Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Neodiprion abietis

Date: August 2023

Summary and conclusions of the rapid PRA

Neodiprion abietis (the balsam fir sawfly) is a sawfly native to North America that attacks coniferous species, including fir, spruce, and pine. Described as a serious pest in Canada, *N. abietis* feeds on host needles, leading to defoliation, reduced growth, and mortality of the host plant. Historically, outbreaks in Canada are localised and periodically last 3-4 years however, in recent years, the outbreaks are larger scale and last much longer. It is expected that this pest could establish in the UK and cause significant damage.

Risk of entry

Various life stages of this pest could be associated with the host plants for planting or host branches and cut trees, however these pathways were rated very unlikely with a high confidence due to the existing prohibitions on these commodities from non-European countries. Natural spread was given a similar rating, given the pest's current distribution. Finally, hitchhiking on non-host plants, as previously intercepted in the Netherlands, was rated as unlikely with medium confidence, considering its strong host preference for oviposition.

Risk of establishment

Outdoor establishment of *N. abietis* was rated likely with medium confidence. The balsam fir sawfly has multiple hosts that are present in the UK, though some uncertainty remains regarding its host range. In addition, the current distribution of *N. abietis* spans climates that are similar to the UK.

By comparison, establishment under protection was rated very unlikely with high confidence, given that its hosts are cultivated outdoors. No infestations of the pest have been reported indoors.

Economic, environmental and social impact

Neodiprion abietis could have a significant economic impact in the UK, given that multiple known hosts are grown for forestry, in estate woodlands or plantations for timber, or for ornamental purposes. The economic impact was rated medium, given that a pest outbreak could impact survival or growth of these trees. A low confidence was provided with this rating, as there is some uncertainty surrounding the host range of the balsam fir sawfly. As defoliated ornamental species would affect the aesthetic appeal of parks, botanic collections and gardens, the social impact of this pest was rated as small with high confidence.

Any defoliation or tree mortality could negatively impact native species that rely on the trees for their survival. As tree mortality is less frequently reported in the literature, the environmental impacts were rated small. Medium confidence was provided, again reflecting the uncertain host range.

Endangered area

Woodland areas and plantations of conifer hosts are most at risk from this pest, though urban spaces with these host species are also threatened. One study suggests that only certain parts of the UK, including Wales, Scotland, and northern areas of England, are at risk of this pest due to the presence of host species combined with other environmental factors.

Risk management options

Given the damaging nature of this pest, and the presence of many of its hosts in the UK, some of which play significant roles in the forestry industry, exclusion of *N. abietis* is the preferred option. There is already an existing prohibition on the import of plants for planting, branches and cut trees of the confirmed hosts (*Abies, Larix, Picea, Pinus, Pseudotsuga* and *Tsuga*) from non-European countries, including all the countries identified within the distribution of the balsam fir sawfly.

If a pest outbreak occurred in the UK, eradication should be attempted with the destruction of all associated material, and the application of general pesticides to eliminate any remaining sawflies, followed by re-inspections of the site over time.

Key uncertainties and topics that would benefit from further investigation

A key uncertainty is regarding the host range of this pest and whether it would attack species deemed uncertain hosts, or European conifer species. This could impact the rating for establishment and potential impact of the balsam fir sawfly in the UK.

If this pest spread to a European country, it would also be useful to understand the natural capability of *N. abietis* to disperse.

Images of the pest

	
Adult female © National Reference Centre, Wageningen (NL)	Empty cocoon on foliage © National Reference Centre, Wageningen (NL)

Is there a need for a detailed PRA or for a more detailed analysis of particular sections of the PRA? If yes, select the PRA area (UK or EPPO) and the PRA scheme (UK or EPPO) to be used.

No	✓

Yes		PRA area: UK or EPPO		PRA scheme: UK or EPPO	

Given the information assembled within the time scale required, is statutory action considered appropriate / justified?

[The text below is a recommendation by the risk analyst which requires approval by PHRG]

Yes Statutory action	✓	No Statutory action	

There is a significant risk that if *Neodiprion abietis* entered the UK, it would become established outdoors and cause high losses to the forestry industry via its impact on coniferous hosts.

However, this Pest Risk Analysis concludes that the pathways for entry range from unlikely to very unlikely, mainly since *N. abietis* currently resides in countries outside of Europe, so natural spread is very unlikely and host plants, including plants for planting, branches and cut trees, are prohibited from being imported into Great Britain and Northern Ireland, under the existing legislation (see section 4). It therefore appears that the pathways are currently being addressed by the existing regulations and no further action is required. However, if further interceptions of this pest were found hitchhiking on non-hosts, this pathway rating may need to be revisited.

