Forestry Commission

Minimising the impact of the great spruce bark beetle

Practice Note

December 2012

The great spruce bark beetle is found in forests throughout continental Europe. It damages spruce trees by tunnelling into the bark of the living trees to lay its eggs under the bark. The developing larvae feed on the inner woody layers, which weakens, and in some cases may kill, the tree. The beetle was first discovered in Britain in 1982 after it was accidentally introduced – most likely via a consignment of imported timber. It has become an established pest in the west of England and Wales but more recently it has expanded its range to southern Scotland. The good news for forest managers is that the beetle can be effectively managed by the controlled release of its natural predator *Rhizophagus grandis*. This Practice Note provides managers with a framework for assessing the risks to forests and advice on what to look out for if trees are affected. Guidance is given on the control techniques that have been developed to minimise the impact of the beetle and what action should be taken if the beetle is found.

Introduction

The great spruce bark beetle *Dendroctonus micans* is found in forests throughout much of Eurasia, from eastern Siberia to the west of Europe – practically everywhere that spruce trees are grown. The beetle breeds under the bark of trees causing damage to the cambium, which debilitates and, in extreme cases, causes the death of the tree. It was first discovered in Britain in 1982, although attacks dating back to 1973 have now been identified. Until 1996, when an outbreak was discovered in Kent, it was thought to be restricted to the west of the country – mainly in Wales and adjoining English counties (which became designated as the '*Dendroctonus micans* control area').

In 2003, following the discovery of other new outbreaks in the Lake District and in southwest Scotland, the Forestry Commission reviewed plant health controls and carried out a consultation exercise with the forestry industry.

Two options were presented as a response to the new outbreaks:

- An extension of the designated *Dendroctonus micans* control area and a continuing policy of restrictions on the movement of timber into Scotland and the northeast of England (known as the '*Dendroctonus micans* protected zone').
- Revocation of Great Britain's European Union (EU) protected zone status.

The second of these options was agreed and the EU Plant Health Directive was amended accordingly. From 15 May 2005, the movement of conifer wood and conifer bark *within* Great Britain was no longer subject to any treatment requirements. At the same time, part of the west of Scotland was designated as as a 'Pest-free area', so that wood with bark, and isolated bark, may be moved to other controlled areas in the EU (currently Greece, Ireland, Northern Ireland, the Isle of Man and Jersey) without treatment under the EU plant passport regime.

Britain now relies on biological control methods to minimise the damage caused by the beetle – in particular the use of the specific predator of the great spruce bark beetle, the exotic beetle *Rhizophagus grandis*, to manage outbreaks.

Vulnerable tree species

The great spruce bark beetle attacks and breeds in all species of spruce grown in Britain. Forest managers are concerned mainly with Sitka spruce (*Picea sitchensis*) and Norway spruce (*Picea abies*). The probability of a successful attack and consequent tree mortality varies between spruce species, as Table 1 shows.

Table 1

The susceptibility of different species of spruce to initial attack by the great spruce bark beetle and the likelihood of tree death.

Risk	Susceptibility to initial attack	Likelihood of tree death
High	Norway spruce (*Picea abies*) Canadian spruce (*Picea alba*) Omorika spruce (*Picea omorika*)	Omorika spruce (*Picea omorika*) Colorado spruce (*Picea pungens*) Oriental spruce (*Picea orientalis*)
Medium	Colorado spruce (*Picea pungens*) Oriental spruce (*Picea orientalis*)	Sitka spruce (*Picea sitchensis*) Canadian spruce (*Picea alba*)
Low	Sitka spruce (*Picea sitchensis*)	Norway spruce (*Picea abies*)

Although the ultimate destructive capability of the beetle is greater on Sitka spruce, adult beetles prefer to attack Norway spruce, even when planted in mixtures. This host preference should be remembered when looking for signs of beetle activity.

Effects on the host tree

The rate and extent of damage to individual trees and forests is variable. Neither the beetle nor its larvae burrow into the wood itself and, consequently, provided the wood is salvaged before the tree is completely dead, the timber is not spoiled in any way. Trees are killed by being completely girdled, at one or more points along the stem, although this may take several years of sustained attack. However, large breeding populations may be being built up long before individual trees are killed, creating a risk of spread to adjacent and nearby trees.

Figure 1 Norway spruce showing typical 'top death' resulting from a well-established attack. Continued attack may result in tree death.

