Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
www.forestry.gov.uk

Managing the Pine Weevil on Lowland Pine

PRACTICE NOTE

BY DAVID WAINHOUSE, SARA BROUGH, AND BRIAN GREENACRE

JUNE 2007

INTRODUCTION

The pine weevil *Hylobius abietis* is a common cause of mortality in young conifers used to restock forest sites after clearfelling. Typically, adult weevils feed on bark of the main stem (Figure 1) and when it is girdled by extensive and deep feeding wounds, the young tree is killed. Insecticides are usually needed to protect trees during the vulnerable establishment period and these are applied either before or after planting. However, there are concerns about the effects of insecticide use in forests on the wider environment. Recent changes in application technique (from dipping to spraying), as well as in the insecticide used, are a reflection of these concerns and of the need to reduce the use of chemicals in forests. Minimising the use of insecticides for the control of pine weevils requires the adoption of Integrated Pest Management (IPM).

Integrated pest management

IPM is a well-established approach to control that emphasises the value of using a range of methods for reducing pest population size or damage to trees. An IPM programme for pine weevil could include, for example, the following three components:

- leaving an appropriate fallow period to allow weevil emergence and dispersal
- using resistant plants
- releasing natural enemies such as nematodes for the biological control of weevil larvae.

Figure 1

An adult pine weevil feeding on the bark of the main stem of a young tree.

One obvious way of reducing the use of insecticides is to apply them only where and when needed to protect young trees. Deciding whether and when to apply insecticide requires information on the timing and likely intensity of weevil attack. This can be obtained by monitoring weevil development in the stump and associated root system (root–stump) to predict the time of adult emergence and the approximate population size. Depending on the risk and likely intensity of attack, the main management alternatives are to delay planting, to restock with pre-treated trees or, if the risk is low, to plant untreated trees. Subsequent monitoring of feeding damage to young trees can be carried out, where necessary, to identify areas that require insecticide spraying.

The methods of root–stump examination and tree monitoring described in this Practice Note were developed at Thetford Forest in East Anglia where they are now standard practice. Routine monitoring has led to a significant reduction in costs of pine weevil management, reflecting to a large extent the reductions in insecticide use that have been achieved. Monitoring is recommended for other areas of lowland pine in southern Britain where the pine weevil life cycle is expected to be similar to that at Thetford. Successful application of monitoring depends on a basic understanding of this life cycle.

THE PINE WEEVIL LIFE CYCLE

The length of the life cycle, from egg to adult, can vary from less than one year to two or more years. The cycle begins with egg laying or *oviposition* by adult females in

FCPN014

the bark of conifer root–stumps. Pine weevils are able to locate new root–stumps on recently clearfelled sites by responding mainly to the odours of resinous compounds from the cut surface of tree stumps. After hatching, the larvae feed in the bark, increasing in size as they pass through about five developmental stages or *instars*. When fully developed, the larvae enter a relatively brief but distinctive pre-adult or pupal stage before moulting to the adult weevil which eventually emerges at the soil surface. In Britain, the main period of emergence is in the autumn but these weevils eventually re-enter the soil to overwinter and re-emerge in the spring on or near the same clearfell site. On some sites, weevils may emerge for the first time in spring rather than in the autumn.

Pine is the natural host of the pine weevil and larvae tend to develop more quickly on it than on spruce. The rate of larval development is temperature dependent, and seasonal or site factors related to the amount of sunshine or altitude, for example, can have a significant effect on the length of the life cycle. In pine, the population of larvae within and between root–stumps is often even-aged with most adult emergence tending to occur during a single autumn period. In lowland pine the life cycle may sometimes be completed within a single year whereas in upland spruce, larval development usually takes from 18 to 24 months. As well as being a less suitable host, development on spruce is probably also influenced by the generally lower temperatures on sites where it is planted. Root–stumps of spruce also seem to deteriorate more slowly than those of pine, with the bark remaining suitable for colonisation for more than one season. As a consequence, spruce root–stumps can be exploited by ovipositing weevils over an extended period, resulting in a larval population of mixed age. The long development time and mixed age populations on spruce can result in several separate periods of emergence occurring over two or more seasons.

Newly emerged or re-emerging adults need to feed for a period before they are able to lay eggs and begin the cycle again. It is during this period of 'maturation' feeding that the main economic damage occurs. Damage to young conifers is highest when sites have been replanted before the weevils emerge in autumn and spring. Pine weevils also feed on the bark of twigs within the crown of mature trees surrounding clearfells. When maturation feeding is complete and the weather warm enough in late spring/early summer, pine weevils fly to new clearfell sites for egg laying. After this period of dispersal, the risk of damage to plants at emergence sites is usually low.

ESTIMATING TIMING OF EMERGENCE

Predicting pine weevil emergence depends on the examination of bark on a sample of pine root–stumps on clearfell sites prior to replanting. Although the method is a very simple one, some experience is needed in recognising juvenile stages of weevils and assessing the degree to which bark resources have been used, either by the weevil larvae or by other insects and fungi.