Stage 1: Initiation

1. What is the name of the pest?

Neodiprion abietis (Harris) (Hymenoptera: Diprionidae)

Common name: balsam fir sawfly, spruce sawfly

Synonyms: *Diprion abietis* (Harris), *Lophyrus abietis* Harris

Strains of *N. abietis* can vary by appearance, host preference, and developmental rate, which has led to these strains being grouped under a single complex of *N. abietis* (Knerer & Atwood 1972).

2. What initiated this rapid PRA?

A single pupa of this pest was intercepted by the Netherlands on imported cut branches of *Gaultheria* (a non-host) imported from the USA in October 2016. As a result, in 2017, *N. abietis* was put on the EPPO Alert List (deleted in 2021). It was also added to the UK Plant Health Risk Register.

An assessment is now required to help decide whether statutory action against future interceptions is justified.

3. What is the PRA area?

The PRA area is the United Kingdom of Great Britain and Northern Ireland.

Stage 2: Risk Assessment

4. What is the pest's status in the plant health legislation, and in the lists of EPPO[1]?

The legislation for Great Britain is the Phytosanitary Conditions Regulation (retained regulation (EU) 2019/2072[2]). This pest is regulated as a provisional quarantine pest, as regulated by The Phytosanitary Conditions (Amendment) (No. 3) Regulations 2022[3].

The legislation which applies to Northern Ireland is the EU legislation: 2019/2072 and 2016/2031[4]. This pest is not listed in the EU plant health legislation and is not recommended for regulation as a quarantine pest by EPPO. It was removed from the EPPO Alert List in 2021.

5. What is the pest's current geographical distribution?

This pest is native to North America and has been detected in Canada and the United States of America ("USA") since the early 1900s (Bird 1930, GBIF Secretariat 2022). *Neodiprion abietis* has also been identified in northern Mexico and is believed to be present there naturally (González-Gaona *et al.* 2021). Finally, this pest is present in Saint Pierre and Miquelon, a French overseas territory off the coast of Canada (Préfet de Saint-Pierre-et-Miquelon 2012). Please see Figure 1 for the trans-continental distribution of *N. abietis*.

[1] https://www.eppo.int/ACTIVITIES/quarantine_activities

[2] Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019 (legislation.gov.uk)

[3] The Phytosanitary Conditions (Amendment) (No. 3) Regulations 2022 (legislation.gov.uk)

[4] The latest consolidated versions can be accessed via a search on https://eur-lex.europa.eu/

In Europe, *N. abietis* has only been detected once on cut branches of *Gaultheria* sp. imported from the USA (Netherlands NPPO 2017). No interceptions in Europe have occurred since (EPPO 2022).

