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The Assessment of Site Characteristics as Part of a Management Strategy to Reduce Damage by *Hylobius*

INFORMATION NOTE

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SUMMARY

The severity of *Hylobius* damage to forest transplants is influenced by both plant and site factors. These have to be considered in order to determine the likely risk to the crop. A structured evaluation of the site to be restocked should enable forest managers to target treatments and to select the most cost-effective strategy to reduce plant damage and to protect the environment and operators. A table summarises the key factors and identifies their likely effect on damage levels.

INTRODUCTION

1. Young trees of all species, both conifers and broadleaves, are susceptible to damage by the large pine weevil, *Hylobius abietis*. Breeding of *H. abietis*, however, occurs only in conifers and following the felling of such crops, losses of plants used for restocking can be extremely high, with an estimated national average of 50% of untreated plants being killed over the first few years of establishment. This threat exists throughout the UK and northern Europe. The area of conifers in Britain being felled and restocked is forecast to increase from 10 000 to 15 000 ha per year by 2010 and proportionate losses can be expected to be at least as great as present levels.

2. Damage to untreated plants varies widely both between forests and from year to year. This is caused by a range of factors that influence both the insect population and the damage it causes. Some factors, such as the species and provenance of the previous crop, may be outside management control, but others may be introduced into management practice to reduce the risk of damage.

3. Currently, insecticides provide the most effective method of protecting plants from damage. However, there is an urgent need to adopt a new approach to the management of this pest as public concerns about the use of chemicals in the environment increase and legislation concerning the use of chemical pesticides necessarily becomes more stringent. This Note proposes an assessment of site characteristics to determine the risk to the crop and to enable the use of insecticides to be targeted more precisely using lower quantities, or eliminated for some sites. As the advice is based on preliminary research findings it should be seen as providing interim guidance on the likely implications of management decisions rather than defining a precise management system for *Hylobius*. It is intended that future Notes will explore the potential for managing *Hylobius* damage through aspects of silvicultural practice.

THE BIOLOGY OF *HYLOBIUS*

4. The immature stages (larvae) of *Hylobius* feed under the bark of stumps and roots where they do no economic damage. However, following a period as a pupa, adults emerge and search for food. They prefer to feed on the bark of young conifers and broadleaves, which will die if the stem is girdled.

5. There are several features of *Hylobius* biology that make this pest difficult to manage. Firstly, the adults may live for up to 4 years and can be present on the site in large numbers unnoticed because of their nocturnal habits. Unless specialist sampling systems are used, their presence is indicated only by the death of plants. Secondly, there are two peaks of *Hylobius* adult feeding activity each year, but their timing and magnitude varies considerably between forests and from year to year. It is thus difficult to predict the need for protective measures and their timing. Thirdly, because the eggs, larvae and pupae develop underground in the bark of roots and stumps, they are difficult to monitor and to control using chemicals. For all these reasons, prophylactic treatment of plants with insecticide is a necessary precaution to protect them from damage. Unfortunately, this has no significant effect on the overall population of insects.

FOREST MANAGEMENT: ITS EFFECT ON POPULATIONS AND DAMAGE LEVELS

6. The potential for damage from *Hylobius* is exacerbated by the current management of plantations in which felled trees produce a large resource suitable for the insect's development in the stumps and roots. At the same time, food available for the adults, such as the finer twigs in the crowns of remaining standing trees, is reduced. The size of the *Hylobius* population and its rate of development on an area of restocking are influenced by both the silvicultural management of the site and its proximity to previous areas of felling.

Site characteristics

7. **Previous crop:** *Hylobius* damage should only occur when the previous crop contained conifers or was adjacent to a felled conifer crop. A felling site within a totally broadleaved woodland may be regarded as having no risk from *Hylobius*.

8. The **species and size** of the previous crop may affect the population; for instance plantations of small prematurely felled lodgepole pine quickly generate high populations of *Hylobius* compared with spruce sites. On the other hand, stumps in older Douglas fir, Scots pine and larch crops remain suitable for insect development for several years although, overall, the *Hylobius* population may be smaller. Lodgepole pine sites must be regarded as very high risk whilst all other species will result in a medium risk.

9. **Windthrow and snow damage:** *Hylobius* will not breed in live plants. Therefore the stumps of trees with snow damaged crowns and also of trees that have been windthrown, but not killed, will not result in a local increase in *Hylobius* populations. The insect will, however, exploit broken tops and any fallen branches in contact with the ground. Any trees within the standing crop that die before felling, such as suppressed trees, plants with waterlogged roots, and trees killed by insects or fire, will also be suitable for *Hylobius* development. In natural forests, such trees are the only breeding sites available and *Hylobius* is well adapted to exploiting such sparse resources quickly and effectively. Sites that have suffered significant death of trees within 6 years prior to felling must be regarded as having a high resident *Hylobius* population ready to exploit the large number of stumps produced during a felling programme.

