chiefly in the wood of broad-leaved species of trees, and, as sickly or unsound stems are for the most part attacked, the actual damage they do is on that account comparatively slight; but at the same time they are not infrequently found on sound stems, which become riddled with holes by the larvæ, and are thus rendered of less technical value than they would otherwise possess.

Annihilative or exterminative measures are hardly ever necessary on any extensive scale, nor could they easily find practical application. The following comprise the chief species :—

The large Oak Cervicorn, Cerambyx heros (*Hammatieherus cerdo*). This beetle is about 1·6 to 2 inches in length. The yellowish-white larva, extending to about 2·8 inches when full grown, is distinguished by having large elliptical horny plates on the upper portion of the different segments. It inhabits old Oaks, occurring frequently in the sound wood, which is of course greatly damaged for technical purposes by the larval borings; these are about as thick as a finger. Its generation is biennial.

The large Poplar Cervicorn, Cerambyx (*Saperdas*) *carcharias* (*vide* Plate I. fig. 11). This is a yellowish-brown beetle, with black-spotted thorax and elytra. The round, footless, yellowish-white larva attains a length of 1·4 inches; it has brown mandibles and scales from the third to the tenth segment. Its generation is biennial, and as larva it feeds chiefly in Poplars and Willows up to about their 20th year.

The Aspen Cervicorn, Cerambyx (*Saperda*) *populnea.* The beetle is only 0·4 to 0·52 inches in length, and black in colour, with yellow hairs; the feelers are alternately ringed with blue and black. The yellow larva, which lives chiefly in Aspen seedlings or stoles of from 2 to 6 years of age, at first feeds in the outer layers of sapwood, but during the second year bores its way into the pith, and produces knots and swellings that are often conspicuous on the slender stems.

Its generation is also biennial. In order to exterminate the insect, damaged stems should be cut back and burned, and the beetles should be collected when swarming during June.

The Spruce Cervicorn, Callidium luridum.—This is in reality a much more injurious species of cervicorn than any of the above-mentioned beetles, but it chiefly attacks conifers (the Spruce in particular) that are in a sickly or already damaged condition. The larvæ feed first of all in the cambial layer, and thus kill the stem before they bore deep into the wood. Next to *Pissodes hercyniæ* this was the species of beetle most numerous in the damaged Spruce forests of Bavaria in 1890, after the Spruce moth (*Liparis monacha*) had begun its ravages (*vide* foot-note on page 88). It is mentioned here, as no special paragraph was considered necessary for coniferous cervicorns. Immediate felling and removal of stems attacked should take place so soon as the insects are recognised by the outpouring of resin, and the gradual withering of the crown of foliage. Its generation is biennial.

95. *Weevils, or Rostral or Proboscid Beetles (Curculionidæ).*

Of this rather numerous family a comparatively small number of very injurious species attack conifers (*vide* pars. 75 to 77), but the great majority of weevils feed on plants of broad-leaved foliage, and not a few of them on our forest trees.

In some cases damage is done by the larvæ, which live in the interior of the plants and destroy their tissue, whilst in others the main injuries are inflicted by the beetles devouring buds, flowers, and foliage; but concerning their full life-history our knowledge is by no means yet complete.

The characteristic feature of the *Curculionidæ* is the elongation or extension of the head to form a rostrum or proboscis, by means of which the majority of the species are easily recognisable.

The so-called green and grey rostral beetles are especially destructive in young plantations and nurseries, where they often commit considerable havoc. These species are characterised and distinguishable by a kind of greenish or greyish metallic lustre, and among them the following are of most frequent occurrence:—

1. *Having a Greenish Metallic Sheen.*

The Silvery-green Rostral Beetle, Curculio (Phyllobius) argentatus.—This beetle gnaws and destroys the buds on Beeches, Birches, and Oaks. It is blackish in colour, with emerald or bluish-green lustrous scales; the elytra have whitish hairs, and the feelers and legs are brownish-yellow. Only 0·2 to 0·24 inches in length.

The Green-necked Rostral Beetle, Curculio (*Phyllobius*) *viridicollis.*—This tiny beetle is only 0·12 to 0·2 inches in length, and of a smooth, glossy, black colour, whilst the sides of the neck-plate and the breast have green scales; the antennæ and legs are brownish-yellow. It chiefly devours the buds of young Oak and Beech, but is also found on Aspen and Sallow.

The Glittering Rostral Beetle, Curculio (*Polydrosus*) *micans.*—This beetle is 0·28 to 0·32 inches in length, and of a blackish ground-colour, covered with greenish, golden-bronze or copperish lustrous scales on the elytra, and whitish scales on the breast. It gnaws the buds of Beeches, Hazels, and Oaks principally, but also of other broad-leaved trees and shrubs, attacking them at the side first and hollowing them out; after the leaves have fully flushed, it feeds on the foliage. Its attacks can easily be prevented by ringing the stems with patent tar in April.

2. *Having a Greyish Metallic Sheen.*

The Hazel-nut Rostral Beetle, Curculio (*Strophosomus*) *coryli.*—This beetle is 0·16 to 0·24 inches in length. It is almost spherical in shape, and brownish-grey in colour. The basal junction of the elytra is black, without hairs or scales; the feelers and the legs are rusty red.

It is principally to be found on Hazel, Oak, Beech, and Birch, whose buds it hollows out, and then proceeds to gnaw the young shoots.[1] Preventive or exterminative measures against these insect enemies, which often occur in large numbers, are only applicable to a limited extent, as, for example, the collecting of the beetles in nurseries, although this is made troublesome by their habit of dropping to the ground whenever the plants they are on are touched or shaken in any way. Altum points out the advantage to be thus gained by ringing the stems with patent tar, as this will effectually prevent the fallen beetles from re-ascending them.

Among the other rostral beetles which make themselves conspicuous by their frequent occurrence may be mentioned *the black Beech hopping-beetle, Orchestes fagi*, a tiny weevil only 0·10 to 0·12 inches in length, and of a black colour, with grey hairs and a rostrum bent back under it; its feelers and legs are of a light

[1] The unwinged imagines also feed on the edges of needles and on the bark of young Pine and Spruce, especially of 2 year-old seedlings, in spring, and have recently done very considerable damage in many localities. (Hess, *op. cit.*, vol. i. p. 243.)—*Trans.*

brown. The female lays its eggs singly under the cuticle near the midrib on the lower side on Beech leaves when they flush towards the end of April or the beginning of May; and when the larvæ appear 2 to 3 weeks later, they mine sidewards, or towards the apex of the leaf in the parenchymous layer, the galleries increasing in breadth very much as they approach the edge. The effect thus produced on the damaged beech-leaves makes them look as if they had been nipped by late frost, as, though the injured parts exhibit whitish markings at first, they soon oxidise to a brown colour. The beetles which make their appearance in June feed on the foliage and the nut-cupules until they descend to hibernate under the dead foliage on the ground.

This insect often occurs in millions in Beech woods, and must, to a certain extent, damage the assimilative power and the increment of trees which are infested by them in large numbers, as often happens on parent standards and near the edges of compartments. There is no practical preventive or annihilative measure suitable for adoption against this insect, whose attacks are, however, least extensive in mixed woods, where insectivorous birds are always most plentiful.

96. *The Saw-horn Beetles* (*Buprestidæ*).

These are mostly beetles of a bright colour having a metallic lustre, and with compressed bodies and weakly developed legs; they are only injurious to woodlands during their larval stage.

The larvæ are white, soft, feetless, and elongated, somewhat resembling the cervicorn larvæ, but distinguishable from these by reason of the strongly developed first abdominal ring or section, and mostly also by two horny tips on the tail that point outwards or behind. They form irregular, sinuous galleries between the wood and the bark, which gradually become broader as the larva grows larger, and which are tightly packed with the bore-dust. The pupal chamber is hollowed out in the sapwood at the end of the larval gallery. Two years after entering the stem, the beetle emerges through a half-moon-like hole flattened on one side.

Though, on the whole, not of great Sylvicultural importance, yet a few species often do very considerable damage here and there. The following are the species of most importance :—

The Green Beech Saw-horn Beetle, Buprestis (*Agrilus*) *viridis* (*vide* Plate I. fig. 7).—This beetle is about 0·24 inches in length, and for the most part of a lustrous blue or green colour. It swarms in June and July, when the female deposits her ova on the bark of young Beech or Oak, on the cambial layer of which the larva feed, thereby causing a sickly condition of growth, or even the death of the sapling if badly attacked. Sturdy Beech transplants are specially liable to be attacked over considerable areas in this manner, but in these cases the observation has always been made that the plants in the first instance attacked have usually been in a sickly condition, in consequence of not having had time to establish themselves thoroughly.

Its generation is biennial. The further propagation and increase in the number of this insect can be hindered by pulling up and burning the plants that are attacked; but the damage done is not usually great.

The Golden-furrowed Oak Saw-horn Beetle, Buprestis (*Chrysobothris*) *affinis.*—This is a copper-brown or dark grey beetle, with metallic lustre, and with two golden furrows on each of the elytra. The larvæ live chiefly in sturdy Oak transplants, in which they bore irregular, sinuous, shallow galleries between the cambium and the sapwood, and often injure or even kill off the saplings in large numbers. Here again the cutting back of the plants that show sickly growth, in consequence of being attacked, is the only way in which the increase of the insects can be prevented, or the damage done in any way repaired.

The thin Oak Saw-horn Beetle, Buprestis (*Agrilus*) *tenuis.*—This beetle is 0·28 to 0·32 inches long, and of a dull green colour passing into olive or bronze. In its life-history, and as regards the damage it does, to Oak and Beech principally, it closely resembles *Agrilus viridis*. Another species, *Agrilus betuleti*, has also been found committing damage on Birch here and there.

97. *Leaf-beetles* (*Chrysomelidæ*).

These beetles are of short, squat, compressed, strongly-arched structure, and are usually of small size, with short feelers and powerful legs partly adapted for springing; they are frequently variegated in colour, and have often a metallic lustre.

Though principally living on broad-leaved kinds of plants, they

do, on the whole, comparatively little injury to species of sylvicultural importance. Both the larvæ and the beetles feed on foliage, gnawing away the parenchym between the ribs and the veins, and leaving only the skeletons of the leaves, so that their attacks are very easily distinguished from those inflicted by other kinds of insects.

As it is principally the less important kinds of forest trees that suffer most from these particular enemies,—trees like Aspen and Saugh, which are themselves not infrequently classifiable as noxious weeds,—the injuries they inflict on woodlands are comparatively slight on the whole, and any real damage that is done is usually confined to Alders and Willows. They are insects with simple annual generation.

The following four species comprise those of chief sylvicultural importance:—

The Blue Alder Leaf-beetle, Chrysomela (*Agalastica*) *alni.* This is a small violet or steel-blue beetle, 0·24 to 0·28 inches long, with black feelers, breast, and legs. The larva is 0·4 inches long, 6-footed, of a blackish colour, with somewhat of a greenish lustre, rather hairy, and with transverse marks across the rings on the back.

Whilst swarming during May and June as beetles, and again as larvæ appearing in June, this insect feeds on the leaves of the Alder, and is at times very troublesome in nursery-beds. By collecting the beetles after August, or during the time of swarming in spring, when it is easier, their numerical increase may be held greatly in check.

The Red Poplar Leaf-beetle, Chrysomela (*Lina*) *populi* (*vide* Plate I. fig. 9). The beetle is 0·4 to 0·48 inches in length; the body is blackish-blue in colour, and the elytra brick-red, with black points at their extremities; the feelers are short, compressed, and thicken considerably towards their ends. The 6-footed larvæ are of a dirty white, with many black dots, and two white excrescences on the sides of the second and third rings.

Both as beetle and larva, they principally feed on Poplars and Aspen, but also on the foliage of Willows, when they can be somewhat destructive, as they may often seriously retard the development of the withes in the willow-coppices.[1] The beetles

[1] Hags of *Salix purpurea* and *S. pentandra*, together with their varieties, suffer most from leaf-beetles.—*Trans.*

swarm in May and June, and the ova are deposited in clusters of 10 to 12 on the foliage of young saplings, shoots, and stoles up to a total of 100 to 150. The larvæ appear about four weeks later; after feeding for about four weeks they enter the pupal state, and appear again as beetles at the end of August.[1]

The Aspen Leaf-beetle, Chrysomela (*Lina*) *tremulæ,* closely resembles *L. populi* in appearance and habits, but is smaller, being only 0·32 to 0·4 inches in length, and has no black tips at the extremities of the elytra. It is in general somewhat more destructive than that insect, for it attacks the shoots whilst they are still quite young and soft. The larvæ and pupæ are hardly distinguishable from those of *L. populi.*

The common Earth-flea (*Haltica oleracea*) *and the springing Oak-leaf Beetle* (*Haltica erucæ*) are both tiny insects of 0·16 to 0·20 inches in length, and of a bluish-green colour, with finely punctured elytra. They both do a good deal of damage at times in gardens and nurseries, and can best be got rid of from the beds by sprinkling these with ashes or lime, or watering them with a weak solution of carbolic acid, or with a decoction of wormwood.

Cantharides or Blister Beetles (*Meloidæ*).

98. *The Cantharis or Spanish Fly, Lytta vesicatoria.*

(*Vide* Plate I. fig. 12.)