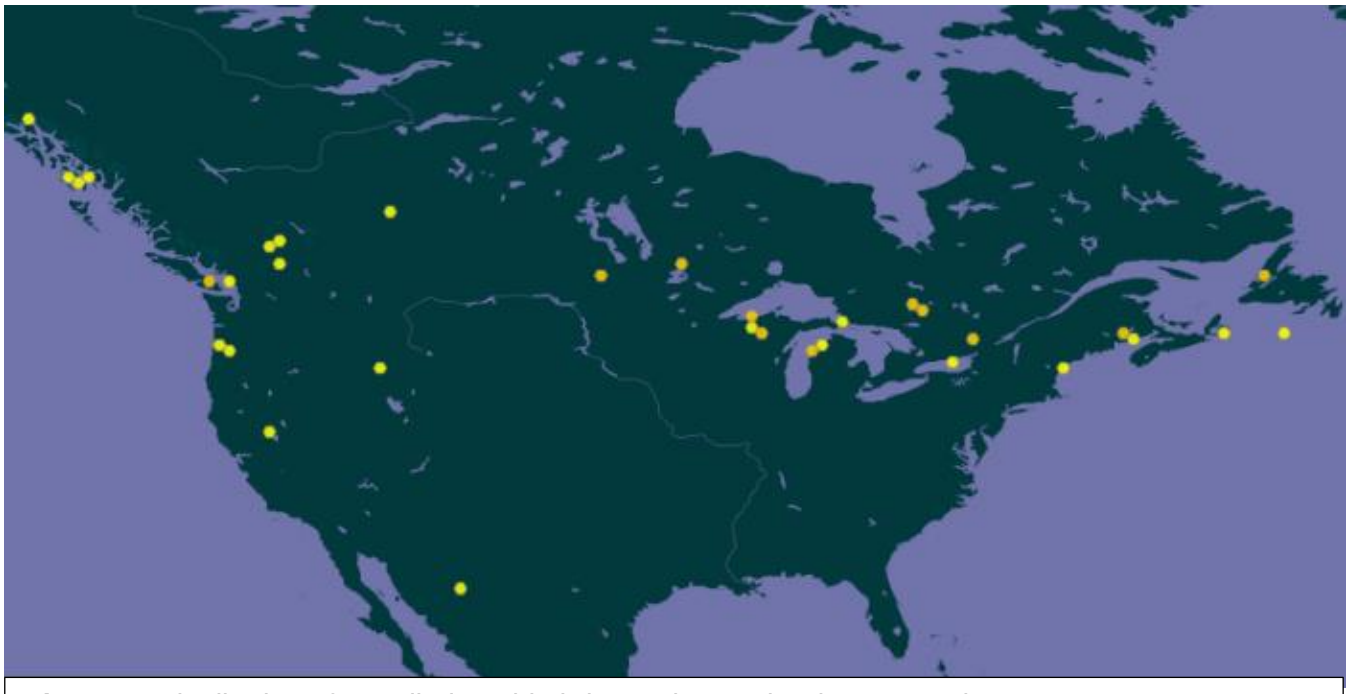

Figure 1: Distribution of *Neodiprion abietis* in North America (GBIF 2023)

Table 1: Distribution of *Neodiprion abietis*	
North America:	Canada, Mexico, Saint Pierre and Miquelon, and the USA.
Central America:	Not present
South America:	Not present
Europe:	Absent, intercepted only.
Africa:	Not present
Asia:	Not present
Oceania:	Not present

6. Is the pest established or transient, or suspected to be established/transient in the UK/PRA Area?

The pest is not known to be present in the UK. There have been no findings of *N. abietis* in the wider environment, nor has it been intercepted.

7. What are the pest's natural and experimental host plants; of these, which are of economic and/or environmental importance in the UK/PRA area?

The main host of *N. abietis* is reportedly balsam fir (*Abies balsamea*) though this pest attacks other conifer species as well. It was suggested that these other hosts are infested at times of high population levels when larvae migrate from defoliated balsam fir trees to other species (Carroll 1962). However, the host preference has been shown to vary depending on the strain of *N. abietis*. Strains with a host preference for balsam fir, white spruce (*Picea laxa*) or black spruce (*Picea mariana*) have all been identified (Johns *et al.* 2013, Knerer & Atwood 1972).

Please see Tables 2 and 3 below for the full list of natural and uncertain hosts respectively.

Table 2: Natural hosts of *Neodiprion abietis*

Host species	Common name	Presence in the UK
Abies amabilis	Pacific silver fir	Present in collections and large gardens.
Abies balsamea	Balsam fir	Not recorded[5]
Abies concolor	White fir	Present but rare with a widely scattered distribution.

[5] This species is not recorded in several different catalogues (Kew 2022, BSBI 2023, Plant Atlas 2023), although this species is found to be sold in the UK as an ornamental (RHS 2023). Therefore, it is likely to be present on a small scale in gardens.

Abies grandis	Grand fir	Present in plantations and estate woodland. An ornamental in parks, estates, and large gardens.
Abies magnifica	Red fir	Not recorded[5]
Larix laricina	Tamarack	Not recorded[5]
Picea engelmannii	Engelmann spruce	Present on a small scale for shelter belts and in plantations.
Picea laxa	White spruce	Present on a small scale for shelter belts and in plantations. An ornamental in some parks and gardens.
Picea mariana	Black spruce	Present but very rare.
Pinus ponderosa	Bull pine	Present in many parks, but less common in plantations.
Pinus strobiformis	Mexican white pine	Not recorded[5]
Pseudotsuga menziesii	Douglas fir	Present in plantations and woodlands. An ornamental in parks and large gardens.
Tsuga heterophylla	Western hemlock	Present in plantations and large gardens.

(BC Gov 2021, BSBI 2023, Christian 2021, González-Gaona *et al.* 2021, Johns *et al.* 2013, Kew 2022, Knerer & Atwood 1972, Linnen & Farrell 2008, Plant Atlas 2023, RHS 2023, Sánchez-Martínez *et al.* 2022, Struble 1957)

Table 3: Uncertain hosts of *Neodiprion abietis*

Host species	Common name	Reason for uncertainty	Presence in the UK
Abies lasiocarpa	Subalpine fir	Reported with few details	Present but very rare.
Picea rubens	Red spruce	Reported with few details	Not present
Picea sitchensis	Sitka spruce	Reported with few details	Present in plantations, dominating huge areas of former moorland and bog.
Pinus banksiana	Jack pine	Reported with few details/ experimental	Present but very rare.
Pinus resinosa	Red pine	Experimental	Not recorded[5]
Pinus rigida	Pitch pine	Old report with few details	Present but very rare.
Pinus strobus	Eastern white pine	Old report with few details	Present in mixed woodland and estates, occasionally found in parks, churchyards, and large gardens.
Taxus canadensis	Canada yew	Experimental	Not present
Thuja occidentalis	White cedar	Old report with few details	Present
Tsuga canadensis	Eastern hemlock	Reported with few details	Present

(BC Ministry of Agriculture 2017, Bird 1930, BSBI 2023, Kew 2022, Knerer & Atwood 1972, Martineau 1984, RHS 2023)

8. Summary of pest biology and/or lifecycle

The balsam fir sawfly deposits its eggs singly into slits cut into the needles of its host plant, one egg per needle of the current-year growth (Carroll 1962, Parsons *et al.* 2005). Unmated females can lay haploid eggs that only develop into males, while mated females can either lay diploid females or haploid males (Carroll 1962). *Neodiprion abietis* larvae then hatch from the eggs in early summer and commence feeding in groups. Studies have shown that larvae tend to target 1 to 3-year old foliage, over current-year needles, yet they benefit from feeding on all age classes of foliage (Moreau *et al.* 2003, Parsons *et al.* 2005).