After felling, the upper part of a root–stump can be rapidly colonised by larvae of black pine beetles (*Hylastes* spp.) and more slowly by the fungus *Phlebiopsis gigantea*. This fungus can be present naturally, but at Thetford it is normally applied to the surface of freshly cut tree stumps for the biocontrol of *Heterobasidion annosum* (formerly *Fomes annosus*). In Poland, colonisation of root–stumps by *P. gigantea* is recognised as an important factor in reducing populations of pine weevil larvae. The larvae of longhorn beetles (Cerambycidae) are also relatively common and, like the other organisms, compete with pine weevil larvae for access to the limited food resources available on a single root–stump.

Root–stump monitoring in lowland pine exploits the fact that development in pine is faster than that in spruce so that the period between oviposition and adult emergence can be less than a year, especially in warm summers. When pine clearfell sites are due for restocking more than a year after felling, examination of root–stumps before planting often reveals that adult pine weevils have already emerged, leaving only evidence of previous feeding by larvae. In contrast, when root–stumps are examined less than a year after felling, larvae or other weevil stages are likely to be present and the aim of root–stump monitoring is to confirm this and assess the approximate degree of development so that the time of adult emergence can be estimated.

It is often possible to get some information on the size of the local pine weevil population based on the abundance of weevils within and between root–stumps. However, a direct relationship between weevil abundance on root–stumps and subsequent damage by adults has not been developed. Predicting the likely intensity of damage on replanted sites is therefore based on experience of the behaviour of local weevil populations and the relative susceptibility of the planting stock used. Nevertheless, it is possible to give general guidance on weevil abundance and damage.

RECOGNISING PINE WEEVIL DEVELOPMENTAL STAGES

Successful root–stump monitoring depends on being able to distinguish the juvenile stages of pine weevils from those of other species that may be present. It also requires an assessment of the developmental stage based on larval size or the presence of pupae or newly moulted adults. Information on the time of felling, and therefore the time when root–stumps were first available to adult weevils for oviposition, can also be a useful although not essential aid to determining the stage of development and likely emergence date.

The eggs of pine weevils are about 1.5 mm in length and newly hatched larvae a little larger (Figure 2). Their small size makes them difficult to see in the field but the larvae increase in size as they develop, most noticeably when they moult from one instar to the next. There is some overlap in body size between the larval stages however, making identification of specific instars difficult under field conditions. The range of larval sizes typically encountered is shown in Figure 3. The last larval instar is followed by a pupal stage in which some features of the adult weevil, such as wings, legs and the typical weevil 'snout', can be recognised (Figure 4). The pupa moults to an adult which is initially pale in colour (Figure 5) but usually much darker by the time it emerges from the soil.

Figure 2

Egg and first instar larva of a pine weevil.

Figure 3

Pine weevil larvae in different stages of development or instars. For monitoring purposes, the two larvae on the left, or any that are smaller, would be classified as 'small-medium'. The three on the right are 'large', the largest of which is fully developed.

Figure 4

Side (a) and ventral view (b) of a pupa in which the legs, wing buds and the typical weevil 'snout' are visible. Pupae are often seen in 'pupal cells' in bark or in the outer sapwood. The cells are excavated by larvae prior to pupation and are usually covered with whitish wood fibres – visible here at the top of (b).

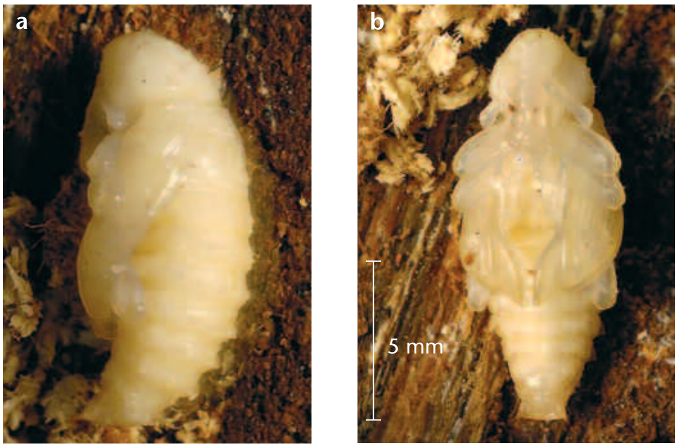


Figure 5

Newly moulted adult pine weevils are usually light brown or reddish in colour. A fully darkened adult ready for emergence above ground can be seen (top right) within an old pupal 'cell'.

Larvae of other insects

Larvae of pine weevil may be confused with those of other insect species commonly found in pine root–stumps. The larvae of black pine beetles tend to occur in sinuous tunnels that are usually close together (Figure 6). These bark beetle larvae can be difficult to distinguish from young pine weevil larvae but the distinctive pattern of their tunnels, and the tendency for them to occur in the bark just above or just below ground level, can help in the identification.

The larvae of longhorn beetles (Cerambycidae) are easily distinguished from those of pine weevils, having a characteristically flattened body and broad 'head' and they grow to a large size (Figure 7). They are often found in older root–stumps.

Figure 6

An adult black pine beetle (*Hylastes* spp.) and fully developed larvae within tunnels in the bark. These larvae can be difficult to distinguish from small pine weevil larvae but commonly occur on the upper part of the main body of the root–stump.