This beetle is about 0·56 to 0·80 inches in length, of a beautiful emerald-green colour, with long black feelers and black legs, and soft, wrinkled and punctured elytra, having a few slightly prominent longitudinal lines. Swarming during June and July, it lays its yellow, club-shaped eggs about 0·8 inches below the surface of the soil in clusters of 40 to 50. The larvæ appearing 3 to 4 weeks later, hairy and of a dark brown colour, quickly scatter in the soil, and appear to feed on humose substances, although recent investigations distinctly suggest their being parasitic, and devouring the ova and larvæ of the earth-bee or humble-bee. A very considerable change in form takes place before the larva enters into the pupal stage. The life-history of this insect has not yet been

[1] According to Taschenberg (*Forstwirthschaftliche Insectenkunde,* 1874, p. 199), this insect frequently has a double generation.—*Trans.*

thoroughly studied, but the generation is probably simple and annual.

These beetles often appear in great numbers in June, and attack the foliage of Ash principally, but also Ligustrum, Woodbine, &c. They devour all the parenchym, leaving the midrib and veins bare, though even consuming these also when they are in want of food. Young Ash-plants in nurseries or plantations are often not inconsiderably damaged in this manner.

The presence of this beetle in large numbers is not only indicated by the rapid loss of leaves skeletoned in this characteristic manner, but also betrayed by the unpleasant smell emitted by it, especially during the early morning, when it is usually at rest on the leaves, and when it can easily be gathered by shaking the young poles, or by tapping them with padded mallets or axe-heads.

The beetles collected can be disposed of to apothecaries for the preparation of the well-known Cantharides, or blistering fluid or plaster, so that the costs of extermination are often more than covered.

II. Moths (*Lepidoptera*).

A. Spinners (*Bombycidæ*).

99. *The Processionary Moth or Oak-spinner, Bombyx* (*Cnethocampa*) *processionea.*

(*Vide* Plate III. fig. 18.)

There is a considerable difference between the sizes of the two sexes of this species, the wings of the female moth having a span of 1·6 inches and those of the male only 1·28 inches. The upper wings are brownish-grey, with two double, darker transverse bands across them, the colours being plainer and more definite in the male; the under pair of wings are yellowish-white, with brownish-green somewhat indistinct transverse bands.

The caterpillar, which has 16 feet, attains a length of 1·4 inches, and is of a bluish or reddish-grey, with black spots on its back, and reddish-brown knob-like warts covered with a growth of very long, brittle, black and white hairs.

The ruddy brown somewhat compressed chrysalis lies in a

barrel-shaped cocoon inside a nest or pupal community spun by mutual labour, and attaining about the size of a child's head.

The moths swarm in August, and are, like other moths, usually most active towards evening. After impregnation, the female deposits about 150 to 200 ova in rows along the deep fissures in the bark of old Oak trees, and covers them up with a little grey wool-like coating as a protection against the wintry cold.

In the following May the young caterpillars make their appearance, and at once commence feeding in large communities. During the day-time they generally collect closely together in a nest in common on the stem, situated just under the junction of one or other of the large branches, and then towards evening setting out in close phalanx-like column to re-commence feeding.

The column is generally headed by one caterpillar, but gradually increases to the middle, and then, after decreasing, again terminates in another single caterpillar; in this marching order the caterpillars range themselves closely together, and whenever the column is broken or disturbed, they endeavour to re-form in proper order again as soon as possible; their track or marching-route is marked by gossamer threads. After they have finished feeding, they usually march back to the same nest, which is gradually increased in dimensions and woven together more closely as the caterpillars grow larger, so that at last it attains the size of an infant's head, and can plainly be seen from a distance. Such nests in common usually contain a good deal of larval excrement. When the tree they happen to be on has been denuded of foliage, the caterpillars migrate to another, still moving always in closed column.

About the beginning of July the pupal state of rest is entered into by the colony, either in the nest in common which they happen to be occupying, or in a new one specially woven for the occasion either at the foot of the bole or else at some height up the stem, but always on the sheltered side of the tree; inside this nest in common each caterpillar forms, as already stated, its individual cocoon, from which the complete moth emerges in August.

It is only the Oak that is attacked by this insect, but as it occurs not infrequently, the injuries inflicted can assume considerable proportions. Trees in the full enjoyment of light and air are, on the whole, most exposed to attacks from the processionary

moth, as, for instance, standard Oaks of all descriptions, and trees near the edges of compartments. When total denudation of the foliage takes place repeatedly, so that not infrequently the mid-summer flush of leaves is destroyed as well as the spring foliage, the results are often not merely confined to temporary loss of increment, but may induce a sickly condition of growth, with "stag-headedness," and may ultimately lead directly to the death of the tree.

But another danger is threatened by the long, brittle hairs, which contain some substance poisonous to both man and beast, and produce swellings and inflammation where they happen to be brought in contact with the skin. When old Oaks growing on grazing land are attacked by the caterpillars, the hairs of the latter are often swallowed by the cattle when feeding, and may occasion them a good deal of suffering.

Protected by these long, poisonous hairs, the caterpillar has few natural enemies beyond the Cuckoo, and a few *Tachinæ* and *Ichneumonidæ;* but, on the other hand, the ova are well-nigh decimated during the winter by tomtits, woodpeckers, &c.

The best annihilative measure that can be adopted against this insect consists in the removal and crushing or burning of the nests containing the caterpillars and chrysalides; when these latter are high up the stem, ladders will either be necessary, or else a pole with a nob of tow dipped in petroleum, and then lighted so as to set fire to the nest. For nests that are too high up for this method to be successful, Altum recommends the use of the gun with a large charge of very small shot and a small charge of gunpowder, so as to knock the nest to pieces.

Whether the caterpillars be collected first or directly destroyed, the greatest caution should be taken to ensure that the woodmen should not have their health injured in any way by the poisonous hairs. Thick gloves, and an adequate protection, as, for instance, a damp sponge over both mouth and nostrils, are necessary; and if the exterminative measures can take place during wet weather, so much the better, as the hairs are not only less brittle then, but are also less apt to float about in the air.

In areas infested for the time being by these caterpillars, the woods should, for obvious reasons, be closed to the collection of berries, the cutting of grass, and the herding of cattle.

100. *The Hop Dog, light Tussock Moth, or Beech Spinner, Bombyx (Orgyia, Dasychira) pudibunda.*

(*Vide* Plate III. fig. 21.)

The female moth has a span of 2 to 2·4 inches, whilst the male, though somewhat smaller, is easily recognisable by its yellowish-brown feathery antennæ.

The front portion of the body and the upper wings are of a reddish-white or whitish-grey colour, with two darker transverse bands; the lower part of the body and the back wings are lighter in colour, and with an indistinct transverse band, looking more like a patch than any regular stripe.

The caterpillar, which attains a length of 1·6 inches, is of a greenish-yellow colour at first, but afterwards turns reddish; it is characterised by four thick, yellowish-grey tufts of hair on the fourth, fifth, sixth, and seventh sections of the body, between which the velvety black incisions stand out prominently, and also by a long red or ruddy brown tuft of hair on the second last section towards its extremity.

The dark brown to greyish-yellow hairy chrysalis passes through the pupal state of rest in a cocoon.

This moth swarms about the end of May and the beginning of June, when the female deposits her ova, to the number of 100 or more, on the bark of poles or tree-stems usually only from about 3 to 10 feet above the ground; the eggs are at first of a greyish-green colour, but gradually darken to a brownish-grey.

About the end of June the young caterpillars make their appearance, devour the egg-shells from which they have just issued, and, like the Spruce-moth, cluster together for a few days in schools or colonies before ascending to begin feeding on the young foliage. At first they only nibble or gnaw the leaves slightly, but later on, with growing strength, they eat large portions of them, and often finally completely gnaw through the leaves near the petiole, so that parts of them fall down and may be found strewn over the ground.

In autumn, about the end of September or October, they descend from the trees on which they have been feeding, and form their cocoons in moss, or under dead foliage or the like, where they hibernate as chrysalides.

The Hop-dog or Beech-moth is to be found now and again in single examples on almost every kind of broad-leaved tree, but large swarms of them occur only on the Beech. It principally attacks the older classes of Beech crops, especially such as grow on soil that is somewhat inferior in quality, and it is usually only when these have been defoliated that it migrates to the pole-forests and the other crops of younger growth. It often occurs in enormous numbers, and is undoubtedly, above all others, the insect that threatens most damage to the Beech.

But the injuries inflicted are essentially diminished by the fact that the feeding of the caterpillars principally takes place during the later half of the summer months, after the formation of the young buds, for the flush of leaves during the following spring, has already taken place; for experience has shown that, although the generation is simple and annual, any plague of these caterpillars seldom lasts longer than two consecutive years, so that as a rule the damage actually done is, for the most part, confined to temporary loss of increment, and to a prejudicial influence, both quantitatively and qualitatively, on the mast-producing capacity of the trees.

The caterpillars have numerous enemies amongst insectivorous birds, including crows, cuckoos, thrushes, finches, tomtits, &c., whilst of predatory insects, *Carabidæ* and *Ichneumonidæ* decimate them; but it is chiefly to diseases of fungoid origin that the sudden disappearance of enormous swarms must be ascribed. At the same time, they are extremely sensitive to sudden changes in the weather, although during the winter months comparatively insensitive to the effects of snow and cold.

As an annihilative and exterminative remedy, experience has shown that attempts to collect the chrysalides, or to collect or squash the caterpillars when descending the trees for the purpose of forming their cocoons on the ground, are, on the whole, of no great practical use, or are, at any rate, not effective in the degree desired. As the eggs are deposited on the smooth bark of the Beech within a moderate height (about 10 feet) above the ground, and are comparatively easy to find owing to their being laid in clusters, they can be easily collected or destroyed, or can be effectively prevented from hatching, or killed off if the larvæ are collected in schools by being smeared over with oil or patent tar, as this brings death to both ova and larvæ. But as the ova are deposited within so short a distance of the ground, the simplest and most

practical method seems to be the formation of narrow rings of patent tar round the stems at about 12 feet in height, as the tar will bite on well to the smooth bark, and will prevent the great majority of caterpillars from ever ascending to feed on the tree-foliage, whilst it will also hinder the caterpillars, from ova deposited above that, being able to descend when following their natural instinct towards chrysalisation on the soil.

101. *Other Spinners* (*Brown-Tail, Lackey, and Gipsy Moths*) *Bombycidæ.*

Although these three species of moths are for the most part injurious to fruit-trees, yet they often occur in great numbers on woodland trees, more especially on Oak, and are therefore deserving of some short mention here.

The Brown-Tail Moth, Bombyx (*Liparis, Porthesia*) *chrysorrhœa.* —This is a white moth with satin-like lustre, having a span of 1·2 to 1·6 inches. The abdomen of the female is for the most part brownish, but with a dense reddish-brown tuft of woolly growth near the termination of the abdomen, whilst the male is of a blackish-brown colour with ruddy-brown tail or fringe of hairs behind. The 16-footed caterpillar is about 1·4 inches long, and of a dark greyish-brown colour, with red stripes along the sides, and covered with yellowish-brown hairs; underneath it is of a grey colour, with yellow marbling.

The moths swarm at the end of June and the beginning of July, when the female lays her 200 to 300 brownish-yellow eggs on the lower side of the leaves of many broad-leaved species of trees, but chiefly on Oak, and covers them up with spongy emission. The caterpillars make their appearance in August, and form nests for themselves round the leaves and young shoots. In autumn, with a view to the coming period of hibernation, they strengthen them, and thus form very tough nests of about the size of a fist. In the following spring they again attack the foliage, and then about the beginning of June enter the pupal state of rest for about three to four weeks in a transparent greyish-brown nest. Their generation is therefore annual.

In orchards the winter nests can easily be destroyed, but this is not practicable when the crowns of lofty Oaks or other forest trees are attacked.

The Lackey Moth, Bombyx (*Gastropacha*) *neustria.*—The span of the wings of this moth is about 1·2 to 1·6 inches. Its body and upper wings vary from yellow to reddish-brown, with broad transverse band having lighter edges; the lower wings are somewhat lighter in colour, and have a faint darker band across their middle. The slightly-haired caterpillar attains a length of 1·8 inches, is alternately striped light blue, reddish-brown, and white like the pattern of a lackey's waistcoat; its head is pale blue, with two black spots.

The moths swarm in July and August towards the evening. After impregnation the female deposits her 300 to 400 brownish-grey ova in the shape of a close band round twigs and small branches of fruit-trees and Oaks principally, but also on Elm, Hornbeam, Poplars, and Willows. About the end of April or the beginning of May the young caterpillars appear, and begin to feed on buds and leaves, living at first in communities inside nests until they are full-grown. They enter the chrysalid stage about the end of June, but before doing so break up their colonies, and betake themselves individually to pupal rest between leaves or in the inequalities of the bark, to which they attach themselves with a few loosely spun threads.

As the Lackey-moth attacks fruit-trees for the most part, active measures can easily be taken to destroy the clusters of ova and the caterpillars' nests in orchards; but annihilative measures are hardly applicable in the case of lofty forest trees.

The Gipsy Moth or Brown Arches, Bombyx (*Liparis*) *dispar* (*vide* Plate III. fig. 19).—There is, as the name implies, a great disparity between the sizes of the male and the female moths. The wings of the female have a span of 2·4 to 2·6 inches, whilst that of the male does not exceed 1·6 to 1·8 inches. The wings of the female are of a brownish-white colour, with darker, zigzag arched lines, and with brownish-grey down near the extremity, whilst those of the male are dark greyish-brown, with similar zigzag arched markings; both have dark-tipped edgings, and in both the lower pair of wings are of a paler colour with fainter markings. The 16-footed caterpillar, which attains a length of two inches, has a large head, is dirty grey along the back, and yellowish-grey on the sides and under part, with small black dots on the skin, and having a white line down the ridge of its back. On each side of this central line it has a row of warts that are blue on the

first five rings, and red on the other six, and from which clusters of long dark hairs issue.

