Department for Environment Food & Rural Affairs

Rapid Pest Risk Analysis (PRA) for:

Ennomos subsignaria

February 2025

Summary and conclusions of the rapid PRA

Ennomos subsignaria (the elm spanworm) is a North American (Canada and USA) moth which intermittently reaches outbreak densities, causing serious defoliation of hardwood forests in its native distribution.

This rapid PRA shows:

Risk of entry

Wood in the rough and fuel wood were rated as **moderately likely** pathways on which this pest could enter the UK. These ratings were made with **medium** confidence due to the lack of detail in the trade data including information about processing. Broadleaved trees for planting, and cut branches and foliage were rated as **unlikely** pathways with **high** and **medium** confidence respectively. Other plants for planting not falling into the broadleaved tree category and cut flowers were both rated as **very unlikely** pathways with **high** confidence. Isolated bark/bark chips and contaminating pest/hitchhiker pathways were also both rated as **very unlikely** pathways but with **medium** confidence.

Risk of establishment

Risk of establishment outdoors was rated as **likely**. This pest is highly polyphagous, feeding on many broadleaved genera and species present in the UK, and UK

temperatures sit within the extremes of the pest's current distribution. This risk was rated with **medium** confidence due to few lifecycle parameters being published for this pest.

Economic, environmental and social impact

All impacts were based on the assumption that established *E. subsignaria* populations could reach outbreak numbers in the UK. Potential economic, environmental and social impacts were all rated as **large** but with **low** confidence due to the uncertainty over this pest's ability to outbreak in a novel climate and environment.

Endangered area

The endangered area was considered to be broadleaved trees in urban and rural environments across the UK.

Risk management options

Many of the host genera of this pest are listed as 'high-risk plants' in the regulations and as such are prohibited from import as plants for planting pending a risk assessment. *Bacillus thuringiensis* (*Bt*) appears to be the most common means of control in North America (USA and Canada). Biopesticides with *B. thuringiensis* are available for use in the UK, but, if required, large-scale or aerial spraying of trees might be controversial. Other management options are discussed but have many uncertainties.

Key uncertainties and topics that would benefit from further investigation

Main uncertainties: Causes of drastic increases in *E. subsignaria* populations and the environmental impacts.

Further investigation: Parasitoids of Lepidoptera and more specifically Geometridae which are present in Europe and their potential to parasitize *E. subsignaria*.

Images of the pest

	
Ennomos subsignaria adult and eggs on the bark of a tree © Heidi Fry, Bugwood.org https://www.ipmimages.org/browse/detail.cfm?imgnum=5445626	*E. subsignaria* late instar larvae and defoliated plant © Heidi Fry, Bugwood.org https://www.ipmimages.org/browse/detail.cfm?imgnum=5445626

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?

Yes, this is a very damaging pest in its native range causing significant economic, environmental and social impacts. This PRA also concluded that the pest is likely to be able to establish in the UK.

Yes Statutory action	✓	No Statutory action	

Stage 1: Initiation

1. What is the name of the pest?

Ennomos subsignaria (Hübner, [1823]) (Lepidoptera: Geometridae)

Widely used synonym: *Ennomos subsignarius*
Other synonyms: *Ennomos niveosericeatus* (Harris, 1855); *Eudalimia subsignaria* Hübner, 1823
Common name: elm spanworm.

2. What initiated this rapid PRA?

This moth was identified as a serious pest during the compilation of the Defra list of pests of *Fraxinus* created during the summer and autumn of 2016. The moth was added to the UK Plant Health Risk Register and given an overall risk rating of 45 (this was the unmitigated and the mitigated scoring). The Plant Health Risk Group agreed that a PRA should be carried out to assess the level of risk more comprehensively.

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]?

This pest is listed in the GB regulations (the Phytosanitary Conditions Regulation (assimilated regulation (EU) 2019/2072)[2]) as a Provisional Quarantine Pest (listed under the synonym *Ennomos subsignarius*).

Ennomos subsignaria is not listed in the EU regulations which apply to Northern Ireland (EU legislation: 2019/2072 and 2016/2031[3]). This pest is not recommended for regulation as a quarantine pest by EPPO, nor is it on the EPPO Alert List.