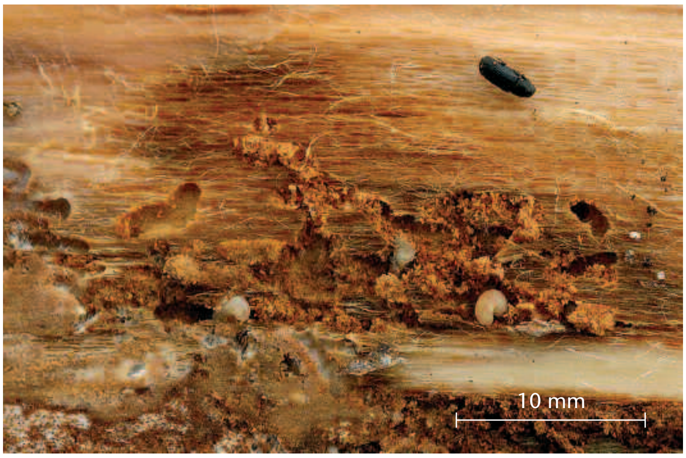


Figure 7

Well-developed larvae of a longhorn beetle. These larva form large individual galleries and tunnel into the sapwood to pupate. When they emerge as adults, they leave characteristic emergence holes on the surface of the root–stump (see Figure 12).

EXAMINING ROOT–STUMPS

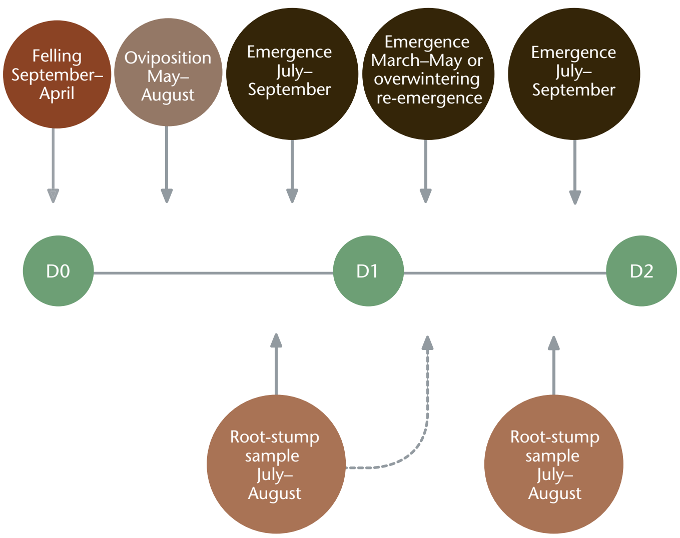
The stage of the weevil life cycle observed in root–stumps depends mainly on when they are examined relative to the timing of oviposition and on temperature-dependent variation in development rate. Most reproductively mature weevils disperse by flight in the late spring–early summer and oviposit in root–stumps on clearfell sites. In warm summers weevils of the next generation may emerge in the autumn of the same year or, in cooler weather, in the spring or autumn of the following year. This pattern is typical of sites clearfelled in late autumn and which are first available to egg-laying weevils in the following spring. However, on sites felled in late summer or early autumn, oviposition may occur in both the current and the following season – in which case the larvae within a root–stump vary in age and so there may be at least two periods of adult emergence.

Likely times of emergence on a site felled during the dormant season are illustrated in Figure 8. Typically, root–stumps would be examined in late summer/early autumn prior to dormant season replanting, but further examination in the following spring or autumn may be necessary to establish with certainty the time of emergence. The methodology of examining root–stumps is described in Box 1.

Figure 8

Development of pine weevil in root–stumps of lowland pine felled during the dormant season.

D0 = dormant season during which trees were felled.
D1 and D2 = subsequent dormant periods when replanting is likely to occur.



Box 1: Examining root–stumps

The following sampling protocol is for a 'typical' clearfell of around 5–10 ha that has been felled as a unit, i.e. without a lengthy period of interrupted felling.

1. Using a narrow spade (about 15 cm wide) clear the surface debris on one side of the root–stump and, avoiding buttress roots, remove soil adjacent to the bark down to around 20–30 cm below soil level (Figure 9a,b). Insert the spade between the wood and the bark at the top of the stump and lever the bark away (Figure 9c,d) so that relatively large pieces break off from the side of the exposed root–stump from about 20–30 cm of its circumference (Figure 9e,f). After examining the bark as described below, repeat this operation on the opposite side of the root–stump.

2. Examine the inner bark where most larvae feed. Larvae are usually easily visible but bear in mind that small ones are similar to those of *Hylastes* and some other bark beetle species (Figure 10a) Large *Hylobius* larvae, which are often 'C' shaped when resting on a surface, are easy to recognise (Figure 3). Larvae, and particularly pupae (Figure 4) and adults (Figure 5) may occur within the thick dead outer bark, samples of which should be broken open (Figure 10b). Pupal cells occur not only in bark but also in the outer sapwood which should also be examined. Pupal cells are usually covered with light-coloured wood fibres produced during excavation by the larvae. By the time adult emergence is completed, the bark of root–stumps is usually darkly discoloured with evidence of extensive feeding by *Hylobius* larvae. Brown granular 'frass' (insect faeces) is usually present on the inner bark and often on the exposed surface of the wood (Figure 10c). Weevil emergence holes may also be visible in the bark (Figure 10d). Significant areas of bark may be colonised by fungi, especially by *Phlebiopsis gigantea* (Figure 11) which may have been applied to the newly cut surface after felling for biocontrol of *Heterobasidion annosum*. The activity of other insects such as *Hylastes* bark beetles or longhorn beetles may also be evident. The presence of emergence holes of longhorn beetles on the cut surface of the stump (Figure 12) is a strong indication, before the root–stump is examined in detail, that exploitation of the bark by insects and fungi is likely to be well advanced.