The time of swarming is about the end of July and the earlier part of August, when the male moths are much more active than the females. During August and September the latter deposits her ova to a total of 300 to 400 in shallow round clusters on the bark of smooth stems or other convenient objects mostly near the ground, and then by dusting off the brownish-grey wool-like hairy down from her extremity, gives them a protective covering resembling a bit of thin fungus or sponge.

The caterpillars appear during the following April or May, but remain together for about ten days in clusters or colonies, before they ascend the stems to commence feeding on the foliage.

About the beginning of July they enter the pupal state of rest, fastening themselves loosely by a few threads between leaves or in the fissures of the bark; about fourteen days later the imagines make their appearance, to repeat the simple annual generation.

This is an extremely voracious and injurious insect in orchards, but occasionally it also causes total defoliation of woodland trees, chiefly of Oak, Hornbeam, Poplar, Willows, Lime, and Alder. Sometimes, if impelled by hunger, it has likewise been known to attack conifers, when it prefers the Scots Pine to the Spruce.

Of these three species of insects, the Gipsy-moth is of most importance sylviculturally, for, though it is principally to be found feeding on fruit-trees in orchards, it is in reality polyphagus on nearly all broad-leaved species; but among forest trees Oaks are on the whole most liable to its attacks in all forms of crops, from coppice-woods to high timber forest. It may be said almost to occur periodically in large numbers, sometimes defoliating trees over extensive areas, and at least leading to a considerable temporary loss of increment on the stems denuded or badly injured.

The exterminative remedy most recommended is the destruction of the easily noticeable clusters of eggs, and Altum suggests that this can best be effected by daubing them over with patent tar.[1]

[1] In the case of the Gipsy-moth, ringing the trees with patent tar would seem the most practical way, considering that the ova are usually deposited near the soil.—*Trans.*

B. Span-worms (*Geometridæ*).

102. *The Winter Moth or Winter Span-worm, Geometra (Cheimatobia) brumata.*

The male moth has a span of about 1 to 1·2 inches, and its front wings are of a reddish-grey or yellowish-grey colour, with dark wavy lines; the hind wings are lighter, and with indefinite, indistinct stripes. The female is about 0·32 inches in length, and of a greyish-brown colour with white scales, long feelers and legs, and very reduced, or in reality only rudimentary, wings; it is therefore incapable of flight.

The 10-footed caterpillar, at first of a grey colour, but changing after the first time of shedding the skin to a yellowish-green, with a pale longitudinal stripe along the back, and a green head, later on assumes a green colour with a dark mark along the back and three light marks along each side; when full-grown it attains a length of 1·04 inches.

The chrysalis is of a light brown colour, and has no protective cocoon.

The winter moth swarms from October till December, when the males fly about towards the close of the day in search of the females that run up and down the stems of the trees. After impregnation has taken place, the female deposits her ova on the buds, leaf-scars, and twig-points in the crowns of the trees; the eggs, which are greenish at first and reddish later on, number about 200 to 300 per individual.

The tiny caterpillars make their appearance from the ova during the following April and May, damaging many leaf and flowering buds by feeding on them, and then later on devouring the foliage which they twist or roll up somewhat in the manner so characteristic of the insects named "leaf-rollers." About the beginning of June they spin down from the leaves on gossamer threads to the ground, for the purpose of passing the pupal state of rest in a smoothly-formed hole, about two inches below the surface of the ground.

This insect is, for the most part, injurious to fruit-trees (to Apple, Pear, and Plum trees especially), but it also occurs very frequently on all sorts of broad-leaved species of forest growth, and is especially to be found on Oak, Hornbeam, Lime, and Elm.

The Northern Winter Moth, or Northern Winter Span-worm, Geometra (*Cheimatobia*) *boreata*, is a closely-allied species, which is principally to be found on Beech amongst the trees of woodland growth.[1] The caterpillar closely resembles that of the former species, but is only about 0·64 inches in length, and can easily be distinguished by its having a black head. In addition to destroying the leaves and buds, it often does a very considerable amount of damage to young seedling growth of Beech; but, on the whole, this insect is principally to be found on the Birch, though damage done by it is often credited to *G. brumata*.

Preventive measures against these two species are only practically applicable in orchards. There rings of patent tar can either be formed round the stems, or else strips of stiff paper can be smeared with the tar and tied firmly round the stems, so as to prevent the wingless female from crawling up into the crowns of the trees. Delving and overturning the soil can also be carried out in orchards, so as to destroy the chrysalides by burying them deeper in the ground.

The large Winter Moth, or large Winter Span-worm, Geometra (*Hibernia*) *defoliaria*,[2] a large species of Span-worm, has a somewhat similar life-history, and inflicts similar injuries, but seldom occurs in such large numbers as the above-named other two species sometimes do.

C. Leaf-rollers (*Tortricidæ*).

103. *The Green Oak-Tortrix or Oak Leaf-roller, Tortrix viridana.*

This little moth, whose wings when extended have at most a span of only 0·88 inches, has upper wings of a beautiful bright

[1] It is somewhat smaller in size, the male having a span of 1·4 inches, the upper wings being whitish-grey, with a brownish-yellow lustre, and the hind wings whitish; as in *G. brumata* the female has only rudimentary wings, but in this case they are even smaller than in the former.—*Trans.*

[2] The male has a span of 1·6 to 1·9 inches; the upper wings are yellow, and dusted with rusty brown, with a brown root or base, and a broad zigzag brown transverse band; the lower wings are bright yellow, with a sprinkling of brown, and one dark spot. The female is wingless and very long-legged, and yellow in colour, with black spots. The 10-legged caterpillar is 1·32 inches long, and of a reddish-brown colour, with a long double back-stripe, and yellow, brownish-red spotted side lines. Though feeding principally on fruit-trees (especially on those with stony-fruit), they are also comparatively frequent on Oaks. (Hess, *op. cit.* vol. ii. 80.)—*Trans.*

green, with yellowish-white fringe round the lower edges, and light grey lower wings, with greyish-white edging.

The 16-footed caterpillar, which attains a length of about 0·48 inches, is of a dark yellowish-green colour, with a black head, and minute black knob-like warts, on which there are a few fine hairs.

The chrysalis is of a blackish-brown colour, and about 0·44 inches long.

This moth swarms from about the middle till the end of June, when the female deposits her ova singly or in small clusters on the buds then being formed on the twigs in the crowns of Oaks. The tiny caterpillars make their appearance during the following spring, when they attack the buds, flowers, and foliage, and then about the beginning of June proceed to enter the chrysalis stage in leaves rolled together, in fissures of the bark, &c., from which they emerge as imagines after a pupal rest of about three weeks. Its generation is therefore simple and annual.

This insect lives exclusively on the Oak, especially on older pole-forest and tree-forests, and occasionally occurs in vast numbers over extensive areas, where it does no inconsiderable amount of damage in Oak woods by destroying the foliage, and scattering all hopes of a good mast-year. In consequence of the ova being deposited on the buds and young twigs, the feeding of the caterpillars always begins near the top of the leafy crown, and gradually extends downwards, often resulting in total denudation of the foliage, which can only be replaced when the midsummer flush of leaves takes place.

Preventive and exterminative measures are hardly applicable. When late frosts have nipped the young Oak foliage during years when the caterpillars have been swarming in large numbers, these have been known to be starved to death in consequence. During the long period of winter many ova are also doubtless destroyed by starlings, thrushes, sparrows, tits, &c.

D. Note on some other Lepidoptera.

Amongst the species of moths which it has not been considered necessary to mention in the text, there are several kinds that are of comparatively frequent occurrence in our British woodlands. These include the following :—

A. *Spinners* (*Bombycidæ*).

The common Vapourer-moth, *Bombyx* (*Orgyia*) *antiqua*, with a span of 1·2 inches ; the male is of a rusty-brown colour, with two dark transverse bands and a white moon-spot on each of the upper wings ; the female is yellowish-grey, with only white stumps as

rudimentary wings; the caterpillar is ashy grey, with yellowish hairs, velvety black back, and carmine warts, with two long black tufts of hair behind its head, other two standing out at right angles to the sides on the 5th section, and one standing upright on the 11th ring. It swarms in August and September, and lays 150 to 300 eggs on the nest from which it has emerged. The larvæ occasionally appear in autumn, but mostly not until spring. Properly speaking, its ravages are confined to the buds, foliage, and young fruit of fruit-trees; but it is also found on Saugh, Mountain Ash, Spruce, and Scots Pine. It enters the chrysalis stage in June or July, which lasts for about six weeks.

The Satin-moth, Bombyx (*Liparis, Leucoma*) *salicis,* has a span of 2 to 2·4 inches, the wings being white and satin-like, and the legs ringed with black and white. The caterpillar is 1·8 inches long, greyish in colour, with yellowish-white spots on the back, small red warts, and light brown hairs. The female deposits 150 to 200 ova in June and July on the bark or leaves of Poplars and Willows, and then covers them up with a white membrane. The caterpillars sometimes appear in autumn, but mostly not until the following spring, when they feed on the foliage till entering the pupal state about the end of May. The chrysalis may be found loosely attached to leaves or twigs.

The Gold-Tail moth, Bombyx (*Liparis, Porthesia*) *auriflua,* lives principally on fruit-trees, but also on Oak, Beech, Elm, Birch, Lime, and Willows, and on many shrubs. It has a span of 1·4 to 1·8 inches. It much resembles *Porthesia chrysorrhœa,* but its body is of a lighter, almost golden colour, and the inside edge of the wings has a longer fringe. The caterpillar is black, with blackish-grey hairs, two vermillion lines along the back, and patches of snow-white hairs. The chrysalis is of a blackish-brown colour, and enclosed in a thin whitish-brown cocoon. During June and July it lays 150 to 200 eggs in clusters on foliage, and covers them up with golden-yellow wool from the abdomen. The caterpillars appear in August, and feed on leaves, buds, flowers, and young fruit, hibernate on the ground or in fissures of the bark near the ground, and recommence feeding in the following spring till they become chrysalides, about the end of May or in June, on rolled-up leaves or on twigs. The use of patent tar in early spring seems recommendable.

B. *Butterflies* (*Papilionidæ*).

Among *Butterflies proper* (*Papilionidæ*), which swarm in the day-time, the only species of anything like sylvicultural importance is *the large Tortoises-hell Butterfly, Vanessa polychloros,* with a span of 2·2 to 2·6 inches. It is of a yellowish-red in the upper part, and dark brown towards the edges; the upper wings are spotted with black, three spots being on the yellow ground; the lower wings have a large black spot on the upper edge, and a blue moon-spot near the fringe. The greyish-blue caterpillar is 1·8 inches long, with yellow stripes along the back and sides, and rusty yellow prickles. The chrysalis is angular, reddish-grey, and with several spots having a mother-of-pearl lustre. The female, after hibernating, lays her blackish-grey eggs in clusters during spring on the twigs of fruit-trees, but also on Elm, Willow, and Aspen. The caterpillars, which appear in May and June, live in colonies in nests, and feed on the foliage till the end of June, when they scatter to become chrysalides.

C. *Clearwing-moths* (*Sesiidæ*).

Of the family of *Clearwing-moths* (*Sesiidæ*), *Sesia apiformis* does a good deal of damage in the wood of young Poplars, especially Black Poplar and Aspen. The moths swarm in June and July, when the ova are deposited in the fissures of the bark near the base. The caterpillars appear in July and August, bore into the

wood of the stem, live there through two winters, and then come out to enter the pupal state of rest in pupal chambers formed on or near the ground out of bore-dust. The imagines appear in June, the complete generation occupying two years. It is very frequently to be found along with *Cerambyx* (*Saperda*) *carcharias* (*vide* par. 94).

D. *Wood-borers* (*Cossidæ*).

Among *Wood-boring moths* (*Cossidæ*), the Goat-moth and the Wood Leopard-moth certainly deserve some passing notice.

The Goat-moth, Cossus ligniperda, has a span of 2·6 to 2·8 inches for the male, and 3·2 to 3·4 inches for the female. The upper wings are greyish brown, with whitish-grey markings, and with many dark brown transverse lines; the lower wings are ashy-grey to greyish-brown. The abdomen is long and blunt, and of a greyish-brown colour, with white edging to the rings. The 16-footed caterpillar is 3·6 to 3·8 inches long, reddish-yellow at first and brownish-red later on, with brown head and breast-plate, darker above than below, naked, and smelling of acetic acid. The thick, ruddy-brown chrysalis has prickly projections on the abdominal sections. It swarms in June and July, when the ova are deposited, to a total of about 25, in the bark-fissures of Oak, Elm, and most softwoods. In July the caterpillars appear and continue boring in the wood till the May of the second year afterwards, the generation being biennial; they do great damage to the timber technically.

The Wood Leopard-moth, Zeuzera æsculi, also does damage technically, but chiefly attacks young stems of Maple, Sycamore, Ash, and Lime among forest trees. It is only about two-thirds of the size of the previous species. The wings are white, with numerous round steel-blue spots, and six similar spots on the trunk of the body. Its abdomen is striped alternately with blackish-blue and white. The caterpillar is yellowish, with little black warts; it appears in August, eats in the splint for the first summer, but then proceeds deeper into the wood, boring upwards into the stem; in June of the second year it returns to near the bark, in order to enter the pupal state within the soft sapwood, and thus complete its biennial generation.—*Trans.*

Appendix.

