Forest Research

Forest Trapping Network 2023

Review of the Forest Trapping Network Year Two Rollout

Alice Walker, Thomas Kendall & Max Blake

The Research Agency of the
Forestry Commission

Forest Research is the Research Agency of the Forestry Commission and is the leading UK organisation engaged in forestry and tree related research.

The Agency aims to support and enhance forestry and its role in sustainable development by providing innovative, high quality scientific research, technical support and consultancy services.

Table of Contents

1 Executive summary

The goals of the FTN are (1) Form a key FSP survey strategy which targets pests that other survey methods cannot detect, including species of non-European Scolytinae and several other non-native Scolytids, several species of non-native *Pissodes* (Molytinae), *Monochamus* spp. and *Xylotrechus* spp. (Cerambycidae), and *Arrhenodes minutus* (Brentidae); (2) Consolidate current trapping programmes into a single network to ease logistical issues (aiming to replace some existing trapping programmes long-term); (3) Improve current trapping methods for quarantine pests; (4) Ensure a cohesive approach across the three countries involved (England, Scotland and Wales).

The FTN is a rolling programme which surveys ~100 forests for EU-survey list pests over five-year cycles. In each forest, plots of oak, pine, spruce, fir and mature mixed broadleaf are chosen to target different pest species. The FTN in 2023 deployed 108 traps across England, Scotland and Wales. General lures (ethanol and alpha-pinene) which give off volatiles produced by dying trees are placed in the traps to attract a broad range of tree pests. All individuals from a set of nine families/subfamilies of interest (most of which contain the target quarantine/priority species) are identified to the lowest taxonomic level possible: Scolytinae (bark beetles), Cerambycidae (longhorns), Molytinae (woodboring weevils including *Hylobius*), Ptinidae (woodboring beetles), Siricidae (wood-wasps), Brentidae (one weevil species on the survey list), Platypodidae (one woodboring native UK species), and bark beetle predators. We trapped 26,814 individuals from the nine groups of interest, but only one quarantine species – *Ips typographus* – which we know to already be present in the *Ips* Demarcated Area in Southeast England.

Questions addressed in this report:

Q1 – Did the FTN 2023 meet its four goals?

Yes – The FTN largely met its four goals: (1) It effectively targeting a suite of quarantine/priority pests that other survey methods do not. (2) The FTN consolidated the PFA Billet Trapping programme, though has the potential to further consolidate more trapping programmes. (3) The trapping methods employed by the FTN are an improvement on past methods due to the broad-spectrum approach, leading to the successful surveillance of one quarantine species and 17 positive control species. (4) The FTN in 2023 was the result of efforts by Forest Research, Forestry Commission, Scottish Forestry, and NRW staff collaborating to select sites, plan logistics, organise trap servicing, and communicate findings.

Q2 – Was the FTN 2023 effective in surveying for quarantine pests?

Yes - whilst we only trapped one quarantine list species, we are confident that it effectively targeted quarantine pests on the EU-survey list. This is evidenced by trapping 18 positive control species, which are analogous to species on the quarantine list, showing that had quarantine species been present the FTN would very likely have detected them.

Q3 – Do any changes need to be planned for 2023 and into the future?

Yes – the sites in Wales should be less clustered in 2024 to achieve a more even spread across the country. The FTN team should place a limit on cutting highly abundant species to save on time costs. If possible, *Monochamus* trapping should be incorporated, but this depends on the availability of areas of recently clear-felled pine in the forests selected for the FTN.

2 Introduction

2.1 Background

The Forest Trapping Network (FTN) is one of the monitoring strategies outlined in the Future Surveillance Plan (FSP) as part of the Forest Research and Forestry Commission Survey Strategy for GB Priority Pest and EU Quarantine Organisms 2021. The strategy was compiled by Max Blake (Forest Research) and Katie Parker (Forestry Commission), in consultation with Ana Perez-Sierra (Forest Research), Patrick Robertson (Scottish Forestry), Mark Hilleard (Welsh Government) and Joe McMinn (Natural Resources Wales). The FSP has been designed to provide high-level surveillance strategies for multi-annual surveys of all priority, quarantine, and provisional quarantine forestry pests, as described in the Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020.

The FTN has been designed to complement the other survey strategies within the FSP (Drone Surveys, Aerial Surveys and National Forest Inventory Surveys), whilst also establishing a long-term replacement for existing trapping programmes for quarantine pests (the Pest Free Area Billet Trapping Network and *Monochamus* trapping programme). There are several insect pests identified in the new legislation that cannot be detected by the other methods in the FSP and are unlikely to be sampled through other trapping programs (e.g. billet and Port, Pier, Processor trapping for quarantine *Ips* spp., or the Wider Environment survey for *Ips typographus*). The FTN aims to better consolidate current trapping programmes into a single network and ease logistical issues, trap efficiently for the new pests identified as part of the EU Exit Regulations 2020 and improve current trapping methods for quarantine pests.

The FTN has been developed as a broad-spectrum, rolling programme which aims to survey 100 forest plots across England, Scotland and Wales over a five-year reporting period, with 20 plots set up each year. Forests will be selected across the three countries, with each contributing at least three of the five tree-species groups (oak, pine, spruce, fir & other broadleaf species). Oak (*Quercus*), pine (*Pinus*), spruce (*Picea*) and fir (both *Abies* and *Pseudotsuga*) all have a number of target species associated with them, while the other broadleaf species (alder, chestnut, beech, cherry, birch and hornbeam) each have only one or two associated pests and therefore require less intensive surveillance. Each forest plot will be surveyed once in the five-year period, with the goal of having at least 40 sites per tree species over the five years, and 20 sites for each target species within the other broadleaf group. Each trap will have lures appropriate to the tree species in which it is placed.

2.1.1 Alpha phase

Forest Research and the Forestry Commission initiated the alpha testing phase for general forest pest trapping in 2020 and 2021 (Blake *et al*., 2021). This consisted of a small-scale programme across England, Scotland and Wales directly comparing the data collected from billet traps in the Ips PFA survey to that of cross-vane trapping. Furthermore, the cross-vane traps were tested with three different lures in each year: ethanol and alpha-pinene, Galloprotect, and *Ips typographus* pheromone in 2020; then ethanol and alpha-pinene, *Ips typographus* pheromone, and a combined ethanol and alpha-pinene plus *Ips typographus* pheromone in 2021.

These pilots revealed several issues with the traditional trapping method for quarantine species (billet trapping), including samples arriving in an unidentifiable condition; the quarantine species *Ips typographus* being missed in samples, despite being present in nearby pheromone traps; and poor sampling leading to false negatives when non-quarantine species indistinguishable from quarantine species in the field (e.g. *Ips sexdentatus*) were not sampled, despite being present in billet piles. The pilots also demonstrated that billet traps caught considerably fewer quarantine species compared with traps containing the experimental lures and showed that different lure types were effective at trapping different species. The results of these pilots therefore highlighted a need for a broader, more adaptable trapping method for quarantine species and other species of interest to tree health.

2.1.2 Beta Phase

The Beta-phase is the last three years of the first 5-year cycle (2022-2024), ahead of the first full five-year cycle starting in 2025. In 2022, cross-vane traps baited for general forest pests were placed alongside the extended *Ips* Wider Environment trapping network as an advanced system test. 38 traps were installed across 10 sites in Southern England, which contained existing *Ips typographus* Wider Environment traps. Years two and three (2023 and 2024) of the FTN will be used to refine the experimental methods that will ultimately become standardised for the first full 5-year reporting period, commencing in 2025.

2.2 Experimental approach

2.2.1 Site selection

This year, we expanded the FTN across Great Britain, including Scotland and Wales in the site list. Twenty-four forest sites were chosen across GB for the FTN year two rollout (Fig. 1, Table 1). In England, several sites were chosen towards the middle and north of the country to work towards filling gaps in this 5-year cycle (Fig. 1). In Scotland, sites were chosen down the length of the country to achieve a good spread. In Wales, sites were chosen towards the South-East due to the availability of a contractor to service the sites, and because this area is near several ports which may pose a greater risk of harbouring quarantine pests. The sites in Wales will be more spread out in future years.

Table 1. FTN 2023 full site list, and numbers of traps set up in different forest types within sites.

Country	Forest	NGR	Fir	MB	Oak	Pine	Spruce
Scotland	Achilty	NH4330057090	1	1	1	1	1
	Glen Loy	NN1291582713	1	1	1	1	1
	Drumnadrochit	NH4618129502	1	1	1	1	1
	Dalbeattie	NX8459556534	1	1	0	1	1
	Keillour	NN9837526076	0	1	1	1	1
	Craigvinean	NN9901043744	1	1	0	1	1
	Devilla	NS9695688368	0	1	0	1	1
	Dean	NT0535487968	0	1	0	1	1
	Gartmorn	NS9143894677	0	1	0	1	1
Wales	Beacon Hill	SO5135105719	1	1	1	1	1
	Chepstow Park	ST4997398309	1	1	1	0	1
	The Hendre, Kings Wood	SO4613114336	1	1	0	0	1
	Wentwood	ST4241994943	1	1	1	1	1
England	Alice Holt*	SU81054410	1	1	1	1	1
	Bedgebury	TQ7215533089	0	1	1	1	1
	Clatford Bottom (West Woods)*	SU1616966714	1	1	1	0	1
	Delamere*	SJ5587570927	1	1	1	1	0
	Great Wood	ST1718337676	1	1	1	1	1
	Green Side Wood	SP98378362	1	1	1	1	1
	Leigh Woods*	ST5490274828	0	1	1	1	0
	Orlestone*	TQ9780534192	1	1	1	1	1
	Savernake*	SU2275366825	1	1	1	1	1
	Thetford*	TL79999185	1	1	1	1	0

Note: * next to site name indicates site is an SSSI or encompasses SSSI areas.