10. **Other previous crop factors:** Past thinning regimes are not likely to be important unless they have occurred within 6 years of the clear fell. *Hylobius* will develop within a standing crop in stumps left after thinning, but because the stumps are shaded and cool, the rate of development is likely to be very slow. In such situations, it may take the larvae up to 4 years to complete their development. Adults developing in this situation will form a resident population able to exploit a clearfell site very rapidly.

11. **Isolation of the site:** *Hylobius* adults can fly considerable distances and may travel over 2 kilometres in a few days. For this reason, all areas of felled conifers are likely to be invaded by weevils migrating to the site during the first summer after felling. The nearer the site is to older felled areas, the larger the initial population is likely to be and therefore the greater the risk of damage. The proximity and population density of previous generations of adults determines the rate at which the insects invade the site and exploit the stumps. Large areas of contiguous felling over a number of years will tend to generate greater problems of *Hylobius* damage.

12. **Standing mature trees:** Adults will feed on smaller shoots in the crowns or lower branches of large trees. Damage to plants within 15 m of the edge of felled areas is likely to be reduced by adult *Hylobius* moving to the surrounding standing crop to feed. Any felling practice that leaves remnants of a standing crop will reduce damage to nearby plants. Where species such as larch and Scots pine have been left standing as seed trees or for other management, the reduction in damage may be slight. However there may be considerable protection afforded by felling regimes such as strip felling so that all parts of the restocking site are only a few metres from nearby standing trees.

13. **Time of felling:** The development of *Hylobius* populations is greatly affected by the time of year the previous crop is felled. Adults are thought to be attracted into the area for oviposition by volatile chemicals from the cut stumps. Insects will be attracted to sites where the brash and stumps are still fresh and these sites are likely to generate the largest populations. Most at risk are areas felled between January and May when the stumps are colonised quickly, leading to emergence of the new generation of insects during August of the following year. Sites that have been felled between June and December are less attractive to the insects and provide a longer period before emergence of the new generation.

Site management

14. **Fallow periods:** The greatest plant damage occurs from adults emerging from stumps during the second August after felling. If sites are left unplanted to allow the *Hylobius* population to decline before planting takes place the risks of damage will be reduced accordingly (i.e. the highest risk is to sites felled between 10 and 21 months prior to planting). However, because the larvae take at least 18 months to develop and adults may live for up to 4 years, significant damage may still occur 5–6 years after felling. Stumps in older Douglas fir crops remain suitable for insect development for several years and, whilst overall the *Hylobius* population may be smaller, the insects tend to be active on the site for much longer. Insects may also invade from adjacent younger sites making the use of a fallow period difficult, especially when policies of smaller, contiguous, felling rather than a single, larger clearfell are being pursued.

15. **Rapid planting:** Because the greatest damage is caused by adults developing and emerging from stumps at least 18 months from the time of felling, it should be possible for plants planted soon after felling to have grown through their most vulnerable period. However, in practice significant damage may be caused by insects invading from nearby older restocking sites within the first 18 months. Account must, therefore, be taken of the proximity of the site to the nearest felling site (see paragraph 11).

16. **Ground preparation:** Cultivation systems will not affect populations of *Hylobius* larvae developing in stumps. However, planting in areas of exposed mineral soil will reduce damage to plants. Cultivation that exposes bare mineral soil is beneficial, but where the brash has been raked without exposing mineral soil damage will not be reduced. If a site has been cultivated, planting should be centrally on mounds or screefs unless this will result in loss of plants due to desiccation or erosion.

17. **Brash treatments:** Stumps under the brash mat generally have fewer *Hylobius* larvae than in more open areas. The brash mat itself will not contribute significantly to the insect population and adult feeding on plants tends to be reduced within an undisturbed brash mat.

18. **Controlled burning:** When felling debris is cleared from the site by use of controlled burning, heat from the fire does not penetrate deep into the ground. *Hylobius* larvae under the bark of the stumps are unaffected by the fire and the blackened surface will absorb heat from the sun to increase the rate of insect development. When the insects later emerge as adults there is usually no vegetation on the site on which they may feed other than the young trees. Mineral soil is not exposed by fire and, therefore, burning does not achieve the same benefits as cultivation (see 16).

19. **Stump removal:** If stumps and the major parts of the root systems are pulled from the ground and piled into windrows, they are likely to deteriorate and quickly become unsuitable for egg laying. However if this is done after the egg-laying period of May and June, the larvae already in the stumps can continue to develop under the bark and damage levels will not be reduced. It is likely that damage will be greatest to plants within 5 m of windrows.

20. **Stump destruction:** *Hylobius* larvae can develop in roots less than 10 mm in diameter and may move through the soil if their food source is depleted. However, most of the larvae are found close to the body of the stump just below the soil level. Unless the system removes all parts of the stump (above and below ground) together with the major parts of the root systems, it will have no significant effect on damage levels.

21. **Vegetation (woody plants):** *Hylobius* adults feed on a wide range of woody weeds including willow herb, bramble, birch and natural conifer regeneration. When this type of vegetation is present on the site it is likely that damage pressures will be reduced. If it is necessary to control woody weeds, spot treatment with herbicides is preferable (Forestry Commission Fieldbook 8).