104. *The Insect Producers of Deformities and Malformations.*

In addition to the injurious insects above treated of, which inflict damage on the timber, bark, foliage, or roots of our woodland trees, there are also numbers of other insects that produce certain variations from the normal growth in the shape of galls, excrescences, and knots, and which are, in short, producers of deformities and malformations. And even though in the most instances the damage caused by them may be slight, and merely such as to render remedial measures only exceptionally advisable or possible, yet it is desirable that the forester should know something of their origin also; hence a few remarks concerning them may here be made.

1. On Conifers.

Plant-lice (Aphidæ).

The Green Spruce Aphis, Spruce-gall Aphis, or Spruce Chermes, Chermes viridis. This minute tree-louse, only 0·08 inches in length, and of a yellowish-green to light brown colour, with whitish down and white wings, bores into the buds of young 10 to 20 year-old Spruce for the purpose of depositing its ova to the number of about 20 to 30 on the edges of the bracts or scales. By means of the puncture thus made, and the absorption of the sap by the young caterpillars, a cone-like swelling of the compressed needles takes place, which assumes a green appearance at first, but afterwards turns ruddy brown, and after it has opened at the edges of the scales or leaf-bracts, so as to permit the exit of the imagines in July and August, finally becomes dry and dull brown. Fortunately the side-shoots are much more frequently attacked than leading-shoots, for the shoots punctured assume curious shapes and bends, and if badly attacked the young plants fall into a sickly and unhealthy condition. The best remedial measure consists in cutting off the galls, and drying and burning them, whenever the insect becomes a pest.[1]

The Red Spruce Aphis, Chermes coccineus, which is somewhat smaller than the above species, and of a brownish-red colour with white downy spot behind, has a similar life-history, but its metamorphosis takes place somewhat more quickly, so that 3 to 4 generations usually take place in one year (Hess). The cone-galls occasioned by this louse are much smaller than the former, and are usually located at the tip of the twigs without any shoots above them; at first of a green colour, they afterwards become red, and finally brown.

The Larch Aphis, Chermes laricis, a small blackish-brown louse, easily recognisable from its white woolly pad, damages the needles of Larch from April till August, by sucking out the sap,

[1] The remarkable manner of reproduction of this insect deserves some notice. When the imagines swarm in July and August, the female, after impregnation, deposits her ova on the needles and twigs, the ova being placed on long stalks and dusted over with powdery wool. The brood issuing from these ova in a few weeks, first hibernates, and then in the following spring deposits the ordinary eggs from which the lice are developed. The insects appearing in autumn are merely females whose sole duty is to deposit ova in the following spring. That is, the male and female insects produce, in the first instance, female eggs only, from which insects appear that, without further impregnation, produce both male and female ova.—*Trans.*

so that they bend over where attacked near the middle of the leaf. When these lice occur in large numbers, they make the look as if besprinkled with snow.

2. On Broad-leaved Trees.

Gall-midges (Cecidomyidæ).

The Beech Gall-midge, Cecidomyia (Hormomyia) fagi, is a small insect of 0·16 to 0·2 inches in length, having a blackish-brown trunk and flesh-coloured abdomen, and brownish wings with grey hairs, which, during its larval stage, produces the hard, conical, pointed, green and red galls often occurring in large numbers on the upper side of Beech leaves.

These midges swarm in April when the female pierces the upper cuticle of the young Beech leaves, and lays an egg in each wound, above which is formed the green cone containing the maggot, or "strig" as it is called in many parts of England. These excrescences gradually change to a deep red colour, and about October drop off to the ground. Very early in the following year the chrysalis is formed inside the gall lying on the ground, when the imago emerges in April to repeat the cycle of reproduction.[1]

Gall-wasps or Gall-flies (Cynipidæ).[2]

Most of the Gall-wasps attack the Oak, on which about 50 different species are known.

[1] Two closely related species, *the Willow or Osier Gall-midges, Cecidomyia salicis et C. saliciperda*, also deserve a passing glance. The former is a small, blackish, long-legged midge, 0·12 to 0·14 inches long, whose abdomen is ringed with red, and has whitish hairs. The ova are deposited on young shoots (principally on *Salix purpurea*) in May, and again in July. Through their suction the reddish-yellow maggots or strigs occasion spindle-shaped swellings which render the withes useless. From May onwards, twigs infested should be cut off and burned. The other species, *C. saliciperda*, is still smaller, being only 0·08 to 0·12 inches in length, with blackish-brown body, and milk-white wings. During May the ova are deposited in a long string on the back of young shoots and stems of Willows (chiefly on *Salix alba, S. viminalis, and S. acutifolia*), and in June the reddish-yellow maggots work their way into the inside, where, from July till the following April, they bore irregular vertical galleries, at the same time causing the formation of spindle-shaped swellings, which ultimately become scabby from the bursting of the bark, and within which the chrysalis remains. When it is not convenient to cut out the shoots or stems infested, the swellings should be smeared with patent tar. (Hess, *op. cit.*, vol. ii. p. 98).—*Trans.*

[2] The Gall-wasps or *Cynipidæ* are, among insects, one of the most interesting families, for, like a good many fungi, they have the peculiarity of possessing an

The Oak-apple Gall-wasp, Cynips (Dryophanta) quercus folii, is the principal of the various kinds of Gall-wasps that attack the leaves of the Oak. It occasions the well-known large green and red "Gall-apples" pendent from the lower side of Oak foliage, and about the size of a cherry.

The Oak-cone Gall-wasp, Cynips (Aphilotrix) fecundatrix, produces the small wooden excrescences like hop-fruits or cones at the point of Oak twigs; these cones are greenish at first, but afterwards turn brown and harden. They are often collected together in clusters.

The Oak-rose Gall-wasp, Cynips (Teras) terminalis, produces the large red, spongy galls at the tips of Oak twigs. These round, rose-coloured, spongy galls are formed by a cluster of different chambers, and are usually found at the terminal bud, where the "roses" grow to the size of a potato.

Plant-lice (Aphidæ).

The Elm-gall Aphis, Tetraneura ulmi, produces the small club-like galls of the size of a pea or bean on the upper side of the leaves of the Elm (and, according to Altum, only on the *Ulmus campestris*), with which the whole of the foliage is sometimes covered. *The Elm-blister Aphis, Schizoneura lanuginosa,* causes the large hairy galls that occur on the tips of the shoots and on the foliage of Elms; during the summer these blisters contain an india-rubber-like fluid in which the lice live from June till August. At first the galls are green and red, but turn brown as they harden and dry. *The Beech Aphis, Chermes fagi,* and *the Ash Aphis, Chermes fraxini,* produce cankerous-like spots on the bark of these trees.

alternative generation; that is to say, winged insects develop a wingless, hibernating, agamic species, which reproduces itself parthenogenetically, or without any sexual intercourse being necessary, and whose brood throws back to the original form in which sexual relations are necessary for reproduction. Thus, *Cynips fecundatrix* produces *C. pilosa,* whose ova develop into imagines as *C. fecundatrix* once more; *Cynips terminalis* deposits ova from which *C. aptera* is developed, and after forming galls on the roots of trees, this insect, without impregnation, lays eggs from which the original *C. terminalis* is reproduced. This is all the more wonderful, when one recollects that *C. terminalis,* produced at the tips of the twigs in the crown, wanders away down to the roots to deposit her ova, and that the agamic form *C. aptera,* when fully developed, migrates up to the summit of the crown, to reproduce the original form there once more.—*Trans.*

Section Third.

PROTECTION OF WOODLANDS AGAINST HUMAN AGENCIES, OR THE ACTIONS OF MEN.

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105. *Nearer Consideration of such Dangers.*

During the long course of centuries the woodlands have certainly been much more disturbed and interfered with in their normal growth and development by human agency than by any other organic or inorganic causes. How many woodland tracts have been damaged and often totally ruined or cleared entirely by their owners through excessive utilisation of timber and of dead foliage for litter, by over-grazing, by neglected or badly carried out reproductive measures, and by imprudent clearances, quite disregardful of their ultimate consequences ?

The forester is helpless to ward off from the woodlands under his charge the effects of injudicious operations determined on by the proprietor, but the principles of Sylviculture, of the Utilisation of Forest Produce, and of the Management of Forests, teach him how the productive capacity of the timber-producing tracts can best be maintained or increased, how the forest produce may be harvested and disposed of in the most economical and advantageous manner, and how the fellings and reproduction throughout the whole growing-stock can be so ordered and arranged as best to satisfy the requirements of the owner, whilst duly safeguarding and protecting the productive capacity of the soil. In most countries in which forests occupy any extensive portion of the total area, as in France, Germany, India, &c., there are legal enactments or Forest Laws for the preservation of the woodlands against mischief and other more serious actions of men; but in Britain there is no necessity for any such special machinery, and actions affecting the proprietary rights in, over, and with regard

to woodlands can quite well be controlled by the ordinary laws of the country. So far, however, as human interference, unauthorised by the owner, is concerned, the Protection of Forests deals with the best methods of obviating the dangers which may accrue to woodlands from actions affecting the ownership, or the rights of user, the thriving of the timber crops, or the productive capacity of the soil.

The actions of men, against which our woodlands will ordinarily require to be safeguarded, may be classified as follows :—

1. Protection of forest boundaries.
2. Protection against misuse of rights or servitudes.
3. Protection against forest offences or misdemeanours.
4. Protection against forest fires (which are nearly always due to human agency).
5. Protection against smoke and atmospheric impurities.

The best measures and methods for harvesting the natural products of forests, including, of course, the intermediate yield and the minor produce, as well as the outturn or final yield in timber or bark, so as not to prejudice the well-being and continuous productive capacity of the soil and the growing-stock, belongs properly to that branch of Forestry which treats of the Utilisation of Forest Produce, and will therefore not be considered here.

CHAPTER I.

Protection of Forest Boundaries.

106. *Means of Protection; Boundary Marks.*

Boundary marks are intended to serve the purpose of protecting the property they mark off from interference by any parties other than the owner or his agents; and where the ownership of one proprietor ceases and that of another begins, it is highly desirable that some distinctive marks should be set up for easy recognition by the parties mutually concerned.

Boundary marks of one sort or another have been customary throughout time immemorial in all lands.[1] Under the most primitive conditions, or even at the present time wherever practicable (as in the formation of State Reserved Forests in India), the choice of lines fell on natural boundaries as forming the most convenient and unmistakable marks, quite definite enough to satisfy all the requirements of an early state of society. The marks usually chosen, and still in many cases remaining even now as the boundaries of large estates, were streams, valleys, ridges of hills, pathways, rocks, and conspicuous trees.

These natural boundary marks are, however, not always permanent and immovable, for streams alter their courses, paths vary and change in the course of time, and trees specially marked, or known by designation far and wide, even when lopped so as to diminish the risk of breakage or windfall, ultimately die off: rocks and ridges of hills have, of course, a practical stability that secures them against any of the objections to these other marks.

But as the original primitive conditions gradually gave way to

[1] It may be of interest to note that in primitive lands the penal laws are usually most severe against offences relating to boundary marks, then in regard to offences relating to a man's wife or wives, then to offences against his person, and finally, to offences against his other property. It thus seems tacitly argued that his most valuable possessions are his land, his wife (or wives), then his own healthy body, and lastly, his personal effects.—*Trans.*

our later developments of proprietary rights, the insistence on and retention of which necessarily led to some system of more exact demarcation of individual rights within the estates that were gradually growing in value, natural features could no longer be relied on in the vast majority of cases, and artificial marks, such as heaps of stones, earthen mounds, stakes, boundary pillars, hedges, green lanes, ditches, &c., had to be used for the delimitation of landed property. And though all proprietary rights are now strictly ascertainable in a legal sense, and easily kept in view by accurate surveys, yet for ordinary purposes the different portions of all landed property are still marked off by walls, ring-fences, posts with notice-boards, hedge-rows, ditches, and the like.

Those different methods of demarcation vary considerably in durability. Ditches fall into disrepair, so as gradually to become almost indistinguishable if not kept in proper order, and even the stoutest poles of heartwood rot and decay in time, although charred, and tarred, and otherwise treated with antiseptics. Hedge-rows, with standard trees here and there, or avenues of timber-trees, have not the stable element of durability and permanence that is desirable, so that in almost all instances the best means of affixing marks of a practically permanent description consist in the use of stone, either in the formation of walls surrounding the estate, or merely as boundary marks at all points of importance.

When stones are used for boundary marks at all angles, it is better to give them a certain amount of dressing than to put them in the ground in a comparatively rough and unhewn condition, and, of course, wherever obtainable, some practically imperishable igneous kind of stone should invariably be selected, like granite, basalt, or greenstone,—for sandstones are liable to waste away, and stratified rocks of clayey composition soon become damaged by frost.

The shape that these boundary stones should take, and the height to which they should project out of the ground, are matters resting, of course, with the individual wishes of the landowner. Very good marks are furnished by stones standing about three feet out of the ground, the portion above the soil being dressed square, and showing by graven lines on its flat head, drawn in the direction of the nearest stones on each side, the angle formed by the boundary lines to that point, whilst the heavier portion under ground remains rough and unhewn. That such boundary stones can,

at the same time, be utilised for bearing other marks, like any sign or the initials of the proprietor, or numbers relative to compartments, administrative divisions, &c., is, of course, a matter purely of administrative convenience.

107. *The Erection of Boundary Marks.*

The affixation of boundary marks over a whole estate is termed its demarcation. This always has for its object the determination of boundaries where they have not already been definitely laid down, or where any doubt on the subject may have arisen. On the Continent any such doubts or difficulties are practically settled by Government land surveyors, but throughout Britain the machinery of the Civil Courts is the recognised and only legal channel for settling any questions relative to the proprietorship over any portions of land at issue. The first necessary operation in demarcating land should, of course, be to erect permanent boundary pillars at all the angles, and then, whenever necessary, to set up intermediate stones between such main angular points as cannot be seen from each other respectively; in place of having angular lines on the heads of these latter, they should have graved on them a straight line in the direction followed by the boundary.