As the larvae develop, their feeding behaviour becomes more solitary and, separately, more damaging to the tree. As defoliation increases, they move to the lower crown of the host tree (Anstey *et al.* 2002, Olofsson 1973) or migrate to adjacent trees when possible (Carroll 1962, Olofsson 1973). Over time, the larvae undergo five to six instars before pupating in cocoons on the host twigs, foliage, in the leaf litter or the soil just below the litter (Clark & Pardy 1972, Craighead 1950, Martineau 1984, Sheehan & Dahlsten 1985, Struble 1957). In the past, it has been reported that pupae can overwinter in their cocoons, though typically it is the egg stage of *N. abietis* that undergoes overwintering (Carroll 1962, Clark & Pardy 1972). After pupation, adults may take flight and disperse (Struble 1957). There is one generation of *N. abietis* per year (Craighead 1950).

Depending on the *N. abietis* strain, the entire needle or just the outside of the needle is consumed (Knerer & Atwood 1972). In the case of the latter, the remainder shrivels, turns yellow and then brick red (Martineau 1984). Defoliation is the first sign of a pest infestation, typically identified by the colouration of the attacked needles. Green current-year growth may hide this symptom, though over time the infestation becomes more evident as the red, partially consumed, foliage drops (Martineau 1984). The presence of *N. abietis* can also result in a large amount of frass that accumulates on the forest floor (Struble 1957).

Periodic outbreaks of *N. abietis* have been observed in Canada that last 3-4 years before collapsing (Moreau 2006). Natural enemies of *N. abetis* are associated with the eventual collapse of outbreak populations (Piene *et al.* 2001). Multiple parasites and predators have been identified in its native range, ranging from insects, spiders and mammals (Buckner 1955, Dowden 1962, Huber & Moreau 2003, Lindquist 1954, Struble 1957). Birds also prey on all life stages of sawflies (Codella & Raffa 1993). In addition, a nucleopolyhedrovirus (“NeabNPV”), naturally occurring in U.S and Canadian populations, has been shown to cause considerable reductions in the pest population and associated with the collapse of outbreaks (Graves *et al.* 2012, Li 2005, Moreau 2006, Olofsson 1973, Struble 1957).

9. What pathways provide opportunities for the pest to enter and transfer to a suitable host and what is the likelihood of entering the UK/PRA area?

Host plants for planting (excluding seeds, tubers and bulbs)

This pest could be associated with host plants for planting, in the form of eggs, larvae, or pupae. Import volumes of live forest trees, conifer trees, and cuttings into Great Britain are significant. However, the vast majority of these imports are from EU countries (HMRC 2023). Plants for planting of *Abies, Larix, Picea, Pinus, Pseudotsuga* and *Tsuga* species are prohibited in Great Britain from non-European countries, as are plants for planting of *Taxus* from non-EU third countries. These prohibitions therefore apply to all countries identified within the distribution of the balsam fir sawfly. Northern Ireland imposes a similar prohibition on these goods.

The imports of *Thuja* plants for planting into Great Britain or Northern Ireland from any country are permitted. As mentioned previously though, this is an uncertain host of *N. abietis*. In addition, imports of *Thuja* plants for planting over the 2022-2023 financial year in England and Wales have only been recorded from European countries[6], none of which are reported to have this pest (APHA, personal communication, 2023).

Therefore, this pathway is deemed very unlikely.

Host plants for planting	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely	
Confidence	High Confidence	✓	Medium Confidence		Low Confidence				

Host branches and cut trees

Eggs, larvae or pupae of this pest could be associated with cut branches or trees of host plants. A pupa of *N. abietis* has been intercepted on a consignment of branches from the USA, though the branches were not from a host plant (Netherlands NPPO 2017). Cut trees could also be a pathway for this pest's entry, given the significant amount of imported Christmas trees into the UK (from 2022 alone, nearly 18 million kg of Christmas trees were imported into the UK). However, similar to plants for planting, these imports are mainly from EU countries (HMRC 2023). Cut trees and branches of *Abies, Larix, Picea, Pinus,*

[6] This was indicated from the imports recorded under the *Thuja* genus by PEACH (Procedure for Electronic Application for Certificates) and IPAFFS (Import of Products, Animals, Food or Feed Service); the systems that record the movement of material relevant to plant health in England and Wales.