Beetle biology

The great spruce bark beetle is among the largest of the bark beetles. A single female beetle can colonise a tree, without the necessity of the 'mass attack' typical of most bark beetles. It has a long life cycle, ranging from 12–18 months under British conditions. This results in extensive overlap of generations so that it is possible to find any stage at any time of year. However, there are periods, particularly in the winter, where most may be at the same stage. The life cycle stages are set out below.

Adult

Adult beetles (Figure 2a) are 6–8 mm long and 2.5–3 mm wide. They are black when mature with a covering of orange hairs. The large size of the beetle enables the females to withstand the resin flow produced when they bore into the bark of trees.

Egg

Eggs are laid within a small egg chamber in the cambium of the tree. Each female can produce up to 300 eggs, laid in groups of 50–80, in interconnecting chambers. Eggs are normally laid on one side of the chamber (Figure 2b).

Figure 2a The adult great spruce bark beetle (*Dendroctonus micans*).

Figure 2b The egg chamber of the great spruce bark beetle.

Figure 2c Mature larvae of the great spruce bark beetle.

Larva

The beetle has five larval stages (instars) which each become progressively larger (Figure 2c). All larval stages feed under the bark in a similar manner: larvae feed side-by-side packing powdery wood debris (or 'frass') and diseased or dead larvae behind them into islands away from the main feeding site. The mixture of resin and frass forms a distinctive quilted pattern which is illustrated in Figure 6 on page 4.

Pupa

Pupae are the immobile resting stage of beetle development before larvae can moult to the adult stage. Pupae are found in pupal cells among the larval frass (Figure 2d). They are often found in close proximity and give rise, upon emergence, to aggregations of adults under the bark. These stages may be prolonged over several weeks or months depending on temperature.

Newly emerged adults

The newly emerged adults are light brown in colour (Figure 2e). As they mature the colour darkens to brown and black. Adult beetles move within and between trees mainly by crawling (at temperatures of 12 °C or greater), but they occasionally fly (at temperatures of 22.5 °C or greater).

Figure 2d Pupae of the great spruce bark beetle.

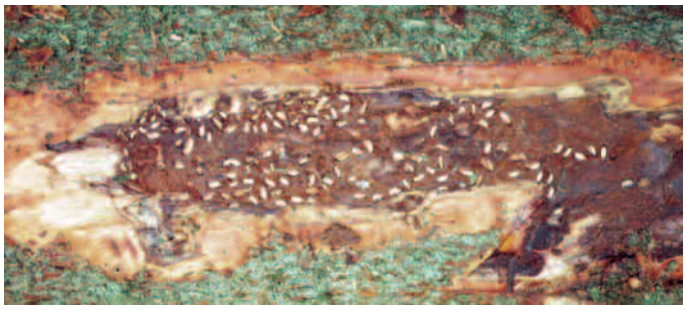


Figure 2e The newly emerged adult beetles are light brown.

Identifying infested trees

The detection of great spruce bark beetles is entirely dependent on visual surveys. (Because the beetles do not use pheromones to detect one another, insect traps using these are ineffective.) Visual surveys are carried out in three main stages:

1. Overall tree health

Look out for signs of poor tree health. Check especially for isolated or small groups of dead or dying trees characterised by browning of foliage over some or all of the crown (Figure 1).

2. Damage to bark

The entry of female beetles into the bark of trees gives rise to characteristic 'resin tubes' on the trunk (Figure 3). Resin tubes and granular resin at the base of the tree (Figure 4) are reliable signs of stem or root attack. Resin tubes vary in colour from white and cream, to shades of purple and brown. They may be accompanied by copious resin bleeds (Figure 5). Loose bark with exposed beetle galleries (Figure 6) usually indicates older infestations that have been attacked by woodpeckers.

3. Under the bark

Inspect the bark around resin tubes, particularly those that are purple to brown. A hollow sound when the bark is tapped often indicates successful attack. Remove the bark carefully and inspect for signs of the beetle. The most characteristic indicator is the presence of a mixture of insect faeces (frass) and bark packed into 'islands' creating a quilted appearance (Figure 6). All beetle stages, from egg to adult, may be present.

Figure 3 Resin tubes created on the bark of a spruce tree following attack by the great spruce bark beetle.

Figure 4 Resin tubes at soil level accompanied by granular resin are characteristic of ground level attack by the great spruce bark beetle.

Figure 5 Copious resin bleed on the trunk of a spruce tree.

Figure 6 Brood area in Sitka spruce showing the quilted appearance of the larval feeding chamber, which is characteristic of this beetle.