When the permanent demarcation of any hitherto undefined boundary takes place, the recognised agents of both parties concerned should be present at the delimitation and the erection of the permanent boundary marks, in order that a fruitful source of subsequent disputes may be obviated; and whenever any periodical revision of the marks is deemed necessary, all parties interested personally in the matter should take care to be represented.[1]

In the olden times it was not unusual to bury broken glass, or bricks, or rubble of any sort, beneath boundary marks, so as to have some means of determining their original position should there be any reason to suspect that they had been surreptitiously removed; but with the modern appliances of surveying, these antiquated safeguards are now no longer necessary.

For extensive forest tracts, such as woodlands owned by the

[1] The *Riding of the Marches* in the border counties of Scotland, and the *Beating of the Boundaries* in many parts of England, are survivals of the old customary revisions that have come down to the present day, though often more as a holiday pageant than anything else.—*Trans.*

State or by the great landed proprietors, a demarcation register should be kept, showing :—

1. The name of each separate locality or forest.
2. The number of its boundary marks.
3. The distance from each mark to the next.
4. The angle (acute or obtuse—expressed in degrees) formed at each mark with those next to it in either direction.
5. The name of the owner, and the nature of the land marching with or contiguous to it.
6. The mention of points at which the boundary is intersected by roads, paths, streams, &c.

108. *The Up-keep of Boundary Marks.*

The maintenance of boundaries in good and serviceable order is just as important as their demarcation in the first instance, for, from one reason or another, they are always liable to get damaged and displaced, especially when they are not of the most durable description. The necessary repairs are generally very simple at the outset, but the longer rectifications are delayed, the greater becomes the difficulty of restoring matters to their original position without a considerable amount of trouble and delay.

It is, therefore, advisable that a revision of all the boundary marks should be made at least once a year, and that on each such occasion any discrepancies should be noted, and, if possible, immediately rectified.

Where the boundary should happen to run through timber crops,—which will seldom occur in British woodlands, except so far as regards the interior and administrative division of the area into compartments and the like,—boundary lines should be kept clear of all growth on neutral strips of land extending equally to each side of the actual or imaginary boundary line, and broad enough to permit of one stone being seen from the other, and these narrow lanes or vistas should be kept clear of boughs, coppice-shoots, shrubs, &c.

When the boundary stones occur at the corner of roads or on spots where they are likely to be damaged or displaced by carts, they should be protected by stones placed at the sides and in front of them. Where the woods are bordered by fields, they are

very frequently surrounded by ditches on the Continent, but are usually, in Britain, fenced in with live or quickset hedges.

How near to the limit of his land the proprietor is entitled to plant, is a point concerning which custom and right vary in different localities of Continental countries; but wherever there is any likelihood of dispute about such a matter, justice and common-sense would rule that the timber crops may only extend so far as not to injure the productive capacity of the adjoining land by causing the drippings from the boughs to fall upon the neighbouring owner's land.

CHAPTER II.

Protection against Misuse of Rights or Servitudes.

109. *Definition, Origin, and various Disadvantages of Rights of User in Forests.*[1]

In many instances, and particularly where Crown or State Forests are concerned, the woodlands are not the absolute property of the owner, but are very frequently burdened with certain rights of user or servitudes, by virtue of which the rights of ownership can only accrue after certain stipulated conditions have been carried out for the benefit of third parties.

Such servitudes are legally of the nature of real property, so far as they relate to the compulsory doing of certain Acts, or the not doing of certain other Acts, by the occupying owner for the time being, whose title is in fact only *dominium limitatum.*

From the manner in which our tenure of land in Britain has developed from the early feudal system, and from the generally clear titles that, rightly or wrongly, have long been held to go with the larger landed estates, the servitudes existing over forest land in this country are altogether slight and infrequent as compared with those existing throughout the greater part of the Continent of Europe, where the present communal forests, and servitudes over woodlands held by the nobles or the State, have grown naturally out of a mixture of the early tribal and the feudal system.

Throughout most of Europe they date from early times, in which the products of the woodlands were of comparatively little exchangeable value, and usually had their origin in agreements made between barons and their villeins, and perhaps the inhabitants of petty towns in the vicinity, or in privileges granted in return for

[1] For this paragraph, and the preceding and following ones, the Translator is practically responsible, as the text in the original referred solely to German conditions.—*Trans.*

favours, or not infrequently in use and custom which, from not being checked until the market value of the forest produce had risen somewhat, in the lapse of years grew to have the legal status of a prescriptive right. Or, on the other hand, in a great many cases the ancestors of those, to whom only servitudes or a certain restricted *dominium utile* now remains, were formerly the actual owners in common of the woodlands, but gradually one or more forged ahead in power and influence, and ultimately either by consent or usurpation assumed for himself and his heirs the *dominium directum* or ostensible possession of the land.

It may easily be understood, with a little reflection, that under certain circumstances the servitudes may be of greater value than the benefits derivable from the nominal ownership of the soil, and that, unless limits be assigned to them, they may ultimately extinguish any benefits derivable from possession.

The nature and the results of servitudes over forest land have little practical interest for Britain, although those on the Continent are interesting, and all the more so as very few of the State Forests of India, the selection and formation of which has for the last 20 years occupied the full energy of the Indian Forest Department, and will still take it many years of unremitting labour, can be set apart without being burdened to a greater or less extent by "*rights or privileges*," accorded with generosity, and too often with a lavish hand, as far as concerns the existing population in the vicinity, and its probable increase in the near future.

The rights and privileges included under such servitudes over woodland areas are of many kinds, varying of course with the nature of the produce of the different localities. Among the most frequent in the Crown forests of England and on the Continent of Europe are the following:—

1. *Rights relating to Timber*, for building purposes, trade-requirements, fuel, softwoods, dead wood, windfall, stumps, brushwood.
2. *Rights relating to Minor Produce*, dead foliage for litter, grazing, pasturage, pannage, tapping for resin, collection of mast, collection of fern, turbary.
3. *Other Rights*, quarrying, mining, right of way, right of transport by land and water.

Such servitudes frequently debar the owner in possession from utilising the land in the most economical way as regards choice

of species of forest trees and methods of treatment to be accorded to them, and not infrequently compel him to adopt a system of management, or mismanagement, opposed to all rational ideas of sylviculture. And in endeavouring to supply the various demands made by those having hereditary rights of various descriptions, it is well-nigh impossible to satisfy everyone, so that ill-feeling is often generated between the forest officials and the parties having rights of user. It is not in India alone that such dissatisfaction occasionally finds its ultimate expression in incendiary forest fires (see note on page 235).

But besides restricting the owner in possession from obtaining such returns from his woodlands as he might otherwise hope to by good management of an unfettered estate, servitudes are a bad thing in general for the countries where they are prevalent, for they directly interfere with the productive capacity of the soil and its utilisation to the best advantage of the owner directly, and of the community indirectly and generally.

How wasteful are the servitudes and the existing senseless legislative enactments in regard to the two great Crown Forests that alone remain in England, the New Forest in Hampshire (64,737 acres, or a little over 101 square miles) and the Forest of Dean in Gloucestershire (22,000 acres, or over 34 square miles), may be easily learned by anyone who takes the trouble to refer to the Report of the House of Commons' Committee on the "*Woods and Forests and Land Revenues of the Crown*," ordered on 26th July 1889 to be printed.

110. *The Attitude of Forest Protection in regard to the Exercise of Forest Rights.*

The measures for safeguarding woodlands against the extinction of other proprietary rights either in consequence of the increase in the number of those entitled to exercise the servitude, or in consequence of the diminution in the productive capacity of the soil, or suggestions relative to the extinctions of existing servitudes, do not properly fall under the province of the branch treating of the Protection of Woodlands, but are rather matters falling under the heading of legal and national-economic studies.

But, on the other hand, it certainly comes within the proper limits of Protection to insist on a proper control of all the various

operations that may be carried out by the privileged parties, and to see that the rights and privileges are exercised in a strictly legitimate manner without excesses being committed. Thus, for example, if it be laid down that every year a certain extent of area shall be open to grazing, pannage, or turbary, it is the duty of the protective establishment to see that the rights of user are not exercised in any portions of the woods not declared open for the satisfaction of such rights during the current year.

It often happens that only certain specified tracts are subject to such rights, and a careful supervision must be exercised to ensure the detection, prevention, and if necessary the punishment of illegal encroachments into other portions of the woodland area.

It is, of course, the duty of the chief officer to superintend the control and check off the exercise of the various rights of user, for which purpose he should from time to time take steps to convince himself that his subordinates are properly acquainted with the nature and extent of the servitudes.

CHAPTER III.

Protection against Forest Offences or Misdemeanours.

111. *Of Misdemeanours in General, and of their Various Different Kinds.*

Any illegal act performed by any person or persons in woodlands owned by, or in the legitimate possession of, other parties constitutes a forest offence in countries where there are special forest laws as in India, Germany, France, &c., but under other circumstances constitutes merely a misdemeanour under the ordinary common law as in Scotland and England.

Such offences and misdemeanours may assume very different forms and characters. They may be offences of commission or of omission; they may be actual thefts, or purloining of forest produce, and as such punishable under the penal laws; or they may include damage caused intentionally, and as such be liable to prosecution for mischief; or they may perhaps take the form of damage caused by negligence, which would not have occurred had the due and requisite precautions ordinarily suggested by the circumstances of the case been observed, and in this respect any action must usually lie in the civil courts; or, finally, they may be contraventions of rules, or of orders issued under rules, made under authorised enactments, for the maintenance of general order and the effective working of protective measures within the forests (as, for instance, within our Indian State Forests during the hot season, when special and often costly measures are necessary to prevent the occurrence of forest fires), and as such would be punishable under the special provisions of the Forest Acts and Rules.

112. *Misdemeanour through Purloining of Forest Produce.*

The various products of woodlands, and particularly the main product timber, have such numerous applications to various wants as to be practically, to a greater or less extent, absolutely neces-

sary for the well-being of everyone, hence there is often very considerable temptation offered to the poorer classes to possess themselves by illegitimate means of some of the benefits derivable therefrom. And this temptation is often strengthened by the fact that, amongst the poorer classes, the theft of timber or other products of woodlands is not at all regarded in the same light as the theft of ordinary articles which may happen to be in the possession of others.[1] Thus in the States within the German Empire it is only in Saxony and Wurtemberg that the purloining of forest produce may be ranked as theft, when the quantity stolen is of some considerable value.

In thickly-wooded tracts where the population is poor there is of course most tendency towards removal of wood for fuel during severe years, and to the removal of grass and other fodder stuffs when the ordinary sources of supply are deficient. But owing to the difficulty of according constant supervision to every part of any extensive forest even during the day time, to say nothing of the hours after dark, well-planned purloining of produce can easily be carried on from time to time without much danger of detection, especially when the movements of the foresters and woodmen have been carefully studied, or if the protective establishment is at all remiss in the performance of its duties.

So far as the well-being of the woods themselves is concerned, many of the effects of purloining of timber, &c., concern to a far greater degree the pocket of the proprietor than the future development of the crop or the productive capacity of the soil, as, for example, the surreptitious removal of dry poles or the cutting of grass or herbage on green lanes. But, on the other hand, such acts as cutting out of sound dominating poles forming a portion of the canopy, or removing dead foliage from the same localities for use as litter, not only directly damage the crop, but also tend indirectly to reduce the timber-producing capacity of the soil.

[1] There is undoubtedly a difference in degree in these matters, for forests were originally a free gift of natural growth ; and if the titles to all woodland estates were examined, it might often be found that the ancestors of the present owners had merely been more swaggering bullies than their neighbours, and had filched ownership from others who had originally equal rights with them in the land.—*Trans.*

113. *Misdemeanours through Wilful Damage or Culpable Neglect.*

Damage may arise to woodlands either by reason of imprudence and carelessness, or from maliciousness and revenge.

Injuries to young growth are often caused by the carelessness and imprudence of the woodmen themselves when engaged in the felling and stacking of timber, and in preparing it for sale, especially when they are engaged in clearing away standard trees after the completion of natural reproduction on any tract. And in the same way, when timber is being dragged or carted out of the forest, damage to young growth, as well as to standing timber, is often caused by sheer carelessness.

Of the injuries caused by maliciousness or feelings of revenge, there are of course endless forms, ranging from damage to the bark or stems of young plants up to incendiarism, resulting sometimes in huge forest fires, often involving the useless destruction of very large quantities of valuable timber.

In the eye of the law these two classes of injuries naturally assume very different aspects, for in the latter case, though the actual damage inflicted may happen to be slight, the intention to inflict injury is in itself a graver offence than accidental damage caused by a due want of prudence and forethought.

114. *Offences Arising from Other Causes.*

Under this heading may be classed all the other petty offences which are due to non-compliance with legitimate orders given under the forest rules in countries that, like India, have special forest laws. They comprise the removal of timber and other produce from the woods at other times, or by other routes, than those that have been sanctioned in order to secure the possibility of maintaining a proper check over it, the removal of timber or other produce after the prescribed time, any neglect of instructions concerning the kindling or extinction of fires, and the like.

In most such cases punishments, if awarded at all, ought in general to be so light as not likely to create revengeful feelings. But at the same time, the damage that can take place from fire in many kinds of forests is too great and much too serious in its possible effects for wilful neglect of instructions to be lightly passed over without any notice being taken of it.