3. When weevils are abundant, 2–5 larvae, pupae or new adults may be seen on each side of the root–stump. The distribution of weevil larvae within and between individual root–stumps can be quite variable so several need to be examined. Aim to sample a total of 10–20 root–stumps on different parts of the clearfell. An overall average of more than four weevils per root–stump indicates that a significant emergence is likely. Use the photographs and descriptions of developmental stages to assess the management options outlined in Figure 13 in the next section.

INCORPORATING THE EXAMINATION OF ROOT–STUMPS INTO MANAGEMENT OF RESTOCK AREAS

When root–stump examination is being introduced for management of pine weevil in lowland pine it should first be used on a small area of restock and, where appropriate, gradually extended to include all restock sites. This step-by-step approach allows the efficacy of the method to be tested locally before its wider adoption within a forest district. This approach will also provide an opportunity to identify any aspects of monitoring that require further research.

When root–stump examination indicates that there is likely to be a significant emergence of weevils at a restock site, the main methods for minimising damage are to use trees pre-treated with insecticide or to delay planting. Where the risk of damage appears to be relatively low, untreated plants may be used and where necessary, feeding damage can be monitored to determine the need for, and timing of, post-planting insecticide applications to young trees.

Planting requirements for a forest area are usually made 3–5 years in advance, with nursery production taking 2–3 years. Any changes to the planting programme as a result of pine weevil management could disrupt the management of restocking. However, the gradual introduction of monitoring should allow plant supply to be adjusted on the basis that some, locally determined, proportion of the clearfell areas will require some delay in planting for pine weevil management.

Figure 9

(a) Removal of the soil around one side of a root–stump, avoiding buttress roots. (b) Exposed root–stump prior to bark removal. (c) Insertion of spade between wood and bark. (d) Levering bark sections from the root–stump. (e and f) Examination of the inner bark. The dead outer bark may need to be broken open to reveal larvae and pupae or young adults (see Figure 10b).

Figure 10

(a) Inner bark showing a mixed population of *Hylastes* and the larger *Hylobius* larvae (arrow). (b) The dead outer bark has been broken open to reveal an adult weevil in an old pupal cell. (c) Exposed xylem of a root–stump showing impressions of larval galleries and deposits of brown granular 'frass' (larval faeces) (arrow), indicating extensive larval feeding. (d) Brown discoloured inner bark utilised by larvae and with exit holes of adult *Hylobius* (arrow).