Pseudotsuga and *Tsuga* are prohibited in Great Britain and Northern Ireland from non-European countries.

Cut trees and branches of *Taxus* and *Thuja* are not prohibited, although *Taxus* imports from the USA must meet specific requirements, such as additional inspections, to ensure freedom from *Phytophthora ramorum*. As *Taxus* and *Thuja* are uncertain hosts of this pest, once again this pathway is rated as very unlikely.

Host branches and cut trees	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			

Hitchhiking on non-host plants

As mentioned previously, a pupa of the balsam fir sawfly was intercepted in the Netherlands on cut branches of a non-host *Gaultheria* sp. imported from the USA (Netherlands NPPO 2017). Some *Gaultheria* species, like *Gaultheria shallon*, are shrubs that grow in the USA and Canada, often under the cover of host plants (such as Pacific silver fir and Douglas fir) (Tirmenstein 1990) and exported in large quantities to Europe for the floral industry (Hobby *et al.* 2010). It is not known how often this pest is associated with non-host plants such as *Gaultheria* species. This is the first known interception, though cut branches of plants such as *Gaultheria* sp. are inspected at a 1% frequency in Great Britain and Northern Ireland when being imported. No interceptions have been reported in the UK, or in the EU since this record in 2016.

Previous studies have shown that *N. abietis* is highly selective in its host preference for oviposition (Johns *et al.* 2013, Knerer & Atwood 1972), suggesting that the eggs or laying adults of *N. abietis* are unlikely to be associated with non-host plants, the latter of which could fly off when disturbed. The recorded pattern of larvae migrating to neighbouring trees for new food sources (Carroll 1962, Olofsson 1973), or pupating on nearby material, such as the leaf litter (Struble 1957), could explain the association of *N. abietis* with a non-host commodity at the pupal stage.

Nevertheless, in a typical lifecycle, *N. abietis* is a larva for only 2-3 months (Bird 1930, Carroll 1962, Struble 1957) and a pupa for an average of 17 days (Li 2005), restricting the likelihood of association with non-host plants. In addition, after being moved to the PRA area, the hitchhiking pest would need to locate a suitable host nearby to continuing feeding, which is less likely at the larval stage. A newly emerged adult would be more likely to locate a suitable host via flying, though it would also require being accompanied by some potential mates. Given these requirements, especially the strong preference for specific hosts, it appears unlikely that oviposition would take place.

Hitchhiking on non-hosts	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

Natural spread

This pest can spread to new countries, as indicated by the arrival of migrant populations in Saint Pierre and Miquelon from Canada (Préfet de Saint-Pierre-et-Miquelon 2019). However, the natural capability of *N. abietis* to disperse long distances is not known. Female adults of *N. abietis* are actively flying insects (Struble 1957), yet they are reported to have a very limited dispersal activity, like many members of the *Neodiprion* genus (Dahlsten 1961, Henson 1964, Moreau *et al.* 2018, Wagner *et al.* 1986). The distance travelled by *N. abietis* adults remains to be determined. Most females of a relative, *Neodiprion sertifer* have been reported to only fly 1-5 m, yet up to 5% of females fly between 5-15 km (Henson 1964). Given the current distribution of *N. abietis*, limited to North America, it is very unlikely that this pest could reach the UK by natural means. The permanent establishment of an insect after long distance dispersal, such as crossing the Atlantic, is already very rare (Holzapfel & Harrell 1968). Zero reports of *Neodiprion* species have been reported as migrant moths in Great Britain and Ireland (Atropos 2022).

Natural spread	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			

10. If the pest needs a vector, is it present in the UK/PRA area?

Neodiprion abietis is a free-living organism and no vector is required.

11. How likely is the pest to establish outdoors or under protection in the UK/PRA area?

This pest has a trans-continental distribution from east-west in North America, showing that it can tolerate a range of climates. However, the limited distribution and impact of this pest in parts of Mexico have been attributed to poor environmental suitability (Sánchez-Martínez *et al.* 2022). Past climatic models have indicated that the distribution of *N. abietis* is determined by temperature and/or precipitation (Grebennikov 2021, Sánchez-Martínez *et al.* 2022), specifically that relatively low annual and maximum temperatures without

noticeable dry periods limit this pest's distribution (Grebennikov 2021). This is unsurprising given that temperature has been shown to influence the developmental stages of this pest (Bird 1930, Carroll 1962, Struble 1957). In addition, adult activity, such as mating and oviposition, has not been observed in temperatures below 10°C (Carroll 1962). Flight activity is also reduced in colder temperatures (Struble 1957).