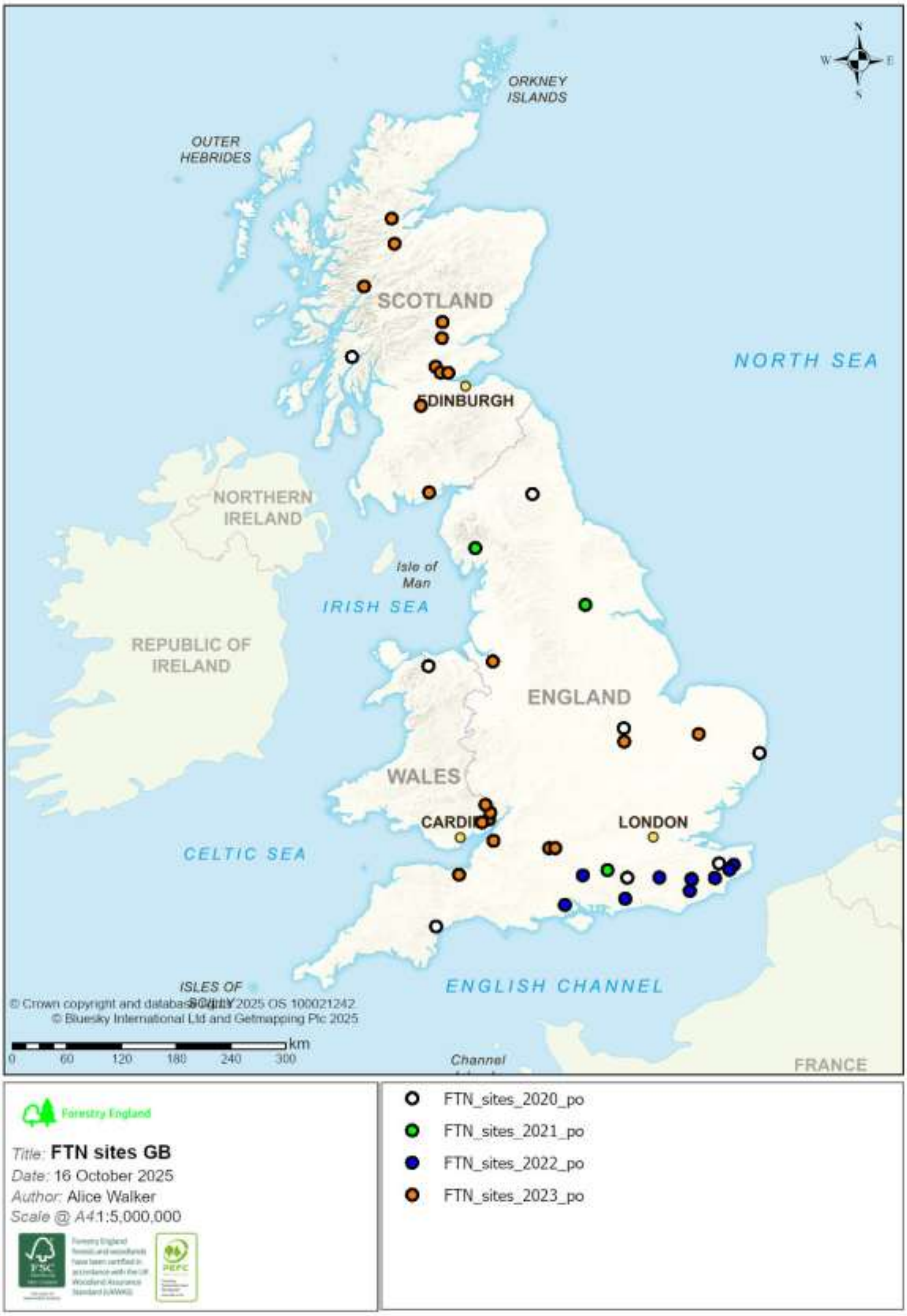
ORKNEY ISLANDS
OUTER HEBRIDES
SCOTLAND
NORTH SEA
EDINBURGH
NORTHERN IRELAND
Isle of Man
IRISH SEA
REPUBLIC OF IRELAND
ENGLAND
WALES
CARDIFF
LONDON
CELTIC SEA
ISLES OF SCILLY
ENGLISH CHANNEL
Channel Islands
FRANCE
© Crown copyright and database rights 2025 OS 100021242
© Bluesky International Ltd and Getmapping Plc 2025
km
0 60 120 180 240 300
Forestry England
Title: FTN sites GB
Date: 16 October 2025
Author: Alice Walker
Scale @ A4 1:5,000,000
FTN_sites_2020_po
FTN_sites_2021_po
FTN_sites_2022_po
FTN_sites_2023_po

Fig. 1. Map of FTN traps set up in sites (labelled) across Great Britain in 2023 (blue points). Sites from FTN 2022 are included (grey points) to illustrate the distribution of sites within this cycle.

Forester Web was used to determine appropriate locations for 4-6 cross-vane traps within each site. The locations met the following criteria at a minimum: within a >1 ha sub-compartment dominated by either oak (50% minimum component), pine (50% minimum), spruce (50% minimum), fir (30% minimum), or mixed broadleaf (alder, chestnut, beech, cherry, birch or hornbeam; 50% minimum), where planting date for oak must be earlier than 1953 (70 years ago), and earlier than 1983 (40 years ago) for the remaining target tree species.

On average, it was possible to select suitably large sub-compartments (several hectares in size) with a high percentage area cover of the target tree groups (Table 2). Where there were multiple sub-compartments within a site containing the different target mixed broadleaf species, we selected multiple sub-compartments in which to install traps (i.e. some sites had two or three traps in mixed broadleaf-dominated sub-compartments, e.g. one in beech and one in birch; Table 3). One cross-vane trap (Fig. 2) was installed in each sub-compartment. 108 traps in total were installed across the three countries, split reasonably evenly amongst the tree species groups (Table 2), corresponding to 13 target tree species (Table 3).

Table 2. Summary characteristics of sub-compartments dominated by each of the five tree species groups selected to host FTN traps in 2023.

Species group	Average sub-compt. area	Average component	Number of traps (England)	Number of traps (Scotland)	Number of traps (Wales)	TOTAL
Oak	4.7 ha	72.0%	10	4	3	**17**
MB	3.1 ha	73.3%	16	14	5	**35**
Pine	5.9 ha	84.0%	9	9	2	**20**
Fir	5.0 ha	65.7%	8	5	4	**17**

Spruce	6.3 ha	74.5%	6	9	4	**19**
		TOTAL	**49**	**41**	**18**	**108**

Table 3. Number of FTN traps set up in sub-compartments dominated by each of the target tree species.

Tree species	England	Scotland	Wales	TOTAL
Alder	1	0	0	**1**
Beech	8	3	4	**15**
Birch	3	7	1	**11**
Corsican pine	4	0	0	**4**
Douglas fir	6	4	3	**13**
Grand fir	2	1	1	**4**
Mixed broadleaf	0	3	0	**3**
Norway spruce	5	5	2	**12**
Oak	9	4	3	**16**
Oak/Birch (50/50)	0	1	0	**1**
Red oak	1	0	0	**1**
Sweet chestnut	3	0	0	**3**
Scots pine	5	9	2	**16**
Sitka spruce	1	4	2	**7**
Wild cherry	1	0	0	**1**
TOTAL	**49**	**41**	**18**	**108**

The lures used in the cross-vane traps were ethanol, α-pinene and the *Ips typographus* pheromone (Fig. 2). Ethanol and α-pinene are general lures for beetles that are attracted to damaged or dying trees, with ethanol generally associated with broadleaved species, and α-pinene with conifers. The *Ips typographus* pheromone is a species-specific pheromone lure for *I. typographus*, which can also attract other species of *Ips*. Within each woodland type, a cross vane trap was set up with appropriate lures: ethanol only (oak and other broadleaf); α-pinene + ethanol (fir and pine); α-pinene + ethanol + *Ips typographus* pheromone (spruce).

2.2.2 Cross-vane trap set-up

All cross-vane traps were set up with 30-50% propylene glycol as a preservative in the base. Trapping started in March or early April and continued until the end of August or early September. Traps were set up on 6ft stakes, or hung between trees. Samples were collected fortnightly by Scottish Plant Health officers in Scotland, Forestry Commission Plant Health Officers and Support Officers (England), and a Forestry Commission contractor (Wales). and sent to Alice Holt and Northern Research Station for processing.

Fig. 2. Set up of a typical cross-vane trap (left). Ethanol and alpha-pinene lures in place in a cross-vane trap (right).

2.2.3 Sample processing and identifications

2.2.3.1 Target species/groups

Our broad-spectrum trapping method inevitably caught large numbers of non-quarantine insects. Although not the primary target of the FTN, the information on the abundances, native ranges, and seasonal dynamics of other insect groups of interest to tree health (such as bark beetles and longhorn beetles) is important. Therefore, specimens within nine specific groups/families/subfamilies were identified to species (where possible) at Forest Research, and are hereafter referred to as target groups. Identifying a broad range of species in this way means that it is unlikely that any target quarantine/priority species will be erroneously put into "bycatch":

a) **Scolytinae** – bark beetles. All identified to species level. Last survey of this group was between 2013-2017 (D. J. Inward, 2020), which collected three species new to the UK. Particular attention should be paid to species of major plant heath significance such as *Ips*, *Tomicus* and the ambrosia beetles. All non-European Scolytinae are included on the EU-survey list (Appendix A).

b) **Platypodidae** – one species, ***Platypus cylindricus***, closely related to the Scolytinae. This is an ambrosia beetle which cultivates the ambrosia fungus in its galleries. It has minor importance as a forest pest, usually attacking stumps and freshly felled logs.

c) **Cerambycidae –** longhorn beetles. All identified to species level. Many species are woodborers, particularly attacking trees that are already stressed, e.g. by climatic stressors or bark beetle infestation. Several species of Cerambycidae are included in the EU-survey list (Appendix A).

d) **Molytinae** – wood-boring weevils: ***Pissodes*** and ***Hylobius***. Identified to species level. Eight species of *Pissodes* are on the EU-survey list (Appendix A) yet few previous surveys have targeted this genus.

e) **Ptinidae –** "spider beetles". This family is extremely diverse but includes a range of woodboring species – some of which are well-known pests, such the furniture beetle (*Anobium punctatum*) and the death-watch beetle (*Xestobium rufovillosum*).

f) **Cossoninae** – wood boring weevils similar to Molytinae. There are 16 species present in the UK but only *Euophryum confine*, which attacks decaying wood (adults) and dry wood (larvae) or various deciduous and coniferous trees, is particularly common. *Euophryum confine* is native to New Zealand but has become widespread throughout Europe and North America during the last century.

g) **Siricidae** – wood wasps. Identified to genus or species where possible. This group is very poorly known but often collected in traps, with new species occasionally intercepted in the past. This is an important group which are pests in warmer climates, and therefore surveying for wood wasps will be crucial for monitoring a potential climate-facilitated spread.

h) **Brentidae** – the oak timberworm, ***Arrenodes minutus***, is a species of weevil on the EU-survey list which the FTN targets.

i) **Bark beetle predators** – ***Thanasimus*** (identified to species) and ***Rhizophagus*** (identified to genus). *Thanasimus* is a specialist bark beetle predator; *Rhizophagus* is more numerous but a facultative predator of bark beetles. *Rhizophagus grandis* is used in biocontrol of *Dendroctonous micans*, and therefore data on these predators may be valuable for future biocontrol programs.

2.2.3.2 Positive controls

Some species within the groups above can be considered "positive controls", which indicate that the FTN is functioning correctly in attracting target species:

- **Ambrosia beetles** (certain species of Scolytinae and Platypodinae), e.g. species in the Xyleborini tribe such as ***Anisandrus dispar***, ***Xylosandrus germanus***, ***Xyleborinus saxesenii***, ***Xyleborus* spp**. and ***Trypodendron* spp**. – there is one specific species of ambrosia beetle on the EU-survey list, *Euwallacea fornicatus*, and many other non-European ambrosia beetles would fall onto the list too (Appendix A). We expect these species to be strongly attracted to the ethanol and alpha-pinene lures, as previous studies and pilot trials have shown (e.g. Blake *et al.* 2020, Inward 2020). Hence, trapping these suggests that the lures are attracting the right kinds of species.