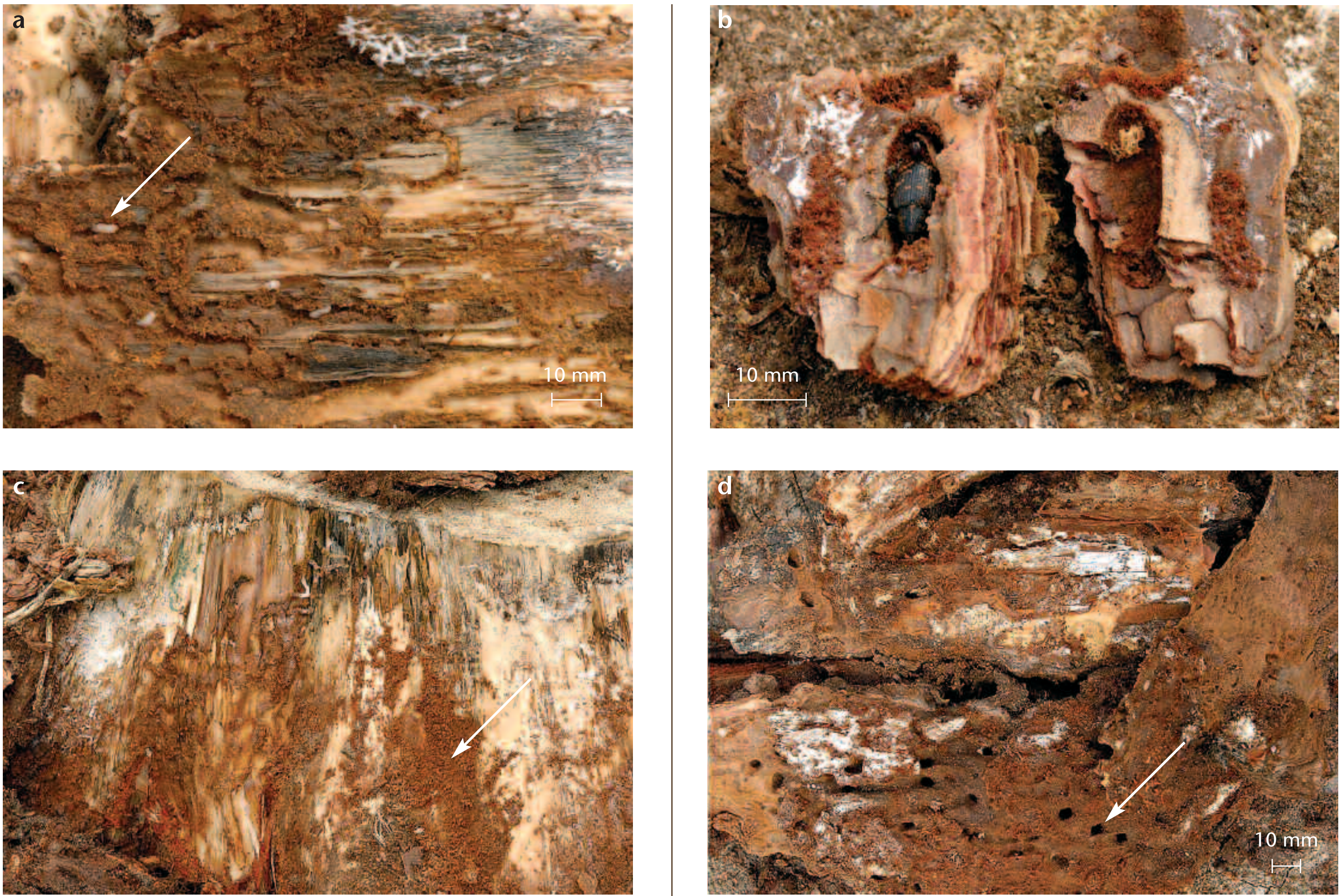


Figure 11

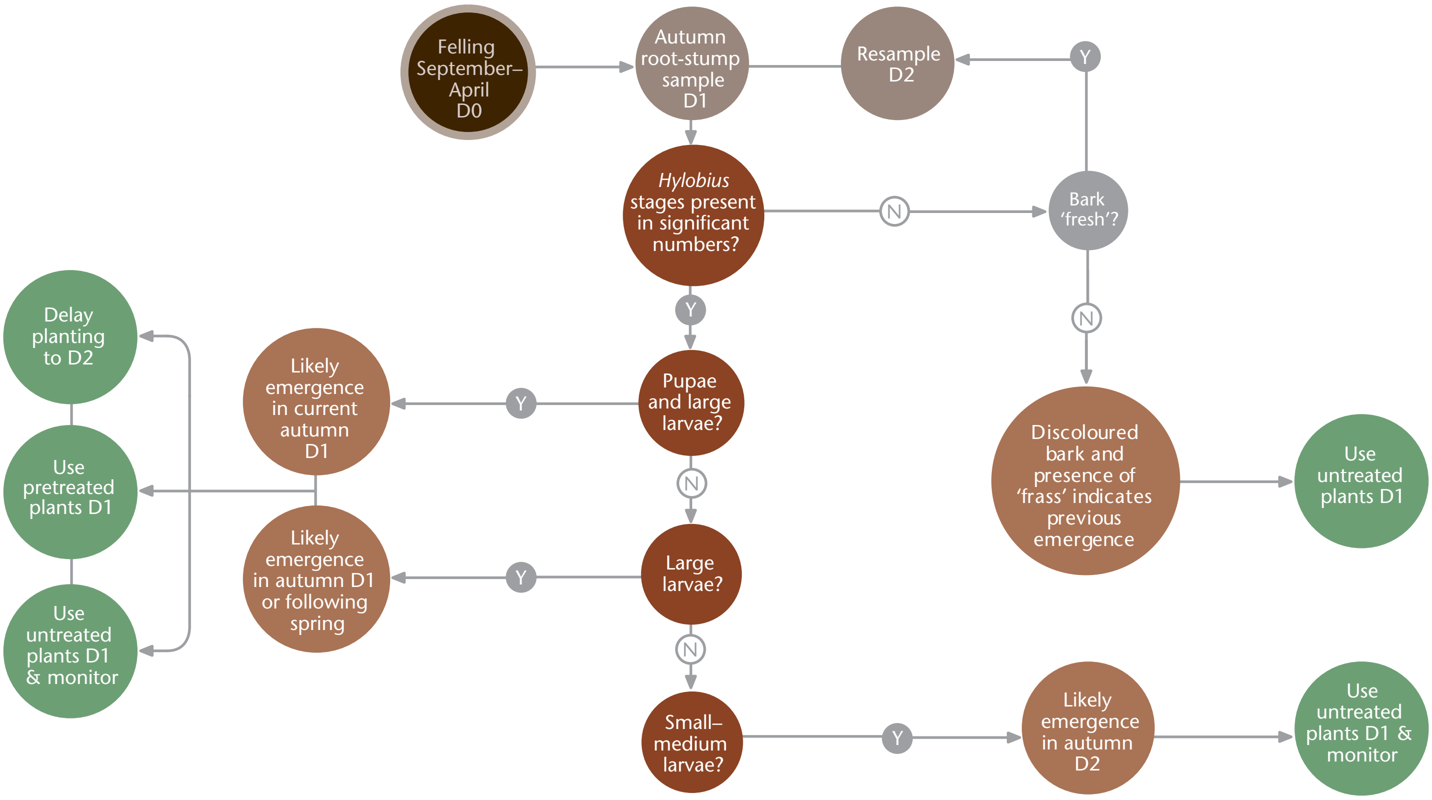
The side of a root–stump with bark removed. Downward colonisation of the bark and xylem by fungi such as *Phlebiopsis gigantea* is indicated by dark discolouration. Fungal colonised bark is unsuitable for development of *Hylobius* larvae. When urea has been used for stump treatment, the bark can be difficult to remove.

Figure 12

Oval-shaped emergence holes of longhorn beetles on the cut surface of the stump.