Assessing risk to trees

If a stand of trees is currently free of the great spruce bark beetle, the risk of a new attack is dependent on the proximity of the stand to other existing infestations. Adult beetles move within and between trees mainly by crawling, but they occasionally fly and so can disperse to more distant trees; isolated stands up to 7 km from known infestations have been known to be colonised. The risks of attack increase with proximity to extraction and haulage routes and also to main roads. Vigilance in these situations must be high at all times; the earlier any infestation is detected, and controls initiated, the better the chances of controlling a potential outbreak.

Evidence from worldwide studies of bark beetles in general, and of the great spruce bark beetle in particular, indicates that a number of factors are associated with the probability of initial attack by beetles and the subsequent rate of spread. Table 2 sets out these factors, which must be taken into account when preparing a pest risk assessment.

The factors have a compounding effect, which is that they can act together to substantially increase the susceptibility of a stand of trees. Consideration of each factor should enable forest managers to identify, using local knowledge, any stands that are at a high risk of infestation and which may require control measures to be implemented.

Table 2 Factors that should be taken into account when preparing a pest risk assessment.

Factor	Increased risk of attack
Location	• Within 7 km of infested stands. • Close to public roads and forest roads leading from infested areas.
Tree/stand age	• Mature and veteran trees.
Climate	• Conditions giving rise to tree stress: for example, low rainfall; low soil moisture; exceptionally dry (or wet) summers.
Windthrow	• High incidence of wind-related problems such as snapped top, windthrown trees and root disturbance.
Site	• Poorly suited to spruce growth. • Previous management. • Extraction damage, brashed trees. • Soil compaction. • Climber damage.
Tree growth	• Poor growth. Malformed trees with multiple forks and other growth irregularities.

Managing risk to trees and stands

As the detection of the great spruce bark beetle is dependent on visual surveys, vigilance is necessary for stands that are at risk. Management operations and choice of species need to be carefully considered as these can influence the level of risk.

Inspection regime

Regular and thorough inspections must be carried out in stands identified to be of high risk. These inspections should be carried out at least annually. General inspection by operational staff in the course of their work is sufficient in low-risk stands but a pest risk assessment should be carried out at 1–2 year intervals since risk levels may change. In particular, new infestations may have become established in the area during the interval between inspections, thus increasing the risk to other stands.

Management operations

Any damage to stems and live branches, e.g. through thinning, brashing and pruning, will encourage beetle attack. Care should therefore be taken to avoid damaging standing trees and live branches when carrying out felling or brashing; pruning should normally be avoided. Similarly, the creation of new road lines, which involves the removal of trees, should be carefully planned to avoid or minimise direct or indirect (e.g. windthrow) damage that could facilitate beetle attack.

Species choice

The selection of suitable tree species for planting should be based on normal management criteria (e.g. site suitability). Thus, if spruce is the obvious choice in terms of management objectives, it should still be planted. If there is a choice between spruce and another equally suitable species that would also meet management objectives, then it would be sensible to consider alternatives to spruce.

Managing infested stands

Thinned stands

Thinning operations provide the opportunity to remove infested or highly susceptible trees during the course of normal management. Where practicable, infested trees should be selectively removed during normal thinning. This may involve a separate survey to identify infested trees and therefore it could represent extra time and labour costs. The extent of such special selection should be related to the risk assessment, i.e. more effort should be put into high-risk stands.

In low-risk stands it is enough for operational staff to keep a close watch on felled trees and to spot peel the bark associated with infestations if they are found (Figure 7). Any larvae in brood chambers exposed in this way will quickly die. Note that, by thinning and opening the canopy, the susceptibility of the stand may increase – partly because the conditions in the stand will be more suitable for beetle development, but mainly as a result of damage to remaining trees during extraction. However, the overall change in risk should be small if care is taken to minimise damage during thinning.

Figure 7 Selective removal of tree bark will expose brood chambers.

Unthinned stands

Unthinned stands should be surveyed annually, with survey intensity related to the risk assessment, so that newly established or rapidly increasing beetle populations are detected. However, it may be impracticable to detect the early stages of infestation. Stands particularly prone to windthrow and windsnap should be inspected more frequently, since conditions more conducive to beetle development will be created. Unless there is a significant probability of extensive tree mortality, the use of biological controls should be the only measure needed in these stands.

Biological control

In 1984, the specific predator of the great spruce bark beetle *Rhizophagus grandis* (Figure 8), found within the beetle's natural range, was introduced and released into infested sites under licence from the UK statutory conservation agencies. *R. grandis* has proved very efficient at controlling beetle populations, and has been more effective than the system of surveys, sanitation felling and controls on the movement of wood and bark residues that were initially put in place to reduce populations of the beetle.