- ***Ips typographus*** – we know *Ips typographus* is present at some of the sites which are in the Ips demarcated area in South-East England. This species is therefore a positive control as it is one of the target species of the FTN (Appendix A).

- ***Ips sexdentatus* –** an established species of *Ips* which is attracted to *Ips typographus* lures (Blake et al., 2021) and is closely related to the three species of *Ips* on the EU-survey list.

- ***Tomicus piniperda*** – a native species which is not on the EU-survey list, but which can be economically damaging to pine forestry. Again, this species is attracted to the lures used (Blake et al., 2021) so trapping it would be a positive sign that the FTN is functioning correctly.

- ***Tomicus minor*** – a native species which is not on the EU-survey list, but which can be highly damaging to pine trees.

- ***Pissodes pini* and *P. castaneus*** – these species are closely related to the eight species of *Pissodes* that are on the EU-survey list (Appendix A).

- ***Hylobius* spp.** – this genus is closely related to *Pissodes*.

- ***Polygraphus poligraphus*** – a rare species associated with Norway spruce, which is within the same genus as one of the EU-survey list species (*Polygraphus proximus*; Appendix A).
- **Woodboring Cerambycidae**, e.g. ***Arhopalus spp.***, ***Clytus spp.***, ***Tetropium spp.*** – trapping these species would be a good indicator that the FTN targets woodboring Cerambycids effectively, several species of which are on the EU-survey list (Appendix A).

Bark beetles were identified using Grüne (1979) & Duff (2016). Species and genera were identified using Duff (2016, 2020), Mike's Insect Keys (2023) and experience.

2.2.4 Data analysis

Sample-size based rarefaction curves were created with iNext in R (Hsieh et al., 2016). Testing species abundances was carried out using negative binomial general linear mixed models from the glmmTMB package in R. Model fit was tested using the DHARMa package to test the residual error.

3 Results

3.1 General summary

Across the 24 sites and countries, and including all forest types, we collected 1,032 samples. 26,814 individuals from the nine target groups (Scolytinae, Platypodidae, Cerambycidae, Molytinae, Cossoninae, Ptinidae, Brentidae, Siricidae, predators) were collected and identified to species, encompassing 80 species of interest to tree health (Appendix B).

In terms of detecting EU-survey pests (the primary goal of the FTN), *Ips typographus* was the only quarantine species trapped (Appendix C). 86 individuals were trapped in England across four sites: three sites were within the Ips Demarcated Area (DMA), but one was outside it in the East of England. The Wider Environment programme also coincidentally had traps at these sites, and due to the time-sensitive nature of the WE programme, the presence of *Ips typographus* at these sites was detected by the WE programme before the FTN. One *Ips typographus* individual was trapped at a forest in Scotland, which was the first record of *I. typographus* in the wider environment in Scotland (Appendix C). Follow-up surveys did not detect a breeding population at this forest. Numbers of *Ips typographus* trapped were highest between the end of May and the end of June, decreasing in July, with another potential peak in early August (Appendix C).

Across all countries, the predator *Rhizophagus*, and the bark beetles *Hylurgops palliatus*, *Tomicus piniperda* and *Dryocoetes autographus* were very abundant (Appendix B). In Scotland and England, the predator *Thanasimus formicarius* and *Hylastes ater/brunneus* were also very abundant (Appendix B). *Hylastes attenuatus*, and the ambrosia beetles *Xyleborinus saxesenii*, *Xylosandrus germanus*, *Anisandrus dispar* were highly abundant in England (Appendix B). The ambrosia beetles *Trypodendron lineatum* and *T. domesticum* were additional abundant species for Wales (Appendix B).

3.2 Sampling coverage

Sampling coverage is the number of species trapped correlated with the number of individuals sampled (a measure of sample size). Extrapolating this tells us whether collecting more individuals (by collecting more samples, i.e. setting up more traps per forest site, or surveying more sites) will lead to trapping more species. We believe that our sampling coverage was adequate (Fig. 3). For Wales particularly, increasing the number of individuals sampled may not have yielded additional species (indicated by a plateau in the dotted line in Fig. 3). For England, even if we had doubled the number of individuals sampled (from ~15,000 to 30,000) we may have only increased the number of species trapped very slightly (Fig. 3). Sampling coverage in Scotland was relatively worse than England and Wales, as the extrapolation suggests we may have caught ~10 more species had we collected more individuals, but this benefit would only be realised if we had tripled the number of individuals sampled from nearly 10,000 to 30,000 (i.e. tripling the number of traps deployed in Scotland), which would be impossible with the current resources available. Thus, we conclude that the FTN 2023 struck an optimal balance between maximising sample coverage whilst minimising costs.

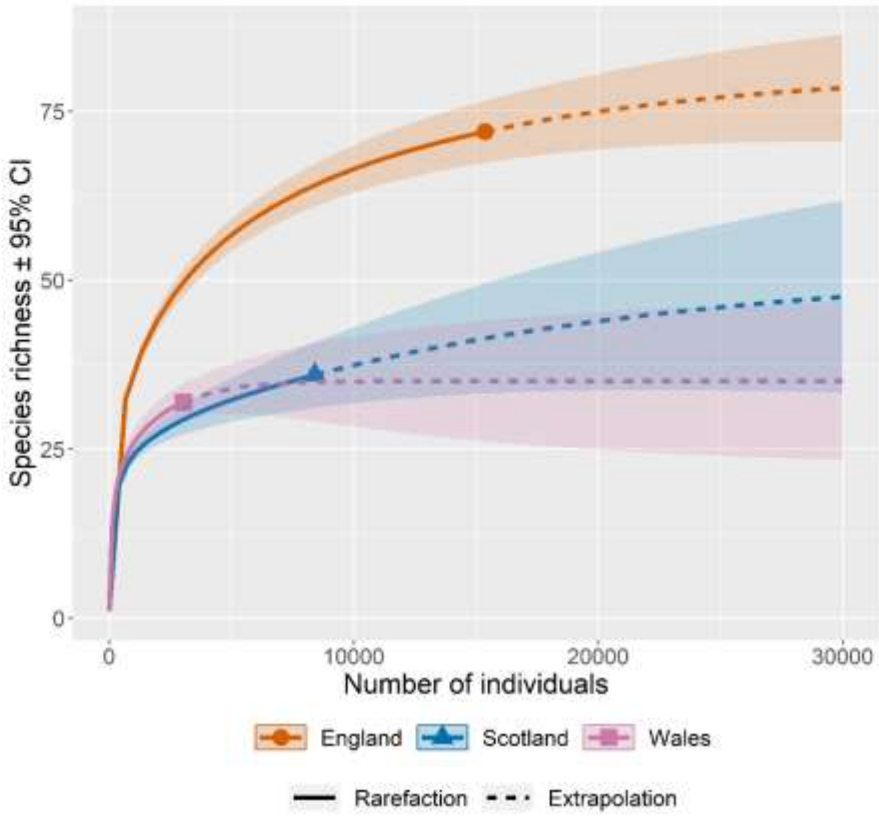

Fig. 3. Rarefaction curve and extrapolated estimation of total species richness of all species from the nine target groups sampled across all sites, forest types and dates. The circle, triangle and square point on each line indicate the total richness of species trapped in 2023 in England, Scotland and Wales (respectively). The solid lines preceding these points indicates the number of species caught based on the number of individuals samples (sample size). The dotted lines are extrapolations from the iNext package, and estimate how many additional species would have been trapped had more individuals been collected through more intensive sampling. The shaded areas indicate 95% confidence intervals.

3.3 Positive controls

As the positive control species give the best indication of whether the FTN is functioning correctly when no quarantine pests are trapped, this report will mainly focus on these species.

The positive control species fall into three families/subfamilies: Cerambycidae, Molytinae and Scolytinae. The FTN trapped 17 positive control species across GB (Appendix B), and good numbers of positive control species across all habitat types, particularly the three coniferous habitat types (Fig. 4). This is a good indication that the FTN is functioning as intended and trapping the right species across all woodland types.

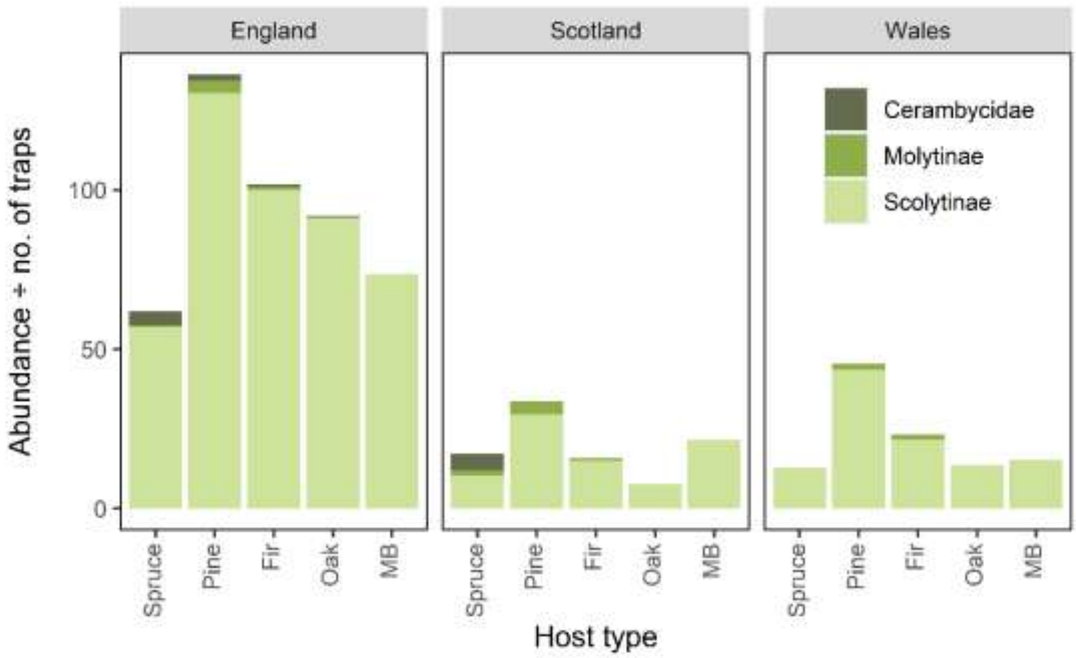

Fig. 4. Abundances of 17 positive control species (grouped by family/subfamily for simplicity) across the five habitat types and three countries, controlled for sampling effort (total abundance ÷ number of traps).

3.3.1 *Tomicus* spp., *Polygraphus poligraphus*, & *Ambrosia beetles* (Scolytinae)

The majority of individuals from positive control species were Scolytinae, which is to be expected as some positive control scolytid species are highly abundant in our samples (e.g. *Tomicus piniperda*, and the ambrosia beetles *Xylosandrus germanus*, *Xyleborinus saxesenii, Anisandrus dispar*, and *Trypodendron* spp., Appendix B, Appendix D), compared with cerambycids and molytids which are relatively much rarer.