One climatic model suggests that this pest would be able to establish in parts of the UK, although it noted some key uncertainties around the host range and current distribution (Grebennikov 2021). Given that the average summer temperature in the UK is between 9-20°C (Met Office 2023), it is likely that this pest would be active in at least some parts of the UK. The presence of this pest in British Columbia, western Canada (see Figure 1) which shares a similar climate to the UK (MacLeod & Korycinska 2019), supports this conclusion.

The balsam fir sawfly has multiple hosts that are present in the UK (see Table 2). Most of these hosts have a scattered distribution, as cultivated plants, in parks, gardens and shelter belts. However, some are grown on a larger scale in estate woodlands or plantations for timber (Christian 2021, Plant Atlas 2023), most significantly, Douglas fir grows on 46 thousand hectares of stocked woodland in Great Britain (Forest Research 2022).

Establishment in the UK would be influenced by whether the strain of *N. abietis* was suited to the located host, given that these pests are highly selective in their local host preference for oviposition even within the identified host range (Johns *et al.* 2013, Knerer & Atwood 1972). This has been noted in the past as a limitation of their distribution. Unless provided with their chosen host, females are known to have died with the majority of their eggs still in the ovaries (Johns *et al.* 2013). There is also some uncertainty on this pest's host range (as shown by Table 3) which significantly influences the likelihood of establishment. For example, in contrast to Douglas fir, one uncertain host, Sitka spruce, grows on 668 thousand hectares of stocked woodland in Great Britain (Forest Research 2022). It is also unknown whether prevalent European species of pine and spruce, such as Scots pine, could aid establishment.

Outdoors	Very unlikely	☐	Unlikely	☐	Moderately likely	☐	Likely	☑	Very likely ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

This pest is unlikely to establish under protection, given that its hosts are grown outdoors for commercial or ornamental purposes. No infestations of this pest have been reported indoors, such as in greenhouses (Netherlands NPPO 2017).

Under Protection	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely ☐

Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐		

12. How quickly could the pest spread in the UK/PRA area?

Most of the existing literature mentions *N. abietis* larvae moving short distances, to different branches or nearby trees, for food (Anstey *et al.* 2002, Bird 1930, Carroll 1962, Olofsson 1973), or dropping to the forest floor when disturbed (Struble 1957). Studies have also shown that *N. abietis* adults travel longer distances to move between stands, contributing to outbreaks (Moreau *et al.* 2006, Moreau *et al.* 2018).

Considering the limited dispersal habits of many *Neodiprion* species (see section 9), the natural spread of this sawfly across the UK is expected to be at a slow pace, even in the presence of hosts. In addition, in its typical lifecycle, *N. abietis* is expected to be inactive for at least 6 months of the year in the egg stage (Bird 1930, Carroll 1962, Knerer & Atwood 1972, Sánchez-Martínez *et al.* 2022). For example, in Mexico, there is no larval or adult activity of this pest from October to April (Sánchez-Martínez *et al.* 2022).

Natural spread	Very slowly	☐	Slowly	☑	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐			

As demonstrated by the movement of the intercepted pest on cut branches, from the USA to the Netherlands, this pest could spread via trade. Multiple trade pathways would allow the spread of this pest, from infested host plant commodities to hitchhiking on non-host plants. A mated female moved on a host plant for planting could lay eggs in that same host plant or a nearby host in the nursery, enabling a population to be established. The larvae or subsequent adults would then spread further to nearby trees or between stands.

This spread via trade could enable outbreaks at disparate sites from which natural spread would then continue. However, no such outbreaks via trade have been reported in the past. In addition, as mentioned previously, the natural spread of this sawfly is expected to be at a slow pace, increasing the chance of the pest being identified in the traded goods and destroyed.

With trade	Very slowly	☐	Slowly	☑	Moderate pace	☐	Quickly	☐	Very quickly ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			

13. What is the pest's economic, environmental and social impact within its existing distribution?

Damage from this pest occurs via defoliation, mortality and reduced growth of the host plant (Martineau 1984). Reports of defoliation vary between studies but have been reported to be up to 63% (Iqbal *et al.* 2012, Parsons *et al.* 2003). Recovery from a *N. abietis* outbreak is slow as this pest avoids feeding on current-year foliage, including the buds. As a result, the host plant is not able to replace foliage quickly as it would when under attack from bud-destroying pests, such as the spruce budworm *Choristoneura fumiferana* (Piene *et al.* 2001).

Severe and prolonged defoliation of 3 to 5 years can result in tree death (Nova Scotia Department of Natural Resources 1999), though in the past, overall tree mortality has been reported to be less than 1% (Struble 1957). Mortality can be associated with other pests, as stressed trees become more vulnerable to attack (Cunningham 1984, Préfet de Saint-Pierre-et-Miquelon 2012, Turnquist 1996). More recent reports have indicated that survival was not significantly impacted in immature balsam fir trees, 12 years after defoliation. By comparison, defoliation caused by *N. abietis* caused a 54% decrease in the survival of mature trees, 12 years on (BC Gov 2021, Iqbal *et al.* 2011).