22. **Vegetation (grasses):** *Hylobius* adults do not feed on grasses but, when feeding on forest plants, prefer the cover provided by dense grass growth. If plants are tightly surrounded by tall grass, feeding damage may occur higher up the stem than is usual. Unfortunately, *Hylobius* adults prefer grass that has been controlled using herbicides and cultivation seems to be the only way to reduce the negative effects of grasses on damage levels.

Plant characteristics

23. **Species:** ALL species of both broadleaves and conifers are susceptible to damage. Young trees vary in their vulnerability to serious damage: while Douglas fir may

remain susceptible to serious damage for several years, 3-year-old transplants of Sitka spruce are unlikely to suffer fatal damage 2 years after planting, although extensive superficial feeding may have occurred.

24. **Plant size:** Some insecticide treatments need to be ingested by the insect before they are effective. Under these circumstances, small amounts of bark damage may occur even though the treatment kills the insect. It is important that the plant is large enough to withstand limited feeding of this type. All plants should have a root collar diameter of at least 5 mm. Generally, plants should be between 30 cm and 40 cm in height.

USING RISK FACTORS TO DEVELOP SPECIFIC MANAGEMENT STRATEGIES TO REDUCE *HYLOBIUS* DAMAGE

25. The risk factors described provide a summary of those elements of forest management that have direct influences on breeding and subsequent damage from *Hylobius*. Assessing the risk of damage on a restocking site should enable forest managers to adopt the appropriate strategy to minimise the use of insecticides. For instance, on isolated, small restocking sites it should be possible to reduce damage to acceptable levels by use of good ground preparation such as by mounding and delayed planting. On large sites with a previous crop of lodgepole pine, it may not be possible to avoid severe losses in the new crop without the use of insecticides. New research into the link between felling date and both the timing and extent of *Hylobius* activity on site will provide a more quantitative basis for assessing and avoiding risks. Combined with more direct strategies, such as biological control of breeding populations in the stumps, decision support systems for management on a site-specific basis are likely to be developed over the next 3–4 years.

Using the table of risk factors

26. The following table provides a method to provide a rough indication of the level of damage that might be expected at a restocking site. The numbers in the first column refer to the paragraphs in the main text, which provide more detailed information on each factor. The primary determinant of the size of the initial weevil population is taken to be the species of the previous crop. The other factors shown in the table may modify the damage that this population causes (shown in the last column). There is insufficient knowledge to quantify the magnitude of these affects and although we suspect that there will be interaction between some factors, the precise details are not understood. The affect of the factors on the level of damage (given in column 3) may be defined as follows:

Increase	these factors will tend to increase damage levels caused by the population.
Neutral	it is unlikely that there will be a significant effect on damage levels.
Delay	the peak of damage may be a year later than otherwise expected.
Decrease	the factors will result in a significant reduction in damage.

Table 1 Risk factors

Paragraph	Risk factor	Level of population	Effect on damage
	Previous crop		
7 & 8	**Species**		
	Lodgepole pine	very high risk	
	Other conifers	high risk	
	Only broadleaves	low risk	
9 & 10	**Quality of crop before felling**		
	Large quantities of conifer stumps or dead wood 0–6 yrs prior to felling		increase
	Large quantities of conifer stumps or dead wood 7+ yrs prior to felling		neutral
	Small quantities of conifer stumps or dead wood		neutral
	Felling		
13	**Time of felling**		
	Felled between January and May		neutral
	Felled between June and December		delay
12	**Felling system**		
	Clearfelling total area larger than 1ha		increase
	Clearfelling total area smaller than 1ha		neutral
	Standing mature trees on site (i.e. strip felling, continuous cover or seed trees)		decrease
	Site location		
11	**Isolation from other felling sites**		
	Less than 5 km from 0–4 year old conifer clearfell		increase
	Between 5–11 km from 0–4 year old conifer clearfell		neutral
	At least 11 km to nearest 0–4 year old conifer clearfell		decrease
	Site preparation		
	Stump treatments		
19 & 20	Stump removal (felled after July and de-stumped before following May)		decrease
	Stumps removed all other times		neutral
14 & 15	**Delayed planting (fallow periods)**		
	Planting 0–4 years after felling		increase
	Planting 5–6 years after felling		neutral
	Planting 7 or more years after felling		decrease
16	**Ground preparation**		
	Needle litter left undisturbed		neutral
	Planting in bare mineral soil (exposed by mounding or screefing)		decrease
	Brash treatments		
17	Brash raking		neutral
18	Controlled burning of brash		increase
	Vegetation and weed control		
21	Woody plants surrounding planted stock (no herbicide or spot treatments)		decrease
	Woody plants surrounding planted stock treated with herbicide		increase
22	Dense grass growth with or without herbicide treatment		increase
	Plant specification		
23	**Plant species**		
	All conifer species		increase
	All broadleaf species		neutral
24	**Plant size**		
	Small plants		increase
	Large plants		decrease

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