Pine yielded significantly higher abundances of positive control species than any other forest type (df = 4, z = 4.298, $p < 0.005$), largely due to the high numbers of the native *Tomicus piniperda* (Scolytinae) trapped in all three countries (Appendix B, Appendix D). It is naturally common throughout England and Wales and more sporadic in Scotland, occurring mostly in the northern Highlands. This species can have a major economic impact on pine forestry as it can be highly destructive to its main host, Scots pine.

In England and Wales, fir forests had the second highest average abundances of positive control species (fir matched spruce for positive control abundances in Scotland; Fig. 4). Again, this was largely driven by relatively high abundances of Scolytinae, in particular the two native species *Tomicus piniperda* and *Trypodendron lineatum* (Appendix B, Appendix D). *Tomicus piniperda* will rarely attack firs (Abies spp.) (Duff, 2016), and was likely trapped frequently in fir forests due to its high abundances in mixed coniferous woodlands. *Trypodendron lineatum* is an Ambrosia beetle for which Douglas fir (included in the fir category in this report) is the preferred host, although it can attack a range of coniferous trees.

Mixed broadleaf woodlands and oak were dominated by Scolytid positive control species in all three countries (Fig. 4). In Scotland and Wales, this trend is largely explained by relatively high abundances of *T. domesticum* (Appendix D). In England, this can be explained by high relative abundances of the ambrosia beetles

Trypodendron domesticum, *Xyleborinus saxesenii*, *Anisandrus dispar*, and *Xylosandrus germanus* in mixed broadleaf forests (Appendix D). *T. domesticum* is a native species of secondary pest which attacks broadleaved species, and can cause reasonable amounts of damage to timber. Changes in precipitation and temperature attributed to global warming are contributing to fungus and insect damage to beech trees, including secondary attacks by *T. domesticum* on health-compromised trees in mainland Europe (Gaubicher et al., 2002), so it will be important to monitor this species with the FTN. *Xyleborinus saxesenii* is a native species which dominated the samples from mixed broadleaf and oak woodlands in England (Appendix D). Only one individual was trapped in Scotland, where it is little-recorded, and 57 in Wales, though 42 of these were from a trap in Scots Pine, likely because the trap was near a mixed broadleaf woodland. It has been highly successful at establishing outside its native range, where it can cause major damage to its host species, though there is no evidence that it has changed its habits and started attacking healthy trees inside its native range (Kühnholz et al., 2001). *Xylosandrus germanus* is native to eastern Asia (Japan, Korea, China), but established in South-East England at some point before 2012 (D. J. Inward, 2020), likely coming from Europe – this is a species that is important to monitor with the FTN.

Spruce yielded the relatively low abundances of positive control species compared with other forest types, particularly relative to other coniferous woodlands (Fig. 4). However, two positive control species were trapped most frequently in spruce: *Ips typographus* and *Polygraphus poligraphus* (Appendix D). The FTN 2023 only trapped *I. typographus* in Norway spruce woodlands (Appendix C), Hence, despite relatively low catch-rates of positive control species in spruce, it is important to continue trapping in these forests.

3.3.2 *Pissodes* spp. and *Hylobius* spp. (Molytinae)

Hylobius abietus was by far the most abundant molytid in all three countries, trapped mostly in pine forests but sometimes fir and spruce (Appendix B, Appendix D).

Hylobius abietus is considered a significant pest of pine - it is a particular problem in the UK and other parts of Europe during the first five years after restocking (replanting) of commercial conifer forests, and occasionally also of recently restocked broadleaved forests. It is especially destructive of seedlings of pine and spruce (Picea genus), some species of which are widely grown in the UK for the softwood timber market. It is important to monitor this species with survey networks such as the FTN as it is one of the most significant insect threats to pine plantations which may affect the future security of softwood forestry if left unmanaged. Forest Research is developing non-chemical techniques to manage this pest.

3.3.3 *Tetropium* spp., *Clytus* spp., *Arhopalus* spp. (Cerambycidae)

These are the three positive control genera of Cerambycidae (longhorns), which were mainly trapped in England. Most of the species trapped are native to GB. *Tetropium castaneum* was the most frequently trapped species (Appendix B, Appendix D) – its distribution spreads from Southern England to the Scottish Highlands, although none were trapped in Wales by the FTN. It is considered a pest, but the damage it causes is usually minor. *Tetropium fuscum* was the second most common of these species (Appendix B, Appendix D), although only seven individuals were trapped across four sites. *T.fuscum* is a pest of spruce that is native to mainland Europe and Northern Asia but is now established in the UK, although its distribution is still very local (Duff, 2016). There is evidence that invasive *T. fuscum* may displace native *Tetropium* species outside its native range (Dearborn et al., 2016), though we trapped such low numbers of *T. fuscum* this would be impossible to infer from our data. The native species *Arhopalus rusticus* and *Clytus arietus* were trapped in relatively low numbers in England (Appendix B, Appendix D).

3.4 Notable species

3.4.1 Species potentially new to the UK

We trapped two individuals of one species that is potentially new to the UK, *Crypturgus hispidulus*, at a site in Kent (Appendix B). However, this record is waiting to be confirmed by a specialist. This is a mainly spruce-feeding bark beetle that is common on fallen trees, likely blown over from Europe (where it is native) by wind currents. Based on the biology of this species it is not thought to be of economic concern, although the FTN is ideally placed to monitor it in the coming years.

3.4.2 Rare species

Several rare species were trapped: the woodboring cossonid *Cossonus linearis* was trapped in England, and is classed as Nationally Notable A; the wood wasp *Sirex juvencus* was trapped in Scotland, which is potentially only the third record here; the bark beetle *Hylesinus wachtli* was trapped in England, where it is classed as scarce; and the bark beetle *Dryocoetus villosus* was trapped in Ross and Cromarty, which is potentially a county record and the farthest north it has been recorded in Scotland (Appendix B). These records are also waiting for confirmation by county recorders.

3.4.3 Recently established species

As previously mentioned, the ambrosia beetle *Xylosandrus germanus* (native to Eastern Asia) is now abundant in forests in SE England. The FTN trapped this species in very large numbers at two sites in SE England (Bedgebury and Orlestone). This species can become highly abundant once it has established in broadleaf forest, apparently becoming one of the most numerically dominant bark beetles in a range of forest types e.g. (Bouget & Noblecourt, 2005; Oliver & Mannion, 2001). Whilst it may attack living but weakened trees, the greatest negative impact within Slovakia is attacks on recently felled logs of oak, beech and spruce trees, which provide high quality timber/lumber (Galko et al., 2018). In England in total, more individuals of this species were trapped than many other common native species which also have broadleaved hosts (e.g. *Trypodendron domesticum* and *Anisandrus dispar*; Appendix B, Appendix D). So far it appears to be confined to SE England, though as the climate warms its distribution may expand as predicted for other invasive *Xylosandrus species* (Urvois et al., 2021). As the economic risk posed by *X. germanus* was deemed to be "medium" in a Rapid Pest Risk Analysis (D. Inward, 2015), this is something that will be important to monitor with the FTN. This is not on the EU-survey list due to its ubiquity across much of Europe.

The ambrosia beetle *Gnathotrichus materiarius* was recently reported as established in the UK (D. J. Inward, 2020). This species colonises conifers and is a typical secondary pest in that it multiplies on decaying trees or trees already infested and killed by other bark beetle species. This is a species native to America and has been spreading across Europe since the 1930s, but so far there is no evidence that this species causes serious damage in Europe (Fiala et al., 2024). We trapped low numbers of *G. materiarius* in 2023 (Appendix B). Although models suggest *G. materiarius* could continue expanding its range across Europe (Witkowski et al., 2022), our data therefore indicate that the establishment and spread of this species are of far smaller magnitudes than that of *Xylosandrus germanus*, and warrants much less concern.

3.4.4 Bark beetle predators

The FTN trapped huge abundances of bark beetle predators across all three countries, particularly *Rhizophagus*, of which there were 11,294 individuals in total (Appendix B). *Rhizophagus* species feed on the eggs and larvae of a range of Scolytinae species. *Rhizophagus grandis* specialises on *Dendroctonus micans* and is commonly used as biocontrol of this species. High numbers of *Rhizophagus* suggests a good level of biocontrol that is naturally provided, and suggests a well-functioning food web. It is a promising indication of the health of our forests as bark beetle populations are being naturally controlled.

3.5 Differences between sites and forest types

When total abundances were controlled for sampling effort, across all countries pine woodland had the highest abundances of species from the nine target groups (Fig. 5). This is likely due to very high abundances of *Tomicus piniperda* and *Hylastes attenuatus*, which are highly abundant species which prefer pine. Spruce had the next highest target species abundances in England and Scotland, and fir had the second highest abundances in Wales (Fig. 5). Oak and other mixed broadleaf woodlands consistently yielded the lowest average abundances of target species (Fig. 5).

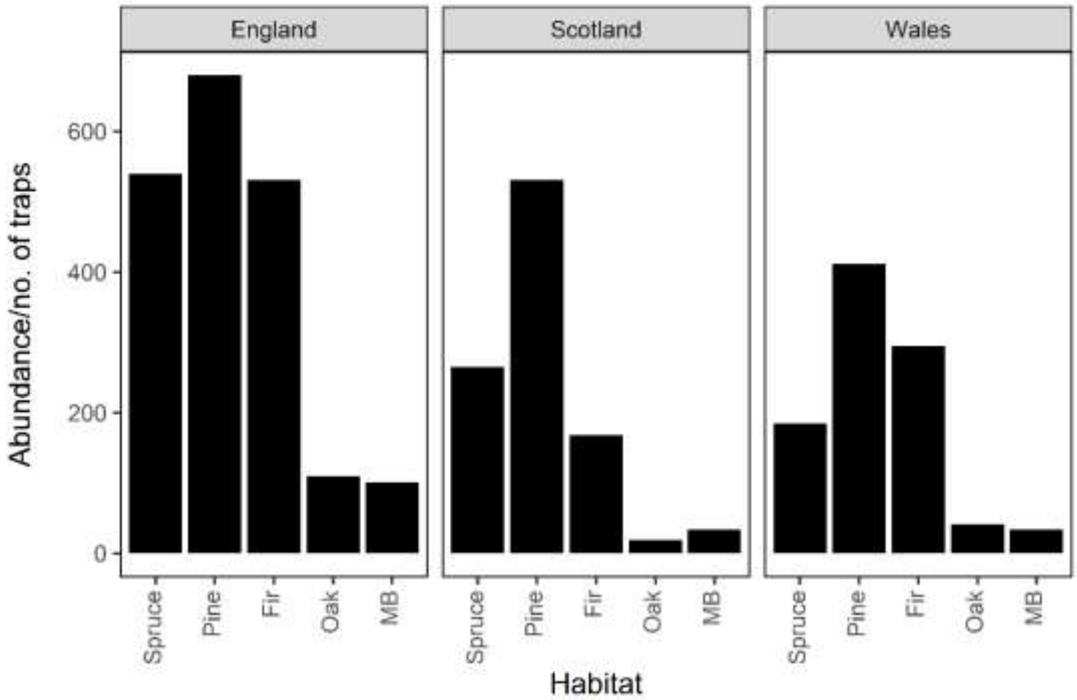

Fig. 5. Average abundances of individuals from target families/subfamilies trapped across the five habitat types and three countries, controlled for sampling effort (total abundance of individuals trapped ÷ number of traps).