115. *Measures for the Prevention of Forest Offences or Misdemeanours.*

In order to carry out protective measures in an adequate manner it is essential that there should be a sufficient, and at the same time efficient, body of men to see that irregularities of various descriptions are not allowed to take place, although, of course, it is only in a State Forest Department, or in private woodlands of such large extent as belong to but a few of the greater landowners, that anything like a full separate staff of employés can possibly be maintained in the interests of forestry alone.

But wherever foresters, wood-bailiffs, timber-overseers, wood-reeves, or whatever they may be called, are employed in the supervision of woodlands, they should be properly instructed in the manner in which they are to take action in the various classes of misdemeanours or more casual offences. Above all things, inspections should be made without any approach to regularity in the daily movements; for if those hankering after an opportunity of purloining any particular kind of produce think they can count upon the forester being occupied at any particular time by duties elsewhere, they are much more likely to decide on carrying out their half-formed intention than when they are never sure at what part of the woods the man in charge, or one of his subordinates, may make his appearance.

CHAPTER IV.

Protection against Forest Fires.

116. *Damage done by Fire; Different Kinds of Forest Fires.*

Forest fires are unfortunately by no means of uncommon occurrence, but constitute in many localities an almost annually recurring danger, threatening to injure the woodland growth to a very considerable degree. With the exception of the comparatively few cases caused by lightning, the causes of forest fires are either directly or indirectly to be found in human action, and not infrequently have their origin whilst other forest offences are being committed. From this point of view it might have seemed advisable to treat of them under paragraph 114, but the importance of the whole special subject seemed to make it worthy of treatment *per se* under a separate heading.

The damage, which may be caused to woodlands by fires, consists chiefly and immediately in the destruction or premature felling of timber crops often covering extensive areas, especially of young seedling growth and plantations; whilst among the indirect consequences of such disturbances of the growing-stock must also be reckoned the loss in the productive capacity of the soil, in being exposed to the exhausting action of sun and wind and of rank growth of weeds and of coarse grasses, the commencement of sand-drifts on poor sandy soils, the sudden increase in the number and the damaging power of many injurious kinds of insect enemies, which find only too favourable breeding-places in the foliage, stems, stools and roots of trees and poles or younger growth that have been brought to a sickly condition of growth in consequence of being scorched by fire, and finally the greater trouble and expense which the re-wooding of such tracts entails.

Forest fires may occur in many different forms, but they are usually distinguishable either as *ground-fires* passing over the surface of the soil and feeding on the dead foliage and scattered

débris littering the ground, or else as *conflagrations* or *crown-fires*, assuming the form of vast flames centred in and devouring the leaf-canopy formed by the crowns of the trees.

This, of course, leaves out of consideration such cases as the burning and destruction of single stems, when hollow, by lighting a fire inside them for the purpose of smoking out a marten, for instance, or a hive of bees, or the still less frequent occurrence of an actual soil-fire when peaty land has become ignited and the fire begins to spread on an extensive scale.

By far the most frequent form of forest-fire is the *ground-fire*, in which the flames, ignited among the dry soil-covering of parched-up grass or dead weeds, run along the ground consuming these and any dry moss or dead foliage scattered about. In the older classes of timber crops, where such soil-covering is usually scantier than in younger woods, and especially in those formed of species with thick cortaceous bark, the damage done is often comparatively slight; but in young seedling crops the tender plants are generally apt to get killed off, and even in pole-forest when the heat developed is intense the bark of the stool and the lower portion of the stem is often so much scorched and damaged as to entail the sickening, and finally the death, of the plants.

When a ground-fire finds sufficient food on the soil it develops in intensity and power, and is apt, more especially in coniferous woods, to secure a hold on the foliage of thickets and of young pole-forests; it then assumes the proportions of a *conflagration* or *crown-fire* sweeping onwards and feeding itself upon the foliage and the branches of the crowns forming the canopy of the crop. When once such a conflagration has established itself, it may be carried on by favourable winds to older crops and leave nothing behind save the charred stems and poles.[1]

[1] The statistics of the Bavarian Forest Department show that in the State Forests covering about 2,325,000 acres, during the seven years, from 1877–1883 inclusive, 509 fires occurred over a total area of 1160 acres, which were classifiable as follows :—

Ground-fires,	416
Ground-fires combined with conflagrations,	70
Ground-fires combined with burning of stems,	15
Burning of stems only,	6
Soil-fires,	2

Note.—Although in India the returns of areas run through by fire too often prove unpleasant reading for those concerned in the administration of the State Forests, it

117. *Causes of Forest Fires.*

The origin of forest-fires is seldom to be found in natural causes (lightning), but is, in by far the most numerous cases, entirely due to human imprudence or negligence,—such as, for example, the lighting of fires in dangerous spots by woodmen or other workmen employed within the forests during dry and windy weather, and then neglecting to extinguish them thoroughly. And there are also many purely sylvicultural operations necessitating the use of fire which, if not conducted to their very end with care and caution, are apt to result in fires; amongst these may be mentioned the burning of gorse and heather, the burning of bark and twigs in order to destroy insects decoyed into it, and the manufacture of charcoal within the woods.

The careless throwing away of cigar-ends, or of still glowing matches, or of the ashes from tobacco-pipes, is not infrequently among the causes of forest fires, more especially in the vicinity of large towns, as may be proved by the frequent origin of such fires in proximity to the paths, and on holidays. When paper and tow are used in place of properly prepared gun-wads, there is also considerably greater danger of their continuing to glow after being fired off, and the use of torches when passing through the woods at night has often ended in their droppings setting fire to the dead foliage and débris on the ground.

A good many forest fires are also caused only indirectly by human agency, from the sparks emitted by locomotives along railways which pass through wooded tracts. Fortunately the number of cases of incendiarism that occur in civilised countries

is not in tropical forests alone that such dangers exist, as the following extracts, cut casually by me in India from English newspapers during September 1891, may show:—

Toulon, 12*th August*.—The conflagration in the forests of Var is still raging, and nearly 5000 acres of timber have already been destroyed.

Halifax, 13*th August*.—Enormous damage has been done by forest fires in Cumberland County, and lumber camps and buildings lying in the path of the flames have been swept away.

Oran (*Algeria*), 19*th August*.—For the last six days a great conflagration has been raging in the forest of Ammi-Moussa, and has now reached enormous dimensions; over 35,000 acres of timber have been already destroyed.

Cannes, 20*th August*.—A forest fire of considerable extent is raging between Mandelieu and Pegomas, and, although the scene of the conflagration is somewhat inland, the cloud of smoke from the burning timber reaches as far as this place. A strong wind is blowing, and renders fruitless all efforts to check the flames, which are spreading rapidly.—*Trans.*

from mischief or out of revenge is comparatively slight compared with the number occurring in India, yet they are much more numerous than they should be.[1]

118. *Factors determining the Extent of the Injury.*

The danger of fires taking place, and the greater or less extent of area over which they can spread, are not anything like the same in all localities, but are always influenced more or less by local circumstances.

Apart from climatic considerations, the principal factor is of course the nature of the soil and situation, for on these are dependent, to a greater or less degree, the nature of the soil-covering, and the species of tree or trees forming the timber crops. Inferior qualities of soil, with their dry covering of heather and coarse grasses, and such deficiency in soil-moisture that the scrubby growth soon becomes dried up and tinder-like in summer, are much more threatened with danger from fire than fresh soils with strong growth of succulent grass and herbage. And, as a rule, the areas with only inferior qualities of soil are mainly given up to the cultivation of conifers, whilst, unfortunately, these resinous species are of themselves much more exposed to danger than the broad-leaved species, more especially as regards conflagrations of the canopy of foliage, from which the latter are only likely to suffer exceptionally during the thicket stage of growth, when dead foliage is still hanging on the twigs.

The class of woodlands most exposed to danger from fire are heathery stretches covered with pure Scots Pine, where the soil and its covering are not only usually dry, but the timber crop is also, *per se*, of an inflammable nature when once fire has broken out.

Young falls of seedling growth are most apt to suffer from ground-fires when the soil is littered with dry, parched-up weeds,

[1] The Bavarian statistics already referred to state that the investigations held concerning the 509 cases of forest fires proved them to have originated as follows:—

	Proved.	Supposed.
From lightning, ...	4	1
,, railway engines, . . .	7	—
,, negligence, ...	47	327
,, incendiarism, ...	9	64
,, unknown causes, . . .	—	50

whilst thickets and young pole-forests are most exposed to crown-fires; but as the timber crops increase in age, the latter danger diminishes. Large, compact, natural reproductions and plantations increase the danger of the spreading of fires that may break out, and at the same time make their extinction a matter of increased difficulty.

So far as the season is concerned during which forest fires are most frequent, experience has shown that in Central and Northern Europe danger is greatest, not during the hot summer months, but during the spring-time,[1] in the months of March, April, and May, when the dead grass of the previous year has got dried up by continuous east winds, and when, at the same time, there are many more workmen employed in the woods than at other seasons, engaged in the felling or removal of timber and fuel, the grubbing-up of stumps, and the cultural operations of sowing, planting, thinning, &c. Indeed, from June till October the danger gradually decreases towards zero near the end of the year.

[1] The previously-quoted Bavarian statistics relative to 509 forest fires showed that they occurred as follows:—

January, . .	4	July, . . .	43
February, . .	4	August, . . .	20
March, . .	118	September, . .	12
April, . . .	114	October, . . .	2
May, . . .	140	November, . .	—
June, . . .	51	December, . .	1

The statistics for Hesse during 1881–1885 exhibit similar percentages.

Note.—I may perhaps be allowed to add the following notes collected during April 1892 from one English daily newspaper alone:—

Hampshire, 3rd April 1892.—An alarming fire broke out in the Woolmer Forest about mid-day to-day. It commenced near the railway station, and covered thousands of acres in extent, and plantations as well as furze were destroyed.

Berlin, 9th April 1892.—An enormous conflagration is raging in the forest district between Hohenschwangau and Tuessen. Already 500 acres of valuable timber have been entirely destroyed, and the fire was burning fiercely when the last news was despatched, although 1000 firemen, with many engines from various towns, were hard at work.

Berlin, 10th April 1892.—Two more destructive fires have been raging to-day—one in the Aldershof Forest, close to this city, and the other in the Finnenhop Forest, near Arnsberg, in Westphalia. The destruction of timber has been very serious.

New York, 10th April 1892.—A telegram from Waterford, New Jersey, states that forest fires have been raging in the Camden county for the past two days.

Though fortunately less frequent in number, the fires that occur in late summer are probably, on the whole, by far the most serious in their ultimate results.—*Trans.*

Continuous drought enhances the danger of fires breaking out, whilst strong winds increase the chances of any fire becoming a serious conflagration; and when these two factors enter into favourable combination, they can speedily produce the most unfavourable and disastrous results for the woodlands, especially in coniferous tracts.

Wherever the forests are in the vicinity of large towns, or are traversed by railway lines, there always exists greater danger of fires breaking out than under exactly the opposite circumstances.

119. *Preventive Measures against Fire.*

Certain measures for the obviation and prevention of forest fires lie outside the scope of Protection, and entirely in the domain of Forest law. These are such as refer to instructions of various sorts framed and issued under rules made subject to legislative enactments dealing with forest matters, and include orders relative to the lighting and extinction of fires in the woods, the use of torches and other naked lights, and sometimes even the prohibition of smoking.

So far as the Protection of Forests can go, it is concerned solely with the measures that can ordinarily be taken by owners of woodlands to obviate the occurrence of fires on the one hand, and, on the other, to prevent their spreading to any considerable extent when once they have broken out. Among such protective measures may be reckoned the following:—

First of all, the prudent conduct of all operations within the woods for the purposes of which it is necessary to employ fire, as, for example, in the burning of bark for the destruction of insects, the burning of turf for the manuring of nurseries, and the firing of heath, &c., before the cultural operations of sowing or planting can be advantageously commenced. It is a matter of very considerable importance that the workmen should be thoroughly impressed with the necessity for prudence in the case of fire, and that a proper amount of supervision should be bestowed on them.

Forest pathways and their immediate vicinity should be kept clear of all inflammable matter, and green lanes should be kept free of long grass. Young growth bordering woods or frequented

paths should especially be cleared frequently, so as to remove all the dead branches or twigs and the dry stems.

Where railway lines pass through woodlands, ditches or naked strips of ground should be formed parallel to them on each side, and these should be planted up with belts of broad-leaved species of trees, so that the sparks are not only most likely to be intercepted by the non-inflammable foliage, but are also little likely to cause fires when they reach the ground, more especially if the soil below these belts of trees be kept free of inflammable material by sweeping with stable-brooms, or ordinary besoms made of scrub.

In extensive woods of Scots Pine formed on heathery tracts, in which the danger from fire is ordinarily greater than under almost any other circumstances, it is exceedingly important that the whole area should be subdivided into compartments by fire-paths and safety-lines or belts of broad-leaved species, so that these may be of some assistance in preventing the spread of fires that may have broken out. The whole woodland area should be subdivided into compartments of moderate size by means of narrow rides, which ought to be carefully kept clear of inflammable matter. These are of themselves usually sufficient to stop the progress of a ground fire, whilst in the case of a crown conflagration, they form very convenient points for at once commencing operations to prevent the fire spreading into the other portions of the woods. These rides should run at right angles to the direction of the prevailing winds, that is, should run generally from north to south (with such deviations to N.E. and S.W., or N.W. to S.E., as local conditions may suggest), and should be planted up with a fringe, or, better still, with a wide belt of some broad-leaved species, which, in the case of a crown-fire, does excellent service in stopping its further progress. In planting up such protective rows or belts, the Birch is the species which is specially deserving of attention in this regard, for it is the tree most easily satisfied with the inferior conditions as to nutriment that are alone offered by the poorer classes of sandy soil; where the Oak finds any suitable home, it also, treated as coppice, is capable of performing very good service in stopping the progress of fires.