Figure 8 *Rhizophagus grandis* beetles reared for release.

Breeding *R. grandis* for release was initially a difficult, time-consuming and expensive process. However, considerable progress has been made in improving the rearing system and the resulting increase in efficiency and flexibility means that each adult now costs around only £0.10 to rear for release. In addition, because *R. grandis* has an extremely well-developed ability to find its prey, together with a rapid reproductive rate, only small numbers of individuals are needed to control each new outbreak –typically around 100 adults per site.

While *R. grandis* will never entirely eliminate all great spruce bark beetle populations, they will reduce them by between 80% and 90%. Research into the populations of the bark beetle in the original infested forests in Wales and the Marches has provided clear evidence that populations of the pest were reduced to virtually undetectable levels within 5–7 years of release of *R. grandis*. Tree mortality is now less than 1% and can be as low as 0.25%. Nevertheless, there are still small populations of the bark beetle present, which ensures the continuing survival of this efficient predator and movement controls are still essential to prevent the introduction of the pest into protected zones elsewhere in the EU.

Designated areas

Protected zones

A 'Protected zone' is an area where, despite favourable conditions for specific pests to establish, they have not done so. Keeping pests out of Protected zones is a key objective of the EU controls set out in the Plant Health Directive. Host material coming from countries outside the EU must be accompanied by a phytosanitary (plant health) certificate confirming that the entry requirements have been met. Imports are subject to inspection on arrival. Similar material originating within the EU must meet the same requirements and, for conifer wood, it must have a plant passport unless it is bark-free. There are three options for sending conifer wood into a Protected zone:

- The wood may be bark-free*
  (no plant passport required).
- The wood may be kiln-dried
  (plant passport required, unless it is also bark-free).

*Wood from which all bark, excluding the cambium, ingrown bark around knots, and bark pockets between rings of annual growth, has been removed.

- The wood originates in an area known to be free of the pests listed as being of concern to the Protected zone (plant passport required, unless the wood is also bark-free).

Similar controls apply to consignments of conifer bark, which must always be accompanied by a 'plant passport'. This will confirm either that the consignment originated in a Pest-free area or that it has been treated by an appropriate treatment against bark beetles, e.g. heat treatment, composting or pulverisation to a particle size of less than 6 mm. The use and storage of the fumigant methyl bromide was banned in the EU in March 2010 and therefore this is no longer available as an appropriate treatment against bark beetles within EU member states.

An EU Member State must carry out annual surveys and publish the results to keep its Protected zone status and to demonstrate the absence of the pest or pests concerned. In some cases it is possible to retain Protected zone status even though the pest is present. However, appropriate measures aimed at eradicating the pest must be in place.

Pest-free areas

A Pest-free area is an area in which a specific pest does not occur as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially monitored. Pest-free areas differ from Protected zones in that they do not have to have a statutory listing. Forestry traders may be authorised to issue plant passports to accompany untreated consignments originating from designated Pest-free areas.

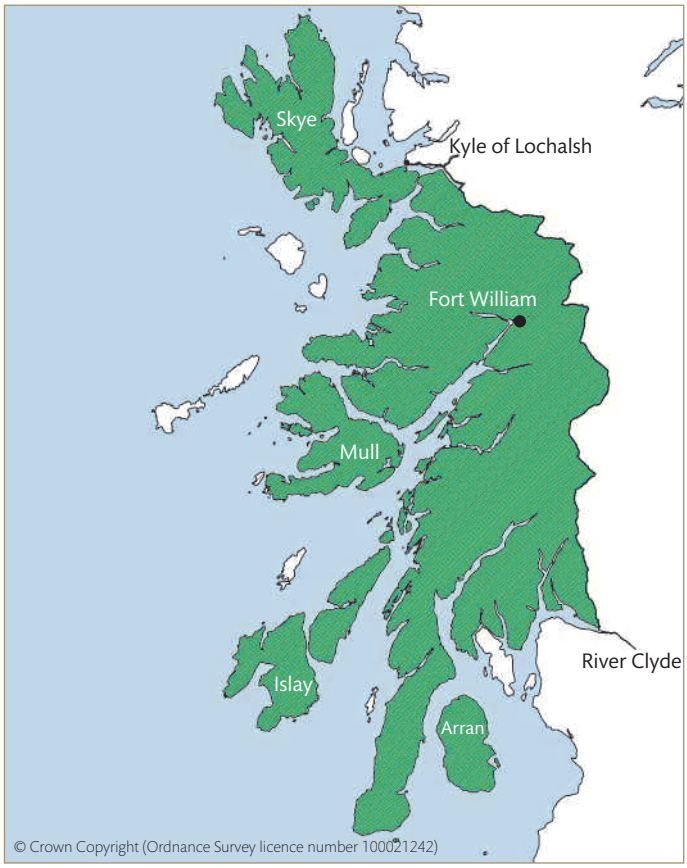
In Great Britain, an area in the west of Scotland has been designated as a Pest-free area (Figure 9). It is regularly surveyed by the Forestry Commission as part of its ongoing programme (which follows the protocol set out in the International