When looking at abundances of individuals from the nine target groups (i.e. the nine groups we identified to species level), there was much variation among forest types (host types) and sites, and some trends (Fig. 6). In general, coniferous forests yielded higher average abundances of most groups than did broadleaf forests (Fig. 4). Pine forests had relatively high or the highest average abundances of most beetle groups – Scolytinae, Molytinae, Cossoninae, Cerambycidae, and bark beetle predators such as *Rhizophagus* spp. – and also of Siricidae (Fig. 6). Spruce forests also yielded relatively high average abundances of Siricidae and most beetle groups aside from Molytinae and Ptinidae (Fig. 6). Molytinae were largely trapped in pine, as pine is the primary host of the most common molytid species, *Hylobius abietus*. That the Ptinidae were mainly found in broad-leaved forests is because the relatively common species trapped (e.g. *Ptinomorphus imperialis*, *Hemicoelus fulvicornis*, *Anobium* spp.) have broadleaved hosts.

Abundances across the different forest sites were far more variable with few consistent patterns. Higher average abundances tended to be accompanied by large error bars (Fig. 6), meaning they are less reliable than the mean values for lower abundances. However, general trends will be discussed. In Wales, Wentwood yielded high average abundances of Scolytinae, Siricidae and bark beetle predators compared with the other three Welsh sites (Fig. 6). This is likely due to the fact that Wentwood is the largest area of ancient woodland in Wales. Chepstow Park also trended towards higher average abundances for most groups aside from Scolytinae and Cossoninae (Fig. 6). Beacon Hill had consistently low average abundances of most groups (Fig. 6).

In England, Leigh Woods (Bristol), Thetford Forest (West Norfolk), Savernake (Wiltshire) and Clatford Bottom (i.e. West Woods, Wiltshire) consistently yielded relatively low abundances of all groups. This is surprising as all four forests are SSSIs, and Leigh Woods and Clatford Bottom (West Woods) are both ancient woodlands, though aside from Thetford these sites are all westerly which may partially explain this trend. Bedgebury, Green Side Wood and Orlestone had the highest abundances of Scolytinae, which may be due to their easterly locations. Perhaps surprisingly, Delamere as the most northerly site scored fourth highest for Scolytinae abundances.

This is largely due to very high abundances of *Tomicus piniperda* at this site, a pine-attacking Scolytid that is thriving in the pine-dominated Delamere forest.

In Scotland, surprisingly one of the most northerly sites, Drumnaodrochit (i.e. Lochletter Wood, Inverness), followed by Achilty (i.e. also Inverness) yielded the highest and second highest average abundances of Scolytinae (respectively). This may be because the area hosts a large concentration of ancient forests making the general area hospitable for tree pests, although the woodlands where the traps were not ancient. In contrast with the trend in England, the three of the most easterly sites, Keillour (Perth), Dean and Gartmorn (both upstream of the Firth of Forth) had the lowest abundances of Scolytinae (Fig. 6), yet Dean had relatively high abundances of Cossoninae and Siricidae. This is possibly because these forests are relatively small compared with the other Scottish sites.

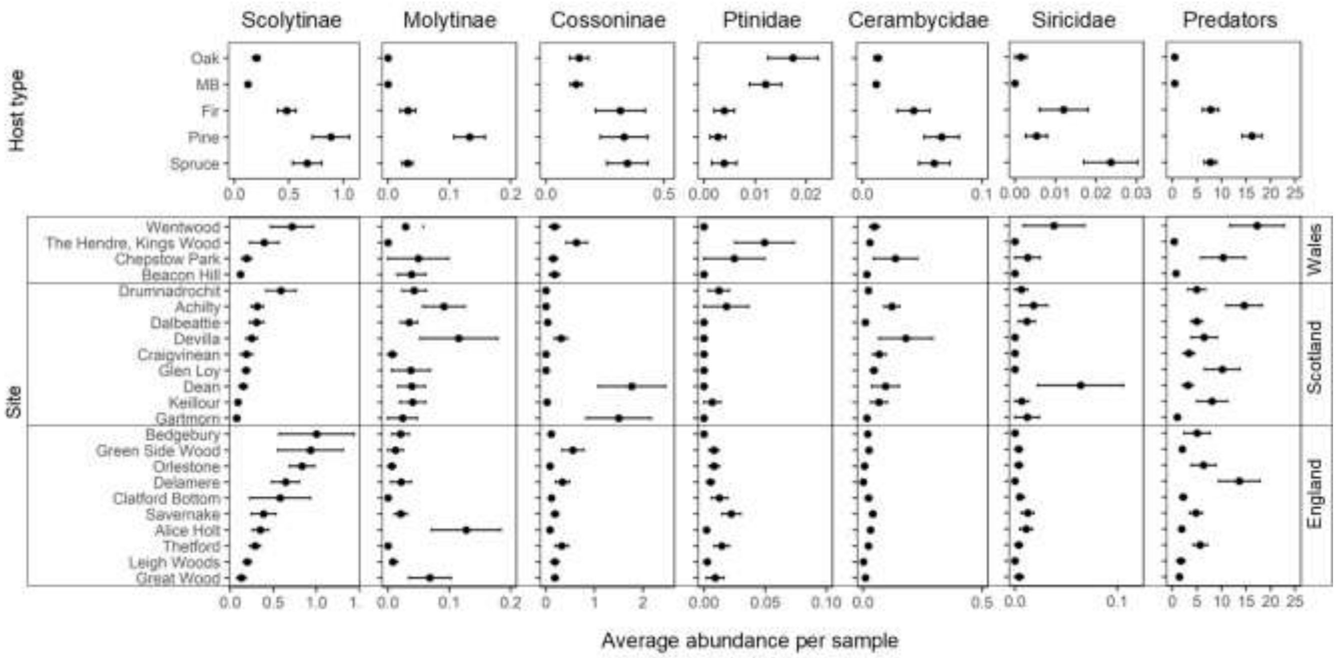

Fig 6. Variation in the average abundances (per sample) of individuals from the nine target groups, sampled across the five host type (forest types) and 24 sites in England, Scotland and Wales. Brentidae and Platypodidae have been excluded due to low abundances. Points indicate the mean, and bars indicate standard error of the mean. If error bars overlap the mean of other groups, there is unlikely to be a statistically significant difference. Means were

calculated by dividing the total number of e.g. Scolytinae collected in e.g. oak forest, by the total number of samples collected from oak forests. Note that these families/subfamilies contained largely native or established species, apart from the quarantine species *Ips typographus* in the Scolytinae subfamily. Note the differing scales on the y-axes.

3.6 Species discovery rate and abundances through the season

The rate at which new species (i.e. not trapped previously this year) were trapped by the FTN started to increase at the end of May, then remained on a steady increase throughout the year until August, when only two new species were trapped (the woodwasp *Sirex noctilio*, and the bark beetle *Pityophthorus pubescens*, Fig. 7). This concurs with the abundances of species trapped from the target families/subfamilies throughout the year: abundances in samples tended to peak between May and July, although there are group-specific differences, for example the abundances of Scolytinae (bark beetles) peaked in late May which corresponds to the flight period of many of these species (Fig. 8). Abundances of Cerambycidae (longhorn beetles) had a narrow peak in mid-June, and abundances of Molytinae (*Hylobius* and *Pissodes*) and Ptinidae peaked in July, whereas the abundances of predators stayed high throughout almost the entire season (Fig. 8).

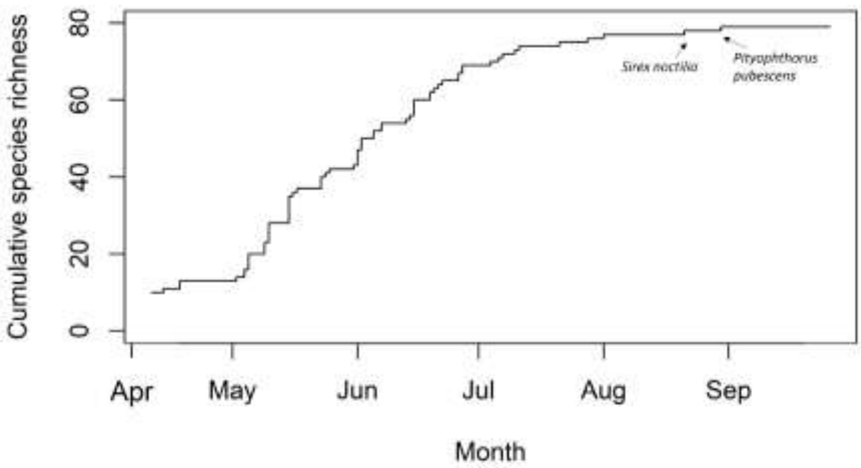

Fig. 7. Species accumulation curve showing how the number of new species that were being trapped continued to increase until August.

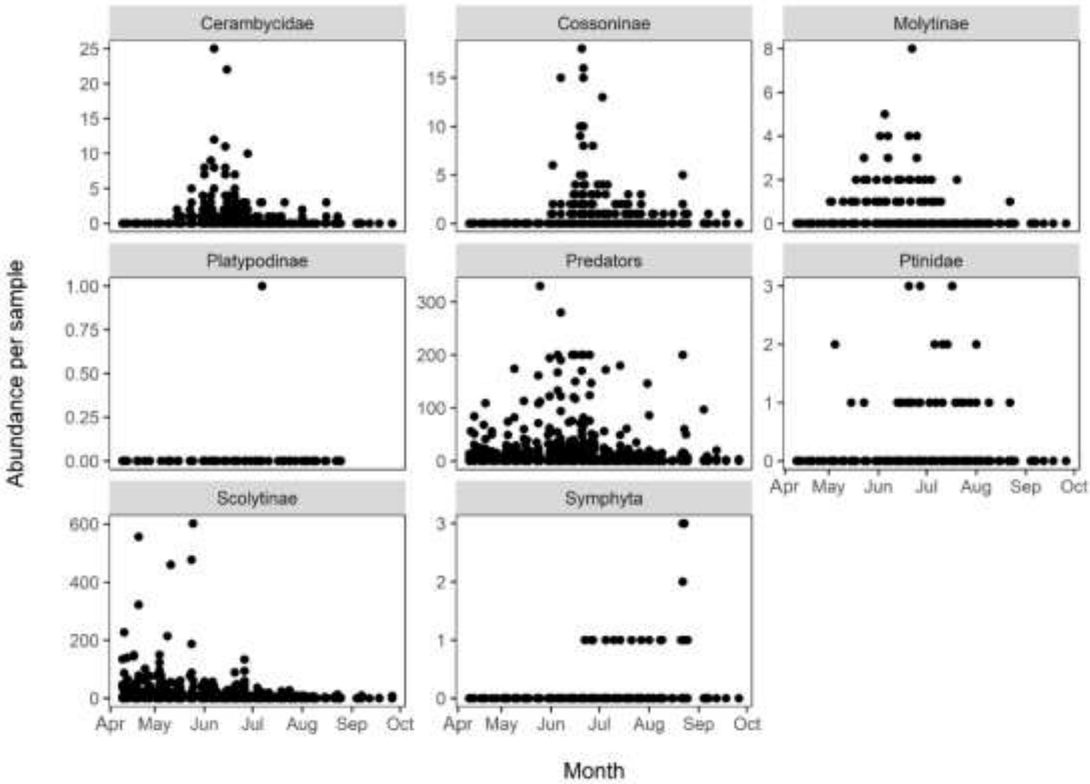

Fig. 8. Per-sample abundances of species from the nine families/subfamilies that are identified to species-level in the FTN (note that Symphyta represents Siricidae).