As it is of very great importance to have speedy information with regard to the occurrence of any forest fire, so that measures

for its extinction may be taken at once, special watchers should be maintained in coniferous forests on the plains whenever there is long, continuous drought in spring or summer, and signals should be preconcerted in order to call together whatever body of men is available for the purpose of taking measures to counteract its spread and to accomplish its extinction. In the North German plain watch-towers are erected of wood, and cow-horns are blown from these as soon as any suspicious smoke is seen, whilst the church bells ring a continuous alarm, and a red flag is run up to the top of the spire to call the attention of the general population to the matter.

120. *Methods of extinguishing Forest Fires.*

Whilst a ground-fire of only petty extent may often quite easily be extinguished by a few men, yet when once it has managed to establish itself, and to assume more considerable proportions, hundreds of men can scarcely suffice to prevent it spreading still further; hence the speediest possible and most energetic action should be taken, for the actual damage done, and the danger of its assuming extensive proportions, increase with every moment lost.

Any forester or woodman, who sees or has been informed that a fire has broken out, should at once get together as many men with axes, hoes, spades, &c., as he can, and hurry to the place where the fire is raging, whilst at the same time despatching messengers, mounted if possible, to the nearest hamlets or villages to call for assistance. Arrived at the place where the fire has occurred, the head man among the party should at once make such disposal of the workmen at his command as he thinks best adapted to prevent the fire spreading into neighbouring woods.

When it is found to be only a ground-fire, as yet of but slight extent, it is often possible to extinguish it by beating the fringe of flame with green boughs from the trees, or with the flat shovels, or by sweeping the fire inwards with besoms, so as to throw it back on to the parts over which it has already passed. This should be the first plan tried, and its adoption is often of itself sufficient to extinguish the fire. When the air is windstill, or if there be merely a slight breeze blowing, such extinctive measures can be adopted from different sides simultaneously; but

when there is any steady breeze, the smoke and heat carried out in front of the fire are generally so strong and inconvenient as to restrict measures to the sides and flanks in the first instance, after which gradual efforts must be made to head and stop it.

In this last case, when the breeze is strong and steady, and the fire has at the same time already gained a foothold and extended over any considerable area, it is advisable to push on some distance ahead of the line of flame and clear a strip of several yards in width, so as to check its progress by removing the inflammable material requisite for its support. This measure can of course only prove successful when undertaken sufficiently far ahead of the fire to let all the operations be completed before the latter reaches the line cleared and fired; it necessarily entails the deliberate sacrifice of a portion of the area in order to save the crops lying behind. Compartment lines, and old pathways or cart-tracks for the extraction of timber, form good points at which to commence such operations, as they can be easily and quickly cleared, and altogether afford a good basis to work upon. Whilst this measure is being carried out, the work of extinguishing the fire along the edges should also of course be proceeded with simultaneously.

When the ground-fire is strong, and the danger of its overleaping such a check is imminent, or even at all probable, it is also advisable to set fire along the inner edge of this cleared line, so as to burn against the wind and meet the fire which it is thus intended to check. For prudential reasons, however, a regular cleared fire-path or ordinary protective line in the forest ought usually to be selected as the base of operations, so as to obviate the danger of sparks being blown into the crops lying behind. This operation is especially useful when there is a strong breeze blowing, so as to diminish the risk of sparks being carried far across the cleared line when the original fire eats its way up to it. Great care is necessary in starting the contrary fire, and the line should be manned with a sufficient number of persons to see that, in place of burning against the wind, it does not burn in the opposite direction and aggravate the damage it was intended to put an end to. When once, however, this line of fire has been well started it soon effects its object, for owing to the ascent of the heated air from the main line of fire the air is drawn towards it, and thus attracts the air in advance, and with it the contrary

line of fire, which thus makes headway against the direction of the breeze.

Every ground-fire that breaks out in a coppice-wood finally develops into a crown-fire if it be of large extent, for whenever it eats its way into thickets and pole-forests it runs up into the crowns, and then the danger is much greater, whilst extinctive measures are far more difficult and troublesome, especially during high wind, when the smoke, flames, and heat are driven on ahead. The conflagration may then assume such proportions that extinctive measures are no longer practically adoptable; such fires may rage till they are stopped by some natural occurrence or adventitious circumstance happening to check them, as, for instance, a broad stretch of unplanted clearance, or a belt of broad-leaved trees, or the reaching of the extreme limits of the woods.

Broad fire-protection paths, planted up with non-coniferous species of trees bearing a good crown of leafy foliage, are the best means of preventing the spread of conflagrations, and are, owing to the interruption of the coniferous canopy, the only sure basis upon which extinctive measures can be soundly adopted. This interruption of the canopy afforded by narrow interior lines can be materially assisted by rapidly clearing away a belt of trees along the further side, and working thus to join one of the main fire lines. But in this work, as well as in quickly removing any inflammable matter from the ground in the case of ground-fires, care must of course be taken to begin operations so far ahead of the fire as to ensure their completion before the fire has had time to come up to the lines. Poles and trees, which it may have been found advisable to fell, should be lopped of their branches, and these should be removed so far into the further side of the woods as to render it improbable that they will catch fire from the sparks.

In crown-fires, too, which have already caught firm hold on thickets and young pole-forest to any considerable extent, the leaf-canopy should be interrupted in as broad a belt as possible by firing the woods along the edge of one of the fire-protection lines or interior paths. Great prudence is of course necessary in doing so, in order to prevent the fire spreading into the crops lying behind the line; but when these are of older growth less danger is in this respect to be apprehended, and the chief attention will

be needed for the growth on the soil, so as to prevent the commencement of a ground-fire.

Tree-fires, that have broken out in the inside of hollow stems, may be put out by shutting off the supply of air, which can be done by plugging up the opening in the trunk with sods of turf or with earth ; if that cannot be done, the tree may be felled for the extinction of the flames with earth.

When a *soil-fire* has broken out in a turf-moor, measures ought of course to be taken to extinguish it long before it reaches any forest tracts. Its progress can be hindered by digging ditches deep enough to reach the mineral soil, and thus isolating the portion on fire.

When once a forest fire has been extinguished, it is always necessary to exercise a certain amount of prudence in regard to leaving watchmen on the spot, especially when any strong breeze is blowing, so as to take instant measures should there be any appearance of a recrudescence of the fire. Glowing stems should be covered over with earth ; the ground to the windward of the limit of the fire should be turned up if possible, and a good watch maintained until all danger is completely at an end.

121. *Measures to be adopted after Fires.*

If woodlands have been more or less damaged by fire, the question at once presents itself as to how the injuries inflicted can possibly be reduced to their minimum.

Young coniferous crops are almost always so badly damaged as to necessitate their clearance and re-formation by means of sowing or planting, whilst young crops of broad-leaved species are, owing to their naturally greater recuperative capacity, able to reproduce themselves if cut back to the stool after being damaged in the bark by ground-fire. Among broad-leaved species the Beech suffers most in this respect owing to its smooth thin bark, which is apt to be injured even by a comparatively light ground-fire, whilst this can often run through older crops without doing appreciable damage, more especially when the trees are of thick-barked kinds like Oak or Scots Pine.

But when such older crops show unmistakable signs of having sustained some considerable amount of damage, by assuming a sickly and unhealthy appearance in the foliage, or by individual

trees dying off here and there, it will often be necessary to take steps towards their clearance; this is more especially the case with regard to conifers, owing to the danger which then becomes imminent from insect enemies. Whenever any considerable fire has occurred in coniferous crops, the attention of the foresters and woodmen will be specially required for the purpose of noting anything like an increase in the number of insects injurious to forest growth, and more especially of the species inclined to breed in or near the roots and the lower portions of the stems.

From a sylvicultural point of view, it will be advisable to replant or sow the areas denuded of their crops, in order to obviate the continuation of the loss of increment on the one hand, and to prevent the soil from becoming covered with a rank growth of grass and weeds, and hence losing its productive capacity, or from becoming exhausted by exposure to sun and wind.

CHAPTER V.

Protection against Damage by Smoke and other Atmospheric Impurities.

122. *Occurrence of Damage by Smoke and Gases.*

For a very long time it has not failed to be noted that the smoke from factories and smelting-works, and under certain circumstances even from railway-engines when frequently passing to and fro, proves prejudicial to the well-being and normal development of woodlands subjected to their influence, producing changes from the natural colour in the foliage, a sickening and dying-off of many kinds of plants, and particularly those of sylvicultural importance. In the great majority of cases the cause of the injury lies in the sulphurous acid contained in the smoke, for only in less frequent cases can it be proved to be due to the action of hydrochloric acid in a gaseous form as evolved in the manufacture of soda, and to arsenious or nitrous acids.

The sulphurous acid is imbibed in its gaseous form through both the upper and the under sides of leaves and needles, and then by oxidation is quickly transformed into sulphuric acid. Drops of fluid water passing over the leaves, as during rainfall, hastens the action of the acid in a considerable degree, without, however, being concerned in the origin of the damage, that is, in the absorption of the sulphurous gas. Under the action of the sulphuric acid formed, the spines or needles become first of all yellow or red at their points, occasionally with a sharply drawn distinguishing line between the still sound green portion and the part affected, which latter gradually extends until the whole spine changes colour and becomes dead. On the foliage of broad-leaved species of trees the action of the sulphuric acid, that is being formed, makes the leaves appear as if they had been

tattooed with lighter and darker reddish-brown spots, which discoloration, in the case of extensive damage, gradually spreads until the green colouring totally disappears, and the leaf dies altogether. When the injury to the foliage is attributable to hydrochloric acid, the leaves are always characterised by a discoloration of their edges.

Coniferous species of trees are most sensitive to the injurious effects of smoke and other atmospheric impurities, and, from self-evident causes, are so in the order represented by the duration of their spines or needles, viz., Silver Fir, Spruce, Scots Pine, Larch. By reason of their annual change of foliage, the broad-leaved species are altogether less sensitive; the Oak and the Plane being those which suffer least, then Maple and Sycamore, Ash, Elm, Poplar, and Mountain Ash, whilst Alder, Lime, and Hornbeam are more sensitive, and Beech apparently the most sensitive of all. The plants best endowed with a capacity for withstanding the effects of impurities appear to be those of agricultural growth and also vegetables.

The damage inflicted is always greatest where narrow valleys almost force the currents of air to set in particular directions, or where the injurious acids and impurities occur largely in the atmosphere. But the local conditions of climate also exert a certain influence in the matter, as the damage is enhanced in places with damp, foggy atmosphere always hanging about them.

The crops injured first of all show a diminution in their increment, and an increased mortality among individual trees, so that the canopy first of all gets interrupted, and, in the case of large quantities of impurities working on sensitive species of trees, gradually more and more broken, till finally the whole crop dies off, and vacant spaces are formed, which are uncommonly hard to re-stock. Young pole-forests of 15 to 30 years of age are liable to suffer most from atmospheric impurities.

123. *Preventive Measures.*

Various plans have from time to time been adopted, but hitherto without much success, for minimising the damage thus caused, and all the more so as in Germany the owners of the factories are held liable to pay compensation for the injury done. Endeavours to transform the sulphurous acid contained in the

smoke into sulphuric acid for economical purposes were found to have many technical difficulties to contend with, whilst only one-quarter to one-third of the injurious gas could be withdrawn from the air; tall chimneys constructed with the intention of conducting the impurities into higher layers of air were practically found to yield no improved results, and occasionally only widened the area over which the injurious effects were noticeable.

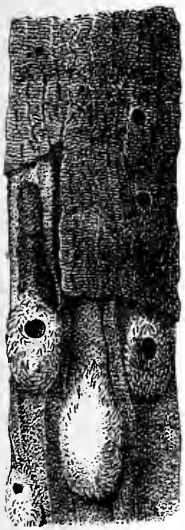
Hence in many places it became the duty of sylviculturists to give some consideration to the matter, so as to minimise the bad effects as far as possible, and in order to prevent the total destruction of the woodlands already more or less damaged. Where areas had already been cleared by the action of the smoke or gaseous impurities, reproductive measures have usually been found to be practically useless efforts, but wherever the injuries have not proceeded quite so far, endeavours should be made to grow the hardier species of trees so as to form protective belts; these should then never be cleared away, but should only be utilised to a minor extent by the selection of a mature stem here and there. Where the various other physical conditions of soil and situation permit of it, the formation of Oak-coppice is perhaps the best method of utilising the ground, for Oak and Coppice have each in their own way proved themselves specially hardy in regard to injuries caused by atmospheric impurities.

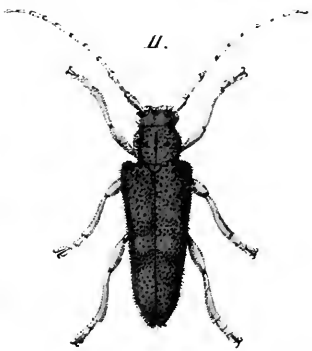
EXPLANATION OF PLATES.

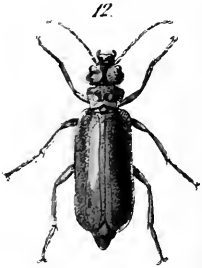
I = Imago or perfect insect.
P = Pupa or chrysalis.
C = Cocoon.
L = Larva or caterpillar.
O = Ovum or egg.

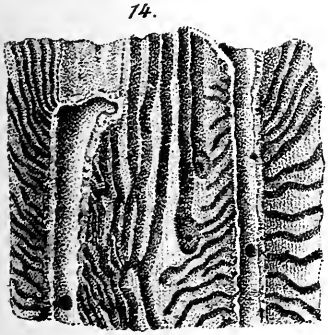
Useful Insects.