Figure 13

Management decision diagram for root–stump monitoring on lowland pine. The key management options (see text) are shown in green. D0 = the dormant season during which trees are assumed to have been felled; D1 and D2 = consecutive dormant seasons after felling.



DECISION MAKING BASED ON ROOT–STUMP MONITORING

Assessing the degree of weevil development in root–stump monitoring is usually straightforward, with larvae either absent or present in significant numbers of a similar developmental stage. However, this pattern may vary in other lowland pine areas. When examining a root–stump, bear in mind that only part of it has been exposed and larvae are likely to be present elsewhere on the main root and sometimes also on buttress roots. As a practical guide, if on average, four or fewer larvae are found per root–stump, the risk to young trees is likely to be low. Higher numbers indicate that there is likely to be a significant adult emergence with the potential to cause extensive damage.

Decisions are more difficult where there is a significant variation in weevil population size between root–stumps or where larvae vary in age as indicated by differences in size (Figure 14). Some size variation is normal because larval development rate is influenced by soil temperatures and therefore by the depth at which individual larvae feed. However, large differences in size among larvae suggest that oviposition has occurred on several separate occasions over an extended period. In such cases, there are likely to be two or more separate periods of adult emergence and root–stumps would need to be examined on several occasions to determine the time and size of each emergence. Similarly, different emergence periods may occur where there is large variation in larval size between root–stumps. In most cases where some larvae

Figure 14

Larvae of different size can occur on an individual root–stump due to differences in development rate or separate periods of oviposition. The predominant stage should be used to assess timing of the main emergence. Further monitoring is usually necessary when there is large variation in larval size.

are detected, it is advisable to monitor young trees during the emergence or re-emergence period.

The estimated emergence time, based on stage of development, and management options related to the time of replanting after clearfell are given in Figure 13.

The main management options are:

- Plant untreated trees
- Plant untreated trees and monitor them for possible post-planting insecticide application
- Plant pre-treated trees with or without subsequent monitoring
- Delay planting until the following dormant season.

MONITORING DAMAGE

Monitoring damage to young trees is done with the aim of determining whether post-planting insecticide applications are needed to prevent tree mortality. Monitoring is of value in areas where untreated trees have been used in restocking and some weevil emergence is expected. Information on the size of local weevil populations can be obtained by looking for evidence of weevil feeding on twigs of established or mature trees immediately surrounding a clearfell as well as by examining root–stumps. When adult weevils emerge in the autumn, many will walk to the edge of the clearfell area and feed on the twigs and small branches of surrounding trees (Figures 15 and 16). This feeding is easy to see and significant amounts of recent feeding is a sign of large local weevil populations.

Figure 15

Feeding damage to the twigs of trees on the edge of a clearfell area from which weevils are emerging. One prominent wound in the centre of the photograph that was made earlier in the season has already begun to heal.

Figure 16

Some twigs of mature trees express resistance to feeding similar to that of resistant transplants. On resistant twigs, feeding is superficial (a) or triggers resin flow (b) that prevents further feeding.

ASSESSING DAMAGE

The amount of feeding damage on individual trees and the distribution of damage between them is influenced not only by weevil population size but also by the level of plant resistance. Corsican pine, which is widely planted at Thetford, is generally more resistant than Scots pine and can tolerate some feeding damage without succumbing. Resistance of individual trees is usually indicated by the flow of resin from feeding wounds and by the tendency for weevil feeding to be restricted to the outer bark rather than penetrating to the xylem. This superficial feeding, which is less damaging to trees, should be taken into account when assessing the severity of damage and likely impact. It is important to remember that feeding damage accumulates over a season so, for areas at risk, trees should be examined at least twice a week during the period when weevils are most active until management decisions are made. In spring, weevils are active from the end of March or early April and at emergence sites from mid-July. The sampling protocol outlined in Box 2 is intended as a general guide and should be used in areas where some damage to trees is anticipated that may require the topical application of insecticides.

Box 2: Monitoring young trees for adult feeding

1. Mark out two sample transects (approx. 10 m x 100 m) using canes along one side of the compartment (Figure 17). Divide each transect into five 10 m x 20 m blocks (1–5) and within each, sample 10 trees to give a total sample of 50 trees in each transect.

2. Select sample trees by walking over the whole area within each block, stopping at 'random' to examine the nearest tree for signs of damage (without removing it). Do not deliberately select or avoid trees that are dead, yellowing or otherwise show signs of stress.

3. Examine the whole of the main stem on each tree. Trees that have died from causes other than weevil damage should be excluded and an additional one sampled. Feeding wounds that appear to be old with signs of healing can be ignored – only current damage needs to be assessed. Determine the number of plants that are:

   a) Dead as a result of weevil feeding.
   b) Damaged by feeding that penetrates down to the xylem on at least some of the feeding areas (Figure 18a).
   c) Damaged by predominantly superficial feeding (Figure 18b).
   d) Not damaged.

   Trees on which current feeding penetrates to the xylem are considered susceptible and are likely to be girdled and killed as damage accumulates. Those with superficial feeding in the outer bark, especially where droplets of resin are visible at sites of feeding, have a degree of resistance and are much less likely to succumb. Note that dead trees are unlikely to be present if sampling is started at the very beginning of the period of weevil activity.