3.7 Geographical variation in diversity

There were some geographical differences in diversity (species richness) between sites in the North, South, East, and West of England. Great Wood and Leigh Woods were the most westerly sites in England and yielded the lowest species richness (Fig. 9), although Savernake Forest is also quite westerly and yielded the highest species richness (Fig. 9). The southerly sites in general (Alice Holt, Orlestone, Bedgebury) yielded a higher richness than in other areas, although the midlands easterly sites Green Side Wood and Thetford yielded a reasonably high richness also. Delamere was by far the most northerly site and yielded the third lowest species richness.

The differences in species richness were less pronounced for Scotland and Wales than for England (Fig. 9). This might be expected for the Welsh sites as they were geographically clustered and may have similar insect communities. Interestingly, the most northerly site in Scotland (Achilty) yielded the highest species richness. There was also a very weak trend of increasing species richness along a West-East gradient, although richness was more clearly linked to country (with English sites tending to have higher species richness; Fig. 9).

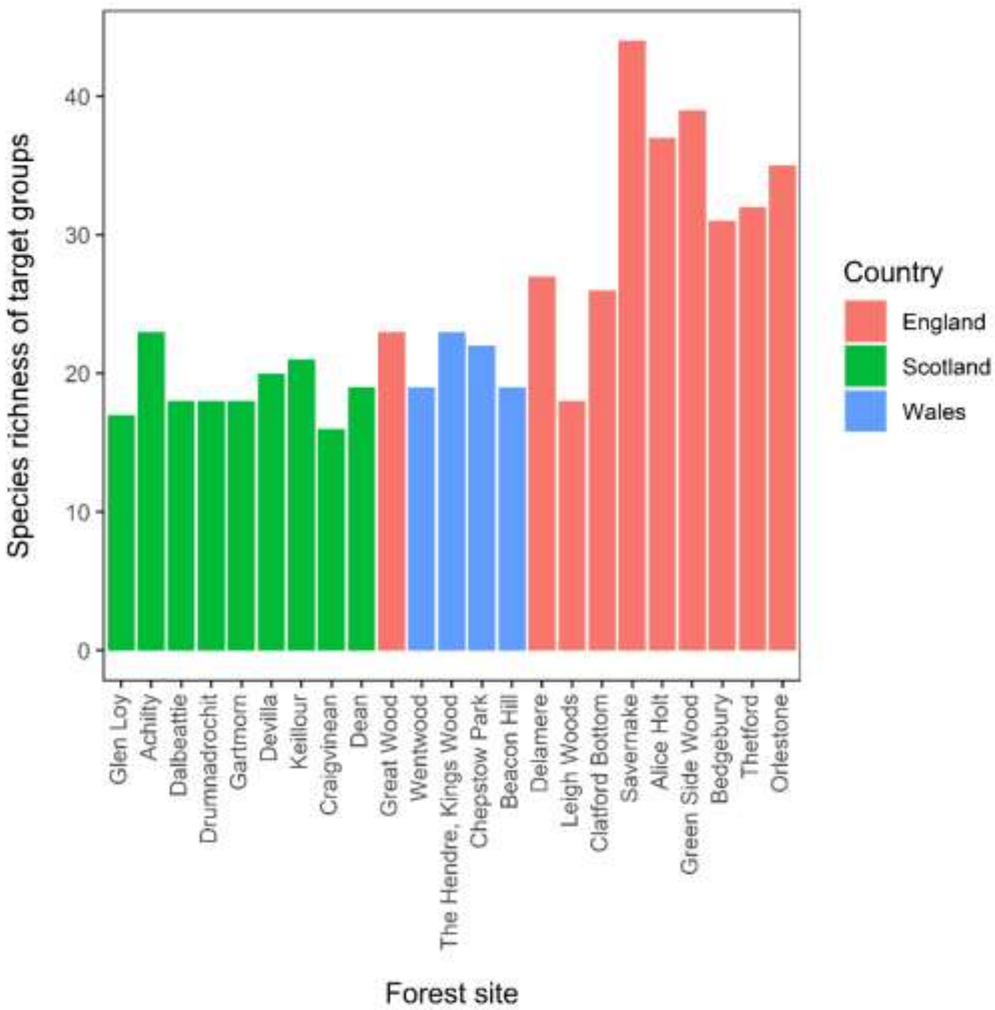

Fig. 9. Total species richness of species from the nine target groups/families sampled at each site, in each country. Sites are ordered West to East.

4 Discussion

4.1 Achievements of the FTN 2023

- Surveyed 24 sites across England, Scotland and Wales.
- No quarantine species other than *Ips typoographus* were trapped in GB.
- Trapped 17 positive control species across GB. Good numbers of positive control species trapped across all countries and forest types, indicating the FTN functioned effectively in terms of attracting the target species.
- Trapped and identified 26,841 individuals from the nine target groups/families to species, encompassing 80 species of interest to tree health.
- Good sampling coverage indicates an appropriate number of traps were deployed across most of GB. The FTN 2023 struck an optimal balance between maximising sample coverage whilst minimising costs.
- High numbers of the established and non-native ambrosia beetle, *Xylosandrus germanus*, which could potentially become a species of concern if spread and numbers increase, suggests that the FTN is achieving a secondary goal of monitoring non-quarantine tree pests.
- Trapped one species potentially new to the UK and, several rare species, and a potential county record.
- High numbers of bark beetle predators gives promising indication that natural bark beetle populations are being controlled.
- Generated a large amount of data that could be used to inform on forest health, and on tree pest population dynamics and biodiversity across GB.
- Formed a novel and one-of-its-kind large-scale, long-term monitoring program targeting tree pests in England.

4.2 Did the FTN 2023 meet its four goals?

(1) Form a key FSP survey strategy which targets pests that other survey methods cannot detect

Although only one quarantine species was trapped, we know that the FTN was effective at targeting this suite of pests because it 17 positive control species from several insect families, indicating that it worked effectively in attracting a broad-range of target species. The one quarantine species (*I. typographus*) that we know to be present SE England and expected to detect, was trapped at four sites in England and one in Scotland (Appendix C). Therefore we are confident that novel, broad-spectrum methods employed by the FTN are highly suitable for meeting its targets and those of the Future Surveillance Plan.

(2) Consolidate current trapping programmes into a single network to ease logistical issues (potentially replacing existing trapping programmes long-term)

In its current form, the FTN can be said to be consolidating the PFA Billet Trapping programme as it specifically targets *Ips typographus* with pheromone lures in spruce woodlands, to deliver data on *Ips typographus* abundances once-yearly. Whilst the FTN will never be able to consolidate all current trapping programmes, it has the potential to consolidate more of them. The most obvious trapping programme to incorporate into the FTN is the *Monochamus* trapping programme (see section 4.4.3), which is a consideration for 2024. Canopy trapping for quarantine *Agrilus* may also be possible to incorporate in the next 5-year cycle, but this would require an increase in budget due to the additional time required to set up the canopy traps (which can be a lengthy process), and for training Plant Health Officers to service the traps. It may be more appropriate for the Agrilus trapping programme to be a separate entity. The Wider Environment (WE) Ips trapping programme (which has now mostly replaced the Pest Free Area Billet Trapping Programme) is required to return results on *Ips typographus* abundances on a fortnightly basis – this would be impossible for the FTN to achieve due to the need to identify far more insect species than required in the WE programme. However, the FTN provides a good second line of defence against Ips and allows a greater area of GB to be surveyed for Ips each year, as FTN sites are often different to WE sites.

(3) Improve current trapping methods for quarantine pests

One of the major benefits of the FTN is that it is broad, both in terms of insects it targets and in terms of area it covers. This makes it an improvement on previously used trapping methods, which only target a single species, or are only used in certain areas (e.g. Ports, Piers and Processor traps). The FTN was also found to have good sampling coverage of species present at the sites, indicating that it would likely trap the target quarantine/priority species if present. As the FTN caught 17 positive control species (Fig. 4), which are analogous to the set of target species on the EU survey list, in high numbers, we are confident that it is a good trapping method for these species. We caught *Ips typographus*, a target quarantine species, at sites where it was present at several points throughout summer (Appendix C) – which is an improvement on the PFA Billet Trapping programme, which only returns one datapoint per site per year. However, we know that the FTN in its current format is not an improvement on trapping methods for canopy-dwelling quarantine species such as *Agrlius* (of which we only caught one individual of a native species), which is an avenue that should be explored.

(4) Ensure a cohesive approach across the three countries

Now that the FTN has had a stable team for two years, collaborations with the three countries have been strengthened. The FTN has now been rolled out in Scotland and Wales for a full year, which went very smoothly. During the pre-trapping season period early in 2023, the FTN team collaborated closely with Scottish Forestry, Forestry Commission England and NRW to select sites and plan logistics. The FTN team presented the project at two meetings in 2023 and 2024 attended by members of Scottish Forestry, Welsh Gov and Forestry Commission. The three countries received regular updates about the FTN, and online or face to face meetings were organised when necessary.

4.3 Was the FTN 2023 effective in surveying for quarantine pests?

The FTN trapped 17 positive control species across GB and in large numbers across all habitat types, particularly the conifers (Fig. 4). This suggests that the EU-survey list species would be attracted by the ethanol and alpha-pinene lures, and would be trapped in the black cross-vane traps used in FTN, if they were present at a sites. Indeed, the quarantine species Ips typographus was trapped readily by the FTN at several sites in the Demarcated Area. We are therefore confident that our methods are robust and will keep them largely the same for 2024.

4.4 Do any changes need to be planned for 2024 and into the future?

4.4.1 Site selection

The sites chosen for the FTN are filling more and more gaps across GB each year, as the goal is to survey as much of GB as possible within five years. Two sites this year were very close by geographically (West Woods at Clatford Bottom, and Savernake Forest, both south of Marlborough). The four sites in Wales were also quite clustered, as the only FC contractor available to service the traps was based in the area. The Welsh sites were chosen with risk in mind, as they are near several ports, but this clustering of sites is something we will actively try to avoid in the coming years of the FTN in order to survey an even spread of sites across GB.