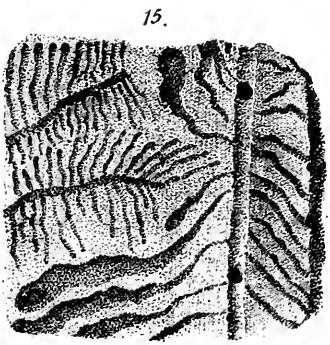
Injurious Insects.



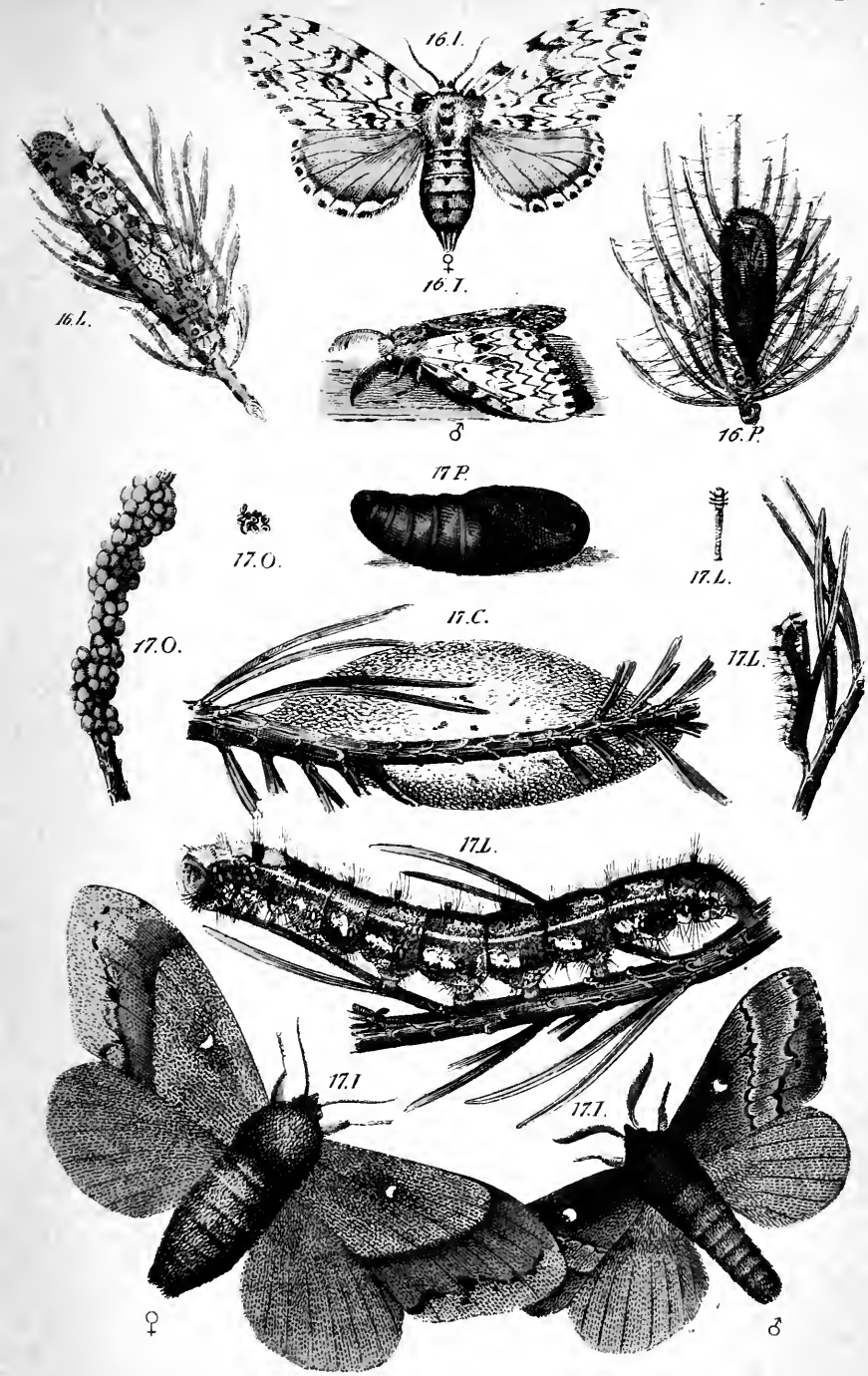




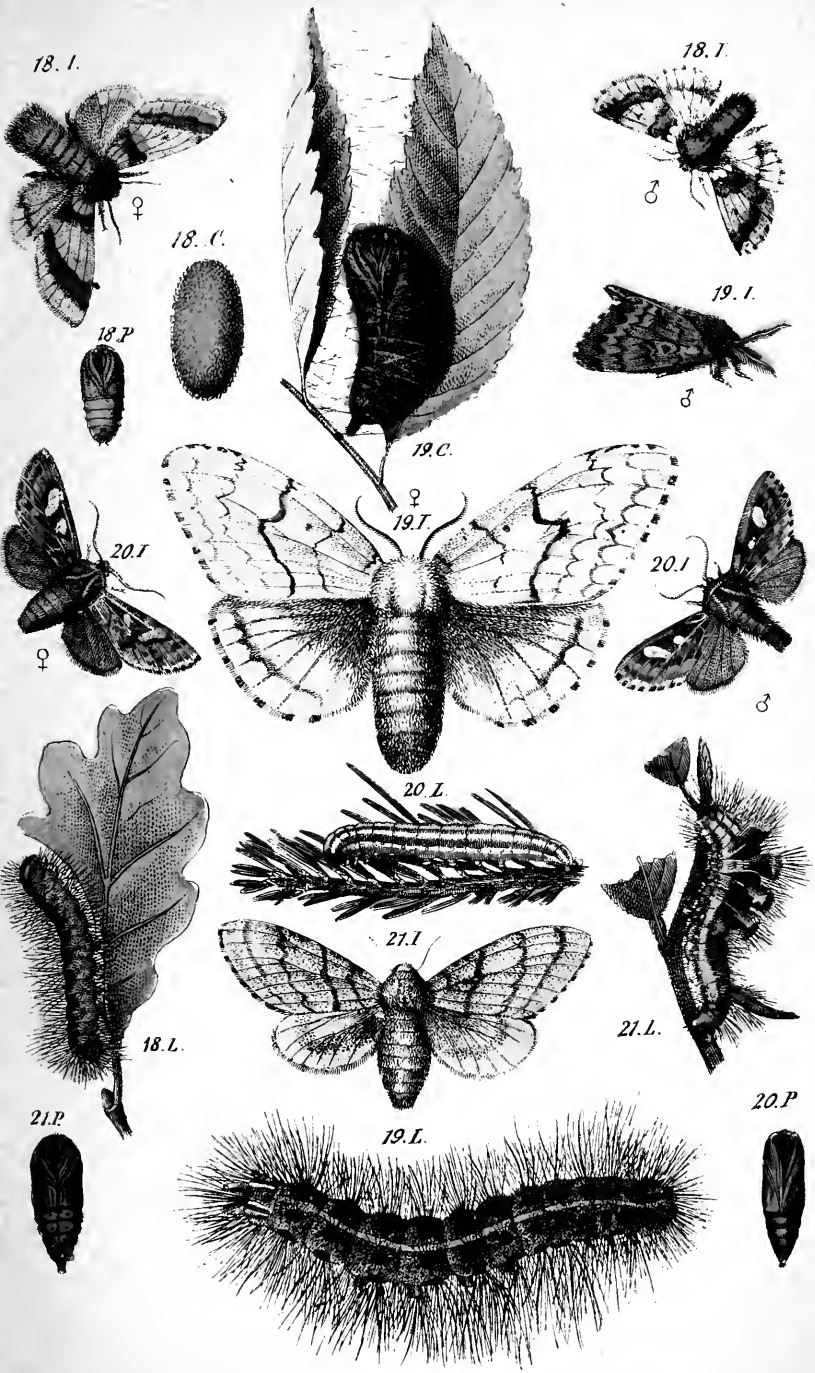




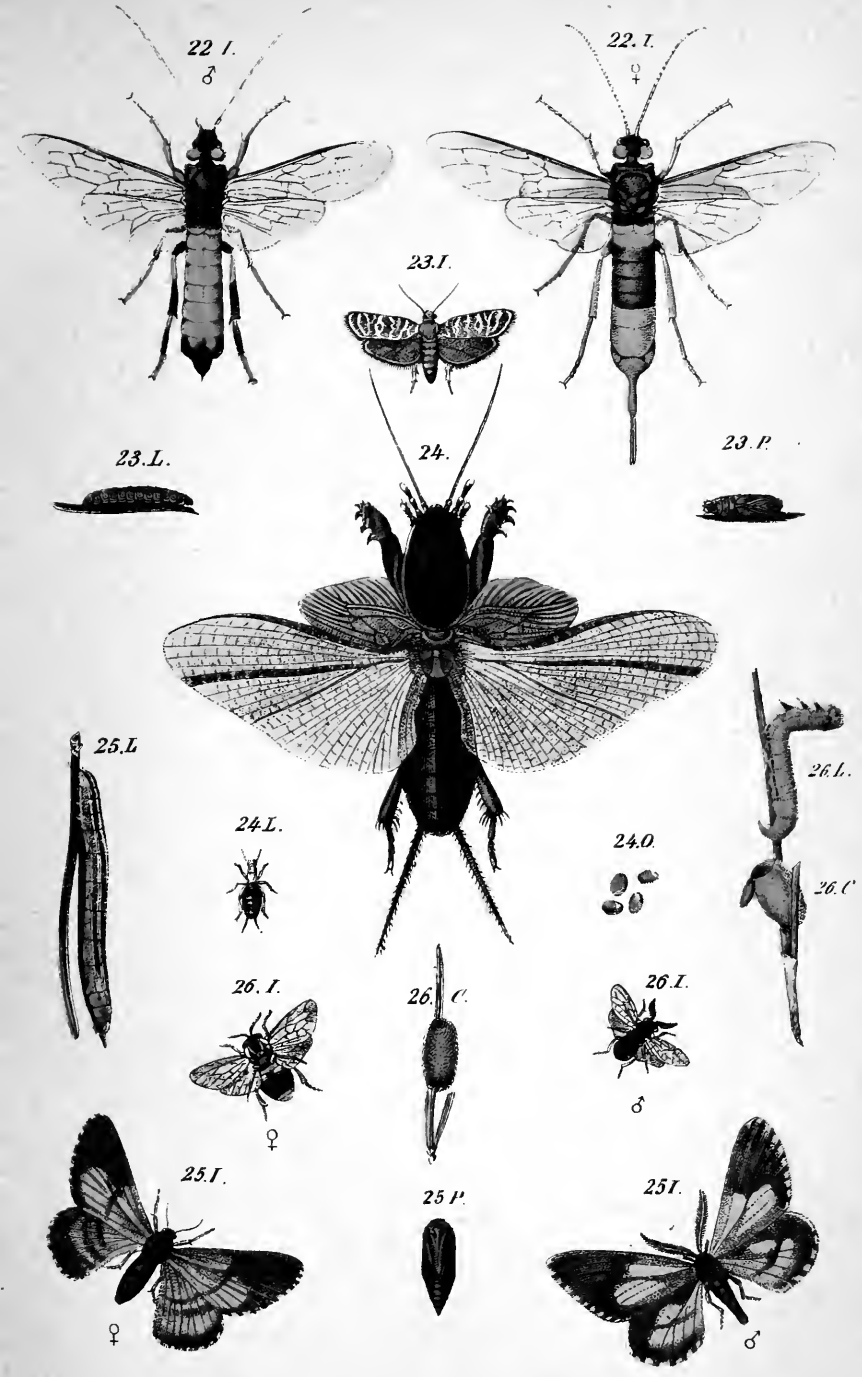
1. Ichneumon Fly *(Ichneumon nigritarius).*
2. Gold Beetle *(Clerus formicarius).*
3. Predatory Fly *(Tachina laevigata).*
4. Pine Beetle *(Hylurgus piniperda).*
5. 8-toothed Spruce Bark-Beetle *(Bostrichus typographus).*
6. Large 12-toothed pine Bark-Beetle *(Bostrichus stenographus).*
7. Green Saw-horn Beetle *(Agrilus viridis).*
8. Small brown Pine weevil *(Pissodes notatus).*
9. Red Poplar Leaf-beetle *(Lina populi).*
10. Pine weevil *(Hylobius abietis).*
11. Large Poplar Cervicorn *(Cerambyx Carcharias).*
12. Spanish Fly *(Lytta vesicatoria).*
13. Larval galleries and pupal chambers of *Pissodes notatus.*
14. Larval galleries of *Hylurgus piniperda.*
15. Larval galleries of *Bostrichus chalcographus.*



16. Black Arches, 'Nun', or Spruce Moth *(Liparis monacha)*.
17. The Pine Moth *(Gastropacha pini)*.



18. Processionary Moth *(Cnethocampa processionea).*
19. Gypsy Moth *(Liparis dispar).*
20. Pine Beauty or Owlet Moth *(Trachea piniperda).*
21. Hop Dog or light Tussock Moth *(Orgyia pudibunda).*



22. Giant Wood-wasp *(Sirex gigas)*.
23. Pine-shoot Tortrix *(Retinia buoliana)*.
24. Mole-Cricket *(Gryllotalpa vulgaris)*.
25. Pine Span-worm or Bordered White Moth *(Fidonia piniaria)*.
26. Pine Saw-fly *(Lophyrus pini)*.

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