In addition, tree growth has been found to reduce by up to 81% after 4 years of defoliation, though this figure varies depending on multiple factors, such as defoliation intensity, tree section, outbreak area and year of the outbreak (Iqbal *et al.* 2011, Parsons *et al.* 2003, Piene *et al.* 2001). More than 400,000 m^3 of incremental growth was lost from an outbreak in one Canadian province (Canadian Forest Service 2008). Growth levels have been shown to recover very slowly, and in severe defoliation cases, can still be impacted over 10 years after defoliation has ceased (Iqbal *et al.* 2012). Iqbal *et al.* (2012) suggested that growth could be impacted for up to 40 years after the outbreak's collapse.

Neodiprion abietis has been described as a serious pest in eastern Canada (Iqbal *et al.* 2011). Typically, outbreaks in central and eastern Canada are localised and last 3-4 years. In recent years, however, the outbreaks of this pest are larger scale and last much longer (Canadian Forest Service 2008, Moreau 2006, Piene *et al.* 2001). Up to 200,000 hectares were infested during a recent outbreak in Newfoundland, a province in eastern Canada (Canadian Forest Service 2008). It is believed that the pre-commercial thinning of trees (typically used to accelerate the height and diameter of the remaining trees) increases defoliation levels following a *N. abietis* attack (Ostaff *et al.* 2006).

Interestingly, the activity of this pest has been much more damaging in eastern Canada than in the rest of North America. Although the pest is present in western Canada, outbreaks have not been observed (Cunningham 1984, Martineau 1984, Rose & Lindquist 1985). In Mexico, although certain host plants are attacked and defoliated, the distribution of the balsam fir sawfly in Mexico is relatively isolated (González-Gaona *et al.* 2021). Consequently, endangered host species of *N. abietis* are not impacted (Sánchez-Martínez *et al.* 2022). In Saint Pierre and Miquelon, the population of *N. abietis* appears to be

declining although, due to the continued risk of this pest, annual surveys are still being conducted. Figures on impact are not reported (Préfet de Saint-Pierre-et-Miquelon 2012, 2019). Finally, in the USA, *N. abietis* is recorded as an occasional pest but not a serious problem (Dahlsten 1961). Defoliation is reported, but on a smaller scale than in eastern Canada, and no significant mortality rates are noted (California Forest Pest Council 2000, 2019).

Impacts	Very small	☐	Small	☐	Medium	☑	Large	☐	Very large ☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐			

14. What is the pest's potential to cause economic, environmental and social impacts in the UK/PRA area?

Despite many hosts of *N. abietis* having a scattered distribution in the UK, this pest could still have a large economic impact on the forestry industry. Multiple hosts are grown in estate woodlands or plantations for timber (Christian 2021, Plant Atlas 2023), including Douglas fir, which grows on 46 thousand hectares of stocked woodland in Great Britain (Forest Research 2022). Western hemlock and grand fir are also significant commercial species of conifer (Samuel 2007). An outbreak of this pest could result in serious losses to growers, by impacting survival or growth, especially given that the latter does not recover for many years after an outbreak (Iqbal *et al.* 2012). In addition, it is likely that these host plants will become more widely grown in Great Britain in the future, following the publication of the revised UK Forestry Standard which reduces the maximum quantity of a single species in a forest management unit (Forest Research 2023).

However, it is possible that the impact of this pest would be limited in the UK like in many parts of North America. It is not certain why the impact of this pest varies between regions in its current range. Like in Mexico, this could be due to low environmental suitability, or potentially a lack of suitable hosts.

As mentioned previously, there is some uncertainty regarding the host range of *N. abietis* (see Table 3), such as Sitka spruce which is a significant commercial species in the UK. In addition, it is not known whether this pest would attack important European species of pine and spruce, such as Scots pine and Norway spruce, once established in the UK.

All of the hosts described in Table 2 are sold by plant nurseries in the UK for ornamental purposes, to grow in parks, botanic collections, and gardens as well as to be displayed as Christmas trees (RHS 2023, Woodland Trust 2023). Therefore, this pest could cause further economic damage, as well as carry some social impact, by attacking hosts and lessening their aesthetic appeal through defoliation.