4. Pool the results of the two sets of blocks 1–5 from the paired transects. For each combined block, with a total of 20 sampled trees, calculate the percentage in categories a–d. When most of the trees with weevil damage occur in block 1, with no or very few affected trees in blocks 2–5, a strong edge effect is suggested. Pool results for all 10 blocks and determine the overall percentage of trees in each damage category.

5. If compartments are very large or factors such as proximity to a previous clearfell suggest that attack may vary between different sides of the compartment, additional samples should be taken. The intensity of further sampling will depend on the objectives of monitoring, e.g. to detect presence or absence of damage, or to determine the distribution and intensity of attack. Additional transects can be taken on one or more of the compartment boundaries or, for experienced observers, informal surveys may suffice to confirm results from the original transects.

6. Refer to page 11 for information on how to use estimates of the amount and distribution of damage to trees to assess the need for insecticide application.

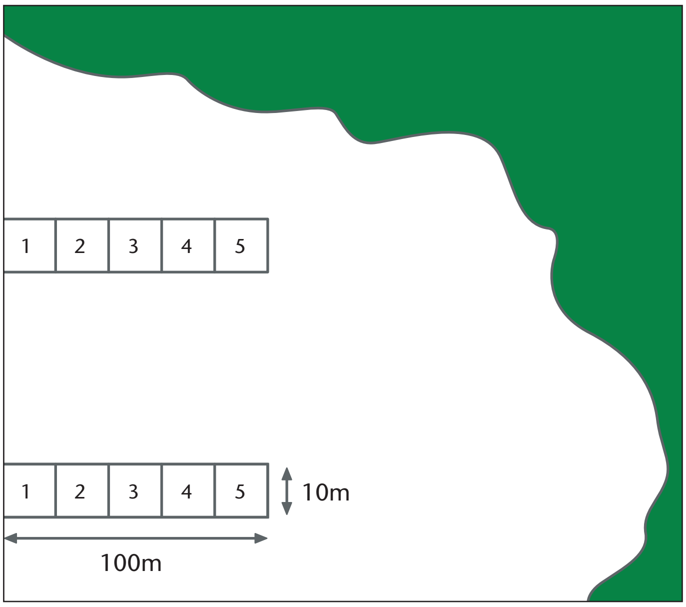
DECISION MAKING BASED ON TREE MONITORING

When monitoring trees, the damage levels that trigger control will depend on a number of factors, the most important of which are the level of acceptable tree loss, weevil population size, area affected and the degree of plant resistance. Reliance on monitoring and post-planting insecticide treatment is not recommended in areas where root–stump examination indicates that significant weevil attack over large areas is highly likely.

If root–stump examination indicates that weevil populations are generally high and emergence will occur when trees are present on site, insecticide treatment may be triggered by the first signs of damage. In such cases, formal transect samples (Figure 17) could be replaced by rapid inspection of approximately 100 trees for any signs of damage, selecting them from different parts of the compartment. Where decisions are to be based on the amount and distribution of damage, the assessment must take into account the accumulation of damage as the season progresses. Trees should be examined on several occasions from the start of weevil activity. In the autumn, weevil feeding coincides with emergence which typically begins in mid-July whereas in the spring, weevils can be active from mid-March. In warm weather, which increases weevil activity, damage can accumulate quickly and at high risk sites trees should be examined two or more times per week until management decision are made.

Figure 17

Diagrammatic representation of a clearfell area and two sample transects (see Box 2) from the edge of a clearfell.



Where the trees used are particularly susceptible, spraying may be triggered when, overall, 5–10% of them are affected by recent feeding that penetrates to the xylem (Figure 18a). When they are more resistant, as indicated by superficial feeding and resin flow (Figure 18b), damage to 15–20% of the plants may be acceptable before spraying operations are considered. Bear in mind that during spring attacks, weevils usually disperse from the site in May or early June after which little damage would be anticipated. Where successive samples indicate that only a few plants are affected by largely superficial feeding, insecticide spraying can usually be avoided.

The intensity of weevil feeding damage can vary across a site, in which case it may be possible to restrict spraying to a particular area. For sites that have been replanted during the dormant season after an autumn emergence, the accumulation of overwintering weevils around the edge of the clearfell area can result in increased feeding on nearby trees when these weevils re-emerge in the following spring. At Thetford, edge effects are especially noticeable where trees are close to windrows formed by root–stumps removed for control of *Heterobasidion annosum* (Figure 19). Root–stumps are frequently lifted *after* oviposition by pine weevil adults, and larvae are often able to complete development on those root–stumps in the inner, shaded part of the windrow. Insecticide application can often be restricted to the affected trees nearest the windrow.

Figure 18

(a) Susceptible pine with weevil feeding damage exposing the xylem and with no resin flowing from the feeding wound.
(b) Resistant pine with superficial feeding in the outer bark and obvious resin flow from the wound.