Plant passports

Within the Single Market, plant health checks are focused on the place of production. There are no border checks for plants and plant products travelling between EC member states, although spot checks may take place anywhere in the trade chain. A limited range of material which hosts the most serious 'quarantine' pests and diseases requires a plant passport to facilitate its movement. Where required, a passport is needed both for movements within and between member states, and additional requirements apply for movements into and within EC Protected Zones.

Under the Plant Health Directive, where there is no fear of spreading pests, EU Member States may exempt certain material, other than plants for planting, from plant passport requirements where it is being moved within a local market. Under these provisions the Forestry Commission does not to require plant passports to accompany either wood or bark where the destination is within Great Britain.

Figure 9 The designated Pest-free area in the west of Scotland.



Standard ISPM04 for determining a pest-free area) and has been found to be free of great spruce bark beetles, the six-toothed spruce bark beetle (*Ips sexdentatus*) and the large larch bark beetle (*Ips cembrae*). These bark beetles all occur in other parts of Great Britain but have never been recorded in, or close to, the area shown in Figure 9. All three are pests against which Ireland, including Northern Ireland, have Protected zone status and where a market for roundwood currently exists. The designation of this part of Scotland as being free of these pests enables producers within the area to supply this market without the need for ensuring timber is bark-free or kiln-dried. Consignments of conifer wood from other parts of Great Britain to any of the relevant EU Protected zones must continue to be bark-free or kiln dried. Isolated bark of conifers must have been subjected to an appropriate treatment against bark beetles. The relevant protected zones for each of these pests are shown in Table 3.

Table 3 Protected zones for bark beetles.

Pest	Protected zone
Great spruce bark beetle *Dendroctonus micans*	Greece, Ireland, Northern Ireland, Isle of Man, Jersey.
Large larch bark beetle *Ips cembrae*	Greece, Ireland, Northern Ireland, Isle of Man.
Six toothed bark beetle *Ips sexdentatus*	Cyprus, Ireland, Northern Ireland, Isle of Man.

New outbreaks of bark beetles

New discoveries of the great spruce bark beetle or evidence of bark beetle activity should be reported to the contact opposite. If evidence of bark beetles is found in the Pest-free area, all authority to issue plant passports will be withdrawn while the situation is investigated. Depending on the outcome of surveys, it may be necessary to re-define the Pest-free area, or remove it entirely. If the outbreak is of a limited nature, it may be possible to mount an eradication programme, but Pest-free status will not be restored until two successive annual surveys have demonstrated freedom from pests.

The need to treat the forest with the beetle predator *R. grandis* will also be assessed. This will depend on how many infested trees are found and whether the outbreak is inside or outside the known infected area. If many infested trees are found, or if the infestation is outwith the known infested area, arrangements will be made to treat the woodland with *R. grandis* as part of the ongoing release programme. All requests to treat infested trees and forests with *R. grandis* should be addressed to the contact opposite.

Preventing the spread of beetles

Two simple hygiene precautions should be taken to minimise the risk of accidental introduction and spread of new pests in the Pest-free area:

- Lorries and forestry machinery should be cleaned of all plant debris, especially loose bark and branchwood or chips before starting their journey to the Pest-free area.

- Vehicles should be checked again on arrival at the destination in the Pest-free area and any such debris found should be removed and safely disposed of.

Useful sources of information

Forestry Commission publications

- The UK Forestry Standard
- Biosecurity: good working practice for those involved in forestry

Other publications

- Requirements for the establishment of pest free areas (ISPM04) International Standard for Phytosanitary Measures [www.ippc.int]

Legislation

- The Plant Health (Forestry) Order 2005 (as amended) [www.legislation.gov.uk]

- Commission Regulation (EC) No 690/2008 recognising protected zones exposed to particular plant health risks in the Community. [www.europa.eu]

Contacts

New discoveries of the great spruce bark beetle or evidence of bark beetle activity should be reported to:

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