4.4.2 Cap on abundances of highly abundant species

Some species are extremely abundant, such as *Hylurgops palliatus* and *Rhizophagus* spp. It is questionable whether it is worth the time it takes to count each individual in a sample, when an estimate (e.g. more than 100, ~250, ~500) may suffice for our purposes. This would greatly speed up sample processing and free up time for planning the following year. We will review this idea for the coming season and likely develop a system by which to estimate large numbers of individuals.

4.4.3 Incorporate *Monochamus* trapping into the FTN

Monochamus spp. are generally considered to be secondary pests not capable of attacking and killing healthy trees, although severe infestations in log yards can lead to significant degradation of stored timber (Evans et al., 2004). *Monochamus* species are also vectors of pine wilt nematode *Bursaphelenchus xylophilus* (PWN), the causal agent of pine wilt disease. A *Monochamus* trapping network had been run by colleagues at FR until 2023, when the project lead (Nick Fielding) retired. The FTN is well-placed to pick up *Monochamus* trapping as the methods and equipment for the two trapping networks are very similar. The FTN is reasonably well-placed to incorporate *Monochamus* trapping, which would involve adding one extra trap with a *Monochamus galloprovincialis* pheromone lure to ~5 FTN sites which have suitable sub-compartments (areas of pine felled within the last three years). The only potential hurdle is the availability of appropriate habitats for *Monochamus* within FTN sites (i.e. sub-compartments containing clear-felled pine within the past 3 years). It may become logistically complicated to select sites that are suitable for the FTN (i.e. 4-6 sub-compartments meeting the criteria) and also have areas of recently clear-felled pine. However, a new step to be incorporated into FTN site selection will be to ask the foresters whether there are any of these suitable sub-compartments at the selected sites.

4.4.4 Length of trapping season

That the FTN does not trap many new species in August (Fig. 5) may indicate that it is not necessary to continue trapping into late August, which would save time and money. However, we plan to continue trapping into August in 2024 to collect another year data on which to base this decision, ahead of the next full 5-year cycle of the

FTN. When we have several years of data to analyse, a decision can be made on whether to shorten the trapping season.

4.5 Progress so far in 2024

Between January and March 2024, the FTN team planned the survey season for 2024. In collaboration with Scottish Forestry and Forestry Commission, sites were selected in Scotland and England, and access was organised with the forest managers. On the whole, logistical planning was carried out efficiently for Scottish and English sites. Traps in Scotland were all deployed by the end of March, and traps in England were all deployed by the first week of April. Due to issues with contractor availability, the lone working ban, and miscommunication, traps in Wales were not set up until the first week of May. It will be important for FR, FC and NRW to work together early in 2025 to decide who will be responsible for servicing FTN traps in Wales next year, to avoid a repeat of this situation. The FTN depends on cross-organisation cooperation which all parties signed up to by funding this programme, and we need to ensure strong lines of communication so that the FTN can be delivered in a timely manner.

In total, eight sites were selected in England, eight in Scotland and four in Wales (Fig. 10; Table 4). Sites were chosen to fill geographical gaps left after the previous four years of surveillance in this 5-year cycle. Sites in Wales were carefully selected to be as spread out in the mid-north of Wales as possible, since the 2023 sites were clustered in the Southeast.

Fig. 10. Sites (pink dots) selected for survey in the Forest Trapping Network 2024.

Country	Forest site	Spruce	Pine	Fir	Oak	MB	Total
England	Abinger Forest	1	1	1	0	3	**6**
	Bourne Wood	1	1	1	1	1	**5**
	Hazelborough Wood	1	1	0	1	1	**4**
	Salcey Forest	1	1	1	1	1	**5**
	Sherwood Pines Forest Park	0	1	0	1	3	**5**
	Staple Park Wood/Staple Common	1	1	0	1	1	**4**
	Wendover Woods	1	1	1	0	1	**4**
	Wykeham Forest	1	1	1	0	2	**5**
Scotland	Elibank/Thornielee	1	1	1	0	1	**4**
	Gatehouse of Fleet	1	0	1	1	2	**5**
	Glentress	1	1	1	0	1	**4**
	Kelburn Estate	1	0	0	0	2	**3**
	New Galloway	1	1	1	0	2	**5**
	Newton Stewart	1	1	1	0	2	**5**
	Torrieston	1	1	1	1	1	**5**
	Wilsontown	1	1	0	0	1	**3**
Wales	Abbeycwmhir	1	1	1	0	1	**4**
	Breidden Forest	1	1	1	1	0	**4**
	Dyfnant Forest	1	0	1	1	1	**4**
	Radnor Forest	1	0	2	1	1	**5**
	Grand Total	**19**	**16**	**16**	**10**	**28**	**89**

Table 4. Site list for FTN 2024 including number of traps set up in the five forest types.

5 Acknowledgements

This work was funded by Scottish Government, Welsh Government and Forestry Commission England. With thanks to Ria Jefferson-Gleed at Forestry Commission, Joe McMinn at NRW, and Cameron Macintyre at Scottish Forestry for assistance with site selection and logistics. With thanks to the Plant Health and Forestry Officers and Support Officers at Forestry Commission, and Tree Health Officers at Scottish Forestry for servicing the FTN traps throughout 2023. Thanks also to entomologists at Forest Research for lab support.

6 References

Blake, M., Kendall, T., & Whitham, T. (2021). *Pilot Protected Zone experimental lure program 2020*. Contracted Report.

Bouget, C., & Noblecourt, T. (2005). Short-term development of ambrosia and bark beetle assemblages following a windstorm in French broadleaved temperate forests. *Journal of Applied Entomology*, *129*(6), 300–310. https://doi.org/10.1111/j.1439-0418.2005.00970.x

Dearborn, K. W., Heard, S. B., Sweeney, J., & Pureswaran, D. S. (2016). Displacement of Tetropium cinnamopterum (Coleoptera: Cerambycidae) by Its Invasive Congener Tetropium fuscum. *Environmental Entomology*, *45*(4), 848–854. https://doi.org/10.1093/ee/nvw045

Duff, A. G. (2016). *Beetles of Britain and Ireland. Volume 4: Cerambycidae to Curculionidae*. A. G. Duff Publishing.

Duff, A. G. (2020). *Beetles of Britain and Ireland. Volume 3: Geotrupidae to Scraptiidae*. A. G. Duff Publishing.

Evans, H., Moraal, L., & Pajares, J. (2004). Biology, ecology and economic importance of Buprestidae and Cerambycidae. *Bark and Wood Boring Insects in Living Trees in Europe, a Synthesis*, 447–474.

Fiala, T., Holuša, J., Resnerová, K., Foit, J., Lakatos, F., Mazur, A., Procházka, J., Witkowski, R., Pyszko, P., & Holzschuh, C. (2024). The invasive ambrosia beetle, Gnathotrichus materiarius (Coleoptera: Curculionidae), in Central Europe. *Journal of Integrated Pest Management*, *15*(1), 14. https://doi.org/10.1093/jipm/pmae006

Galko, J., Dzurenko, M., Ranger, C. M., Kulfan, J., Kula, E., Nikolov, C., Zúbrik, M., & Zach, P. (2018). Distribution, habitat preference, and management of the invasive ambrosia beetle Xylosandrus germanus (Coleoptera: Curculionidae, Scolytinae) in European forests with an emphasis on the West Carpathians. *Forests*, *10*(1), 10.

Gaubicher, B., De Proft, M., & Gregoire, J. (2002). Trypodendron domesticum and Trypodendron signatum: Two scolytid species involved in beech decline in Belgium. *Ecology, Survey and Management of Forest Insects*, 134.

Grüne, S. (1979). *Brief illustrated key to European bark beetles.* Verlag M. & H. Schaper.

Hackston, M. (2023). *Mike's Insect Keys*. https://sites.google.com/view/mikes-insect-keys

Hsieh, T., Ma, K., & Chao, A. (2016). INEXT: an R package for rarefaction and extrapolation of species diversity (H ill numbers). *Methods in Ecology and Evolution*, *7*(12), 1451–1456.

Inward, D. (2015). *Rapid Pest Risk Analysis for Xylosandrus germanus (Coleoptera: Scolytinae)*. Forest Research, Alice Holt Lodge: Farnham, UK.

Inward, D. J. (2020). Three new species of ambrosia beetles established in Great Britain illustrate unresolved risks from imported wood. *Journal of Pest Science*, *93*(1), 117–126.

Kühnholz, S., Borden, J. H., & Uzunovic, A. (2001). Secondary ambrosia beetles in apparently healthy trees: Adaptations, potential causes and suggested research. *Integrated Pest Management Reviews*, *6*, 209–219.

Oliver, J. B., & Mannion, C. M. (2001). Ambrosia Beetle (Coleoptera: Scolytidae) Species Attacking Chestnut and Captured in Ethanol-Baited Traps in Middle Tennessee. *Environmental Entomology*, *30*(5), 909–918. https://doi.org/10.1603/0046-225X-30.5.909

Urvois, T., Auger-Rozenberg, M. A., Roques, A., Rossi, J. P., & Kerdelhue, C. (2021). Climate change impact on the potential geographical distribution of two invading Xylosandrus ambrosia beetles. *Scientific Reports*, *11*(1), 1339. https://doi.org/10.1038/s41598-020-80157-9

Witkowski, R., Dyderski, M. K., Bełka, M., & Mazur, A. (2022). Potential European geographical distribution of Gnathotrichus materiarius (Fitch, 1858)(Coleoptera: Scolytinae) under current and future climate conditions. *Forests*, *13*(7), 1097.

Appendix A

List of pests on the Plant Health (Phytosanitary Conditions) (Amendment) (EU Exit) Regulations 2020 that the FTN is targeting, i.e. any pest which cannot be targeted by other survey methods in the FSP.