Figure 19

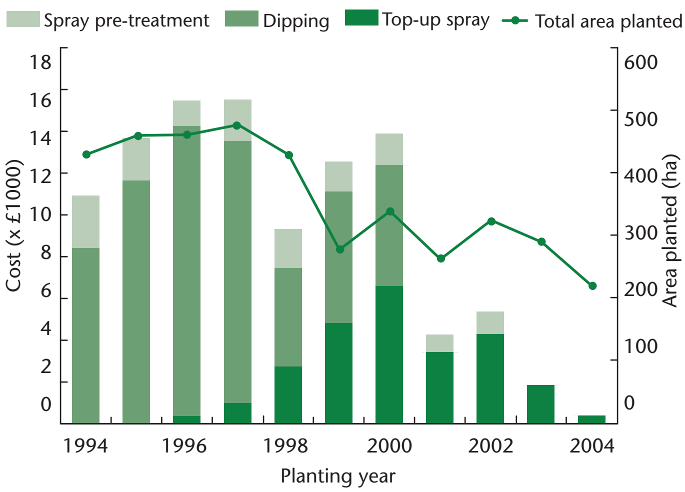
Windrow formed from root–stumps lifted to prevent colonisation by *Heterobasidion annosum* on susceptible sites. Weevil larvae present before lifting may complete development and emerging weevils can increase attack on adjacent trees.

REDUCING INSECTICIDE USE THROUGH MONITORING

In Thetford, root–stump and tree monitoring for management of pine weevil was first used on a small area of restock in 2000. Monitoring was gradually extended to all restock sites, resulting in a significant reduction in insecticide use and therefore costs of control (Figure 20).

Figure 20

Reduction in the cost of *Hylobius* control at Thetford Forest following implementation of root–stump and tree monitoring. Although there has been an overall reduction in the total area replanted each year, there is evidence of a significant reduction in the costs of control on a per ha basis. The major savings have been achieved by switching from the use of pre-treated trees to the use of post-planting insecticide sprays where necessary.



TRAINING REQUIREMENTS

Extending this simple monitoring scheme to lowland pines other than in Thetford Forest requires some training in recognition of insect stages and some experience in interpreting results of sampling. Training in the different aspects of monitoring can be arranged where necessary. For additional information or to provide useful feedback, see the contact details below.

USEFUL SOURCES OF INFORMATION

Forestry Commission publications

Forestry Commission Information Note 38.
The assessment of site characteristics as part of a management strategy to reduce damage by Hylobius.

Forestry Commission Information Note 87.
Resistance of conifer seedlings to feeding damage by Hylobius abietis.

The UK Forestry Standard. The government's approach to sustainable forestry. 2nd edition.

For information on how to obtain these publications and to view and download pdf copies, visit:
www.forestry.gov.uk/publications

Other publications

BEJER-PETERSEN, B., JUUTINEN, P., KANGAS, E., BAKKE, A., BUTOVITSCH, V., EIDMAN, H., HEQVIST, K.L. and LEKANDER, B. (1962).
Studies on *Hylobius abietis*: Development and life cycle in the Nordic countries. *Acta Entomologica Fennica* **17**, 1–106.

BURMAN, M., PYE, A.E. and NÖJD, N.O. (1979).
Preliminary field trials of the nematode *Neoaplectana carpocapsae* against larvae of the large pine weevil, *Hylobius abietis* (Coleoptera, Curculionidae). *Annales Entomologici Fennici* **45**, 88.

EIDMANN, H.H. (1979).
Integrated management of the pine wevil (*Hylobius abietis*) populations in Sweden. In: *Current topics in forest entomology*. Forest Service General Technical Report WO-8, USDA.

MOORE, R., BRIXEY, J.M., and MILNER, A.D. (2004).
Effect of time of year on the development of immature stages of the large pine weevil (*Hylobius abietis* L.) in stumps of Sitka spruce (*Picea sitchensis* Carr.) and influence of felling date on their growth, density and distribution. *Journal of Applied Entomology* **128**, 167–176.

SKRZECZ, I. (1996).
Impact of *Phlebia gigantea* (Fr.:Fr.) Donk on the colonization of Scots pine (*Pinus sylvestris*) stumps by the large pine weevil (*Hylobius abietis* L.). *Folia Forestalia Polonica* **38**, 89–101.

TILLES, D.A., SJODIN, K., NORDLANDER, G. and EIDMANN, H.H. (1986).
Synergism between ethanol and conifer host volatiles as attractants for the pine weevil, *Hylobius abietis* L. (Coleoptera: Curculionidae). *Journal of Economic Entomology* **79**, 970–973.

UKWAS STEERING GROUP (2006).
UK Woodland Assurance Standard (UKWAS). 2nd edition.
www.ukwas.org.uk/standard

VON SYDOW, F. and BIRGERSSON, G. (1997).
Conifer stump condition and pine weevil (*Hylobius abietis*) reproduction. *Canadian Journal of Forest Research* **27**, 1254–62.

WAINHOUSE, D. (2004).
Hylobius abietis – host utilisation and resistance. In: *Bark and wood boring insects in living trees in Europe, a synthesis*, eds F. Lieutier, K.R. Day, A. Battisti, J.C. Grégoire and H.F. Evans. Kluwer Academic Publishers, Dordrecht, 365–379.

WAINHOUSE, D. (2005).
Ecological methods in forest pest management.
Oxford University Press, Oxford.

Enquiries relating to this publication should be addressed to:

David Wainhouse
Forest Research
Alice Holt Lodge
Wrecclesham
Farnham
Surrey
GU10 4LH

T: 01420 22255
F: 01420 23653
E: david.wainhouse@forestry.gsi.gov.uk

ISSN 1460-3810
ISBN 978-0-85538-730-3

© CROWN COPYRIGHT

FCPN014/FC-GB(ECD/CLM)/ALDR-2K/JUN07