[1] https://www.eppo.int/ACTIVITIES/quarantine_activities
[2] https://www.legislation.gov.uk/eur/2019/2072 (link to latest consolidated version)
[3] The latest consolidated version can be accessed on the left-hand side of https://eur-lex.europa.eu/eli/reg_impl/2019/2072/oj

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

The distribution of *E. subsignaria* includes the USA and Canada (referred to as North America in this PRA)(Table 1). It is limited to the eastern half of the USA and the southern and eastern Canadian provinces .

Table 1: Distribution of *Ennomos subsignaria*	
North America:	Canada (Manitoba, New Brunswick, Newfoundland and Labrador, Ontario, Quebec and Saskatchewan); USA (Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Vermont, Virginia, West Virginia and Wisconsin)
Central America:	No records
South America:	No records
Europe:	No records
Africa:	No records
Asia:	No records
Oceania:	No records

Figure 1 shows records of *E. subsignaria* moths gathered from a variety of sources by the North American Moth Photographers Group. The distribution map of *E. subsignaria* on iNaturalist, however, indicates that it may occasionally be found further West (Fig. 2).

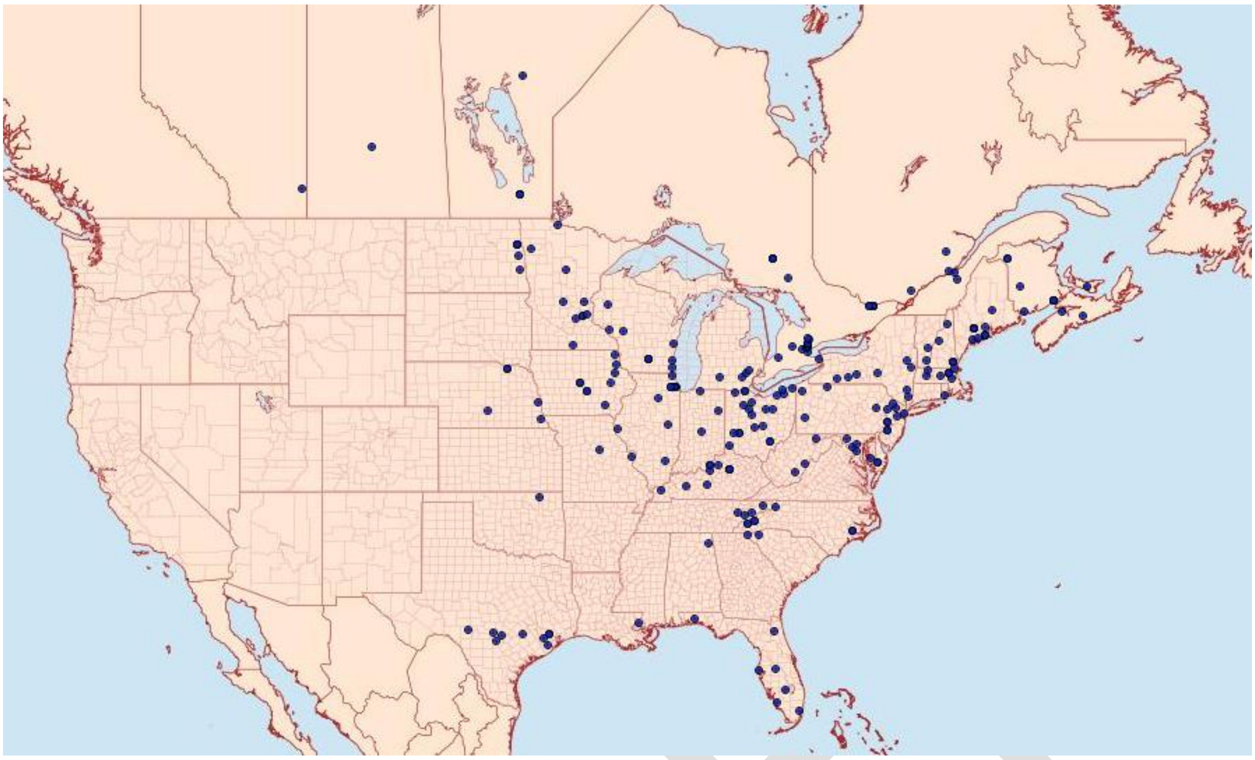

Figure 1 Records of *Ennomos subsignaria.* Complied by the North American Moth Photographers Group using museum and state databases, literature, collector and photographer's records. Some records may only be of adults i.e. not evidence of breeding populations. Reproduced with permission (MPG, no date)