Economic Impacts	Very small	☐	Small	☐	Medium	☑	Large	☐	Very large	☐
Confidence	High Confidence	☐	Medium Confidence	☐	Low Confidence	☑				

Social Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

All of the known host plants of *N. abietis* are non-native to the UK, although many have been introduced and growing in the UK for hundreds of years (Samuel 2007). Over this time, these species have acquired ecological roles in the natural environment. For example, Douglas fir trees provide habitats for the red squirrel and pine marten and food for finches and small mammals. They are also associated with bats and birds such as buzzards, sparrowhawks and firecrests (Peterken 2001, Woodland Trust 2023). Any defoliation or tree mortality could negatively impact native species that rely on these trees for their survival. In the past, insect defoliators have been shown to reduce cone production of infested trees, by reducing the fitness of the plant, although this has not been specifically demonstrated with *N. abietis* (Kulman 1971, Rockwood 1973). As tree mortality is less frequently reported in the literature, the environmental impacts were rated small. Again, there is some uncertainty as to the host range of this pest and whether it would attack European conifer species.

Environmental Impacts	Very small	☐	Small	☑	Medium	☐	Large	☐	Very large	☐
Confidence	High Confidence	☐	Medium Confidence	☑	Low Confidence	☐				

15. What is the pest's potential as a vector of plant pathogens?

This pest is not a known vector for plant pathogens.

16. What is the area endangered by the pest?

Woodland areas and plantations of conifer hosts are most at risk from this pest, though urban spaces with these host species are also threatened. One study suggests that only certain parts of the UK, including Wales, Scotland and northern areas of England, are at risk of this pest due to the presence of host species combined with other environmental factors (Grebennikov 2021).

Stage 3: Pest Risk Management

17. What are the risk management options for the UK/PRA area?

Exclusion

Exclusion of this pest from the UK is the preferred option, as currently the balsam fir sawfly is not known to be present. Given the damaging nature of this pest, and the presence of many of its hosts in the UK, some of which play significant roles in the forestry industry, exclusion measures should be implemented.

The import of host plants from non-European countries is prohibited in the retained Implementing Regulation (EU) 2019/2072[2]. This prohibition covers all known countries where *N. abietis* occurs. The impact of this prohibition may be indicated by the fact that no UK interceptions of this pest have been found on host plants (including plants for planting, cut trees and branches).

If this pest successfully establishes in European countries, careful inspection of the host plant material (cut branches and trees, plants for planting) particularly focusing on the needles and shoots, at the production, packaging, transport, and post-entry stages of import should help to prevent the entry of this pest at different life stages (Strażyński *et al.* 2017). Discolouration of the needles or defoliation could indicate a pest attack (Martineau 1984), whilst cut edges on the needles would suggest the presence of laid eggs – though this is likely to be undetected during inspections. Other potential measures include the application of strict sanitary measures during production, such as the removal of plant debris from the previous crop and the use of new packaging. Production should take place in an area free of the pest (Strażyński *et al.* 2017).

Eradication

Eradication should be possible if the infestation of the newly established pest was caught at an early stage. Early detection may be difficult, however, as there are nine species of conifer-feeding Diprionidae present in the UK, and the larvae of some of these species are similar in appearance to, and could be confused with, *N. abietis*. If a pest outbreak was identified in Great Britain, the destruction of all associated material appears to be very effective (Strażyński *et al.* 2017). General pesticides could be sprayed to eliminate any remaining sawflies and the site should be re-inspected for the presence of *N. abietis* over time.

Non-statutory controls

Suppression of this pest with biological controls has historically been tested in Canada, with trials of the NeabNPV being sprayed on the ground and in the air (Cunningham 1984,

Graves *et al.* 2012). This was shown to be an effective control on *N. abietis*, causing infected larvae to cease feeding, and die, resulting in high mortality in populations of *N. abietis* (Cunningham 1984, Graves *et al.* 2012, Li 2005, Olofsson 1973) and much lower feeding damage and defoliation on the host trees (Cunningham 1984, Olofsson 1973). A biological control product, known as Abietiv™, has been developed with NeabNPV and applied in several different Canadian provinces to control outbreaks of the balsam sawfly (van Frankenhuyzen *et al.* 2016). As *N. abietis* is not present in the UK, it is confidently expected that this biological control is not currently approved for use.

In the past, synthetic pesticides such as lead arsenate, DDT and fenitrothion have been effective against the balsam fir sawfly (Bird 1930, Eidt & Mallet 1986, Struble 1957), though these specific examples are not currently approved for use in the UK (DDT is specifically banned by the EU and the UK) and/or considered obsolete (PPDB 2023). There is little recent information on the use and effectiveness of systemic pesticides against *N. abietis* (Strażyński *et al.* 2017). In absence of control methods, defoliation can be monitored with severe cases being prioritised for harvesting (BC Gov 2021, Turnquist 1996).

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This PRA has been undertaken following IPPC International Standards for Phytosanitary Measures (ISPMs 2 and 11) and it provides technical evidence relating to the risk assessment and risk management of this pest.

This PRA has also been undertaken taking into account the environmental principles laid out in the Environment Act 2021. Of particular relevance are:

The prevention principle, which means that any policy on action taken, or not taken should aim to prevent environmental harm.

The precautionary principle, which assists the decision-making process where there is a lack of scientific certainty.

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