Group	Pest Species	Tree Species	Focus
Scolytidae	Scolytidae spp. (non-European)	Mixed Broadleaf	Primary
Brentidae	*Arrenodes minutus*	Mixed Broadleaf	Primary
Scolytidae	*Pseudopityophthorus minutissimus*	Mixed Broadleaf	Primary
Scolytidae	*Pseudopityophthorus pruinosus*	Mixed Broadleaf	Primary
Scolytidae	*Euwallacea fornicatus*	Mixed Broadleaf	Primary
Cerambycidae	*Xylotrechus* spp.	Mixed Broadleaf	Primary
Cerambycidae	*Neocerambyx raddei*	Mixed Broadleaf	Secondary
Scolytidae	Scolytidae spp. (non-European)	Oak Dominant	Primary
Brentidae	*Arrenodes minutus*	Oak Dominant	Primary
Scolytidae	*Pseudopityophthorus minutissimus*	Oak Dominant	Primary
Scolytidae	*Pseudopityophthorus pruinosus*	Oak Dominant	Primary
Molytinae	*Pissodes nitidus*	Pine Dominant	Primary
Molytinae	*Pissodes punctatus*	Pine Dominant	Primary
Molytinae	*Pissodes strobi*	Pine Dominant	Primary
Molytinae	*Pissodes zitacuarense*	Pine Dominant	Primary
Molytinae	*Pissodes cibriani*	Pine Dominant	Primary
Molytinae	*Pissodes nemorensis*	Pine Dominant	Primary
Molytinae	*Pissodes yunnanensis*	Pine Dominant	Primary
Scolytidae	*Polygraphus proximus*	Pine Dominant	Primary
Scolytidae	Scolytidae spp. (non-European)	Pine Dominant	Primary
Cerambycidae	*Monochamus* spp. (European and non-EU)	Pine Dominant	Secondary
Molytinae	*Pissodes strobi*	Spruce dominant	Primary
Molytinae	*Pissodes nemorensis*	Spruce dominant	Primary
Scolytidae	*Polygraphus proximus*	Spruce dominant	Primary
Scolytidae	Scolytidae spp. (non-European)	Spruce dominant	Primary
Scolytidae	*Ips typographus*	Spruce dominant	Primary
Scolytidae	*Ips amitinus*	Spruce dominant	Primary
Scolytidae	*Ips duplicatus*	Spruce dominant	Primary
Molytinae	*Pissodes fasciatus*	Fir dominant	Primary
Scolytidae	*Polygraphus proximus*	Fir dominant	Primary
Scolytidae	Scolytidae spp. (non-European)	Fir dominant	Secondary

Appendix B

List of species trapped in the FTN 2023. Values in columns give the abundances of each species in different forest types. "+" preceding the species name indicates a positive control species.

Species	Scotland	Wales	England	Total	Species	Scotland	Wales	England	Total
Anaglyptus.mysticus	0	0	6	**6**	*Pityogenes.bidentatus*	0	1	3	**4**
+Anisandrus.dispar	0	30	268	**298**	*Pityogenes.chalcographus*	5	27	33	**65**
Anobium.inexpectatum	0	0	3	**3**	*Pityogenes.quadridens*	2	0	0	**2**
Anobium.punctatum	0	0	1	**1**	*Pityogenes.trepanatus*	37	16	93	**146**
+Arhopalus.rusticus	0	0	22	**22**	*Pityophthorus.pubescens*	0	0	1	**1**
Asemum.striatum	20	32	11	**63**	*Pityophthorus.spp.*	1	0	0	**1**
+Clytus.arietus	0	0	5	**5**	*Platypus.cylindrus*	0	0	1	**1**
Cossonus.linearis	0	0	1	**1**	*Polygraphus.grandiclava*	0	0	3	**3**
Cryphalus.asperatus	29	15	92	**136**	*+Polygraphus.poligraphus*	0	9	73	**82**
Crypturgus.hispidulus	0	0	2	**2**	*Ptilinus.pectinicornis*	1	5	21	**27**
Diprion.pini	0	0	1	**1**	*Ptinomorphus.imperialis*	0	1	2	**3**
Dryocoetes.alni	2	0	1	**3**	*Ptinus.subpilosus*	0	0	2	**2**
Dryocoetes.autographus	344	77	260	**681**	*Rhagium.bifasciatum*	136	20	35	**191**
Dryocoetes.villosus	24	22	33	**79**	*Rhagium.inquisitor*	0	1	0	**1**
Ernobius.mollis	0	0	3	**3**	*Rhagium.mordax*	19	2	7	**28**
Ernoporicus.caucasicus	1	0	0	**1**	*Rhizophagus.spp.*	5178	1833	4283	**11294**
Ernoporicus.fagi	0	0	4	**4**	*Rutpela.maculata*	0	2	2	**4**
Euophryum.confine	99	33	231	**363**	*Scolytus.intricatus*	0	0	9	**9**
Gnathotrichus.materiarius	0	0	12	**12**	*Scolytus.multistriatus*	0	0	3	**3**
Grynobius.planus	5	0	1	**6**	*Scolytus.ratzeburgi*	0	0	0	**0**
Hemicoelus.fulvicornis	0	0	8	**8**	*Sirex.juvencus*	1	0	4	**5**
Hylastes.angustatus	20	0	121	**141**	*Sirex.noctilio*	4	0	0	**4**
Hylastes.ater.brunneus	228	4	209	**441**	*Stenocorus.meridianus*	0	0	5	**5**
Hylastes.attenuatus	0	2	1784	**1786**	*Taphrorychus.bicolor*	0	0	2	**2**

Hylastes.cunicularius	52	6	45	**103**	*+Tetropium.castaneum*	50	0	24	**74**
Hylastes.opacus	34	0	152	**186**	*+Tetropium.fuscum*	0	0	7	**7**
Hylesinus.crenatus	0	0	2	**2**	*+Tetropium.gabrieli*	0	0	3	**3**
Hylesinus.varius	0	0	9	**9**	*Thanasimus.formicarius*	334	1	592	**927**
Hylesinus.wachtli	0	0	1	**1**	*+Tomicus.minor*	0	0	11	**11**
+Hylobius.abietus	51	8	44	**103**	*+Tomicus.piniperda*	232	40	1396	**1668**
Hylurgops.palliatus	1040	574	3167	**4781**	*+Trypodendron.domesticum*	222	60	298	**580**
+Ips.sexdentatus	0	0	5	**5**	*+Trypodendron.lineatum*	208	127	39	**374**
+Ips.typographus	1	0	85	**86**	*+Trypodendron.signatum*	16	18	80	**114**
Leiopus.nebulosus	1	0	3	**4**	*Urocerus.gigas*	8	5	5	**18**
Molorchus.minor	0	2	2	**4**	*Xeris.pallicoxae*	0	0	1	**1**
Orthotomicus.laricis	0	0	9	**9**	*Xeris.spectrum*	0	0	1	**1**
Pachytodes.cerambyciformis	0	1	0	**1**	*Xestobium.rufovillosum*	0	0	1	**1**
Phloeotribus.rhododactylus	1	0	0	**1**	*+Xyleborinus.saxesenii*	1	57	1229	**1287**
Phymatodes.testaceus	0	0	2	**2**	*+Xyloborus.monographus*	0	0	9	**9**
+Pissodes.castaneus	1	0	0	**1**	*+Xylosandrus.germanus*	0	0	485	**485**

Appendix C

List of quarantine species trapped in 2023 – *Ips typographus* was the only quarantine species trapped from the list in Appendix A. Specific details of sites are available to the respective countries upon request.

Country	Trap number	Collection date	Site ID	Host species	Host type	Species	Abundance
Scotland	99	07/06/2023	12	Norway spruce	Spruce	*Ips.typographus*	1
England	62	15/05/2023	5	Norway spruce	Spruce	*Ips.typographus*	1
England	44	24/05/2023	2	Norway spruce	Spruce	*Ips.typographus*	13
England	44	06/06/2023	2	Norway spruce	Spruce	*Ips.typographus*	3
England	42	22/06/2023	1	Norway spruce	Spruce	*Ips.typographus*	2
England	44	20/06/2023	2	Norway spruce	Spruce	*Ips.typographus*	16
England	83	20/06/2023	9	Norway spruce	Spruce	*Ips.typographus*	15
England	44	04/07/2023	2	Norway spruce	Spruce	*Ips.typographus*	3
England	42	20/07/2023	1	Norway spruce	Spruce	*Ips.typographus*	1
England	44	19/07/2023	2	Norway spruce	Spruce	*Ips.typographus*	5
England	83	19/07/2023	9	Norway spruce	Spruce	*Ips.typographus*	1
England	44	01/08/2023	2	Norway spruce	Spruce	*Ips.typographus*	10
England	83	03/08/2023	9	Norway spruce	Spruce	*Ips.typographus*	1
England	44	15/08/2023	2	Norway spruce	Spruce	*Ips.typographus*	4
England	83	17/08/2023	9	Norway spruce	Spruce	*Ips.typographus*	3
England	42	29/08/2023	1	Norway spruce	Spruce	*Ips.typographus*	1
England	44	30/08/2023	2	Norway spruce	Spruce	*Ips.typographus*	4
England	83	31/08/2023	9	Norway spruce	Spruce	*Ips.typographus*	2

Appendix D

List of positive control species, and their abundances trapped across the three countries and five woodland types surveyed by the FTN.

	England						Scotland						Wales					
	Fir	MB	Oak	Pine	Spruce	**Total**	Fir	MB	Oak	Pine	Spruce	**Total**	Fir	MB	Oak	Pine	Spruce	**Total**
Cerambycidae																		
Arhopalus.rusticus	4	0	2	16	0	**22**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Clytus.arietus	0	0	3	1	1	**5**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Tetropium.castaneum	0	0	0	0	24	**24**	0	0	0	2	48	**50**	0	0	0	0	0	**0**
Tetropium.fuscum	1	0	0	0	6	**7**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Molytinae																		
Hylobius.abietus	5	0	0	35	4	**44**	3	0	0	34	14	**51**	7	0	0	1	0	**8**
Pissodes.castaneus	0	0	0	0	0	**0**	1	0	0	0	0	**1**	0	0	0	0	0	**0**
Pissodes.pini	0	0	0	1	0	**1**	0	0	0	3	0	**3**	0	0	0	3	0	**3**
Scolytinae																		
Anisandrus.dispar	1	151	111	4	1	**268**	0	0	0	0	0	**0**	0	15	13	1	1	**30**
Ips.sexdentatus	0	0	0	0	5	**5**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ips.typographus	0	0	0	0	85	**85**	0	0	0	0	1	**1**	0	0	0	0	0	**0**
Polygraphus.poligraphus	28	0	0	4	41	**73**	0	0	0	0	0	**0**	3	0	0	0	6	**9**
Tomicus.minor	2	0	0	9	0	**11**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Tomicus.piniperda	481	0	0	878	37	**1396**	1	0	1	194	36	**232**	3	2	0	34	1	**40**
Trypodendron.domesticum	1	186	111	0	0	**298**	0	192	30	0	0	**222**	0	36	20	0	4	**60**
Trypodendron.lineatum	4	14	8	11	2	**39**	64	17	0	71	56	**208**	80	0	1	9	37	**127**
Trypodendron.signatum	1	53	25	0	1	**80**	10	6	0	0	0	**16**	0	9	6	1	2	**18**
Xyleborinus.saxesenii	43	360	446	197	183	**1229**	0	1	0	0	0	**1**	0	14	1	42	0	**57**
Xylosandrus.germanus	39	119	213	71	43	**485**	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Grand total	**610**	**883**	**919**	**1227**	**433**	**4072**	**79**	**216**	**31**	**304**	**155**	**785**	**93**	**76**	**41**	**91**	**51**	**352**

Alice Holt Lodge
Farnham
Surrey, GU10 4LH, UK
Tel: **0300 067 5600**

Northern Research Station
Roslin
Midlothian, EH25 9SY, UK
Tel: **0300 067 5900**

Forest Research in Wales
Environment Centre Wales
Deiniol Road, Bangor
Gwynedd, LL57 2UW, UK
Tel: **0300 067 5774**

info@forestresearch.gov.uk
www.forestresearch.gov.uk

Forest Research will consider all requests to make the content of our documents available in alternative formats.

Please send any such requests to: research.info@forestresearch.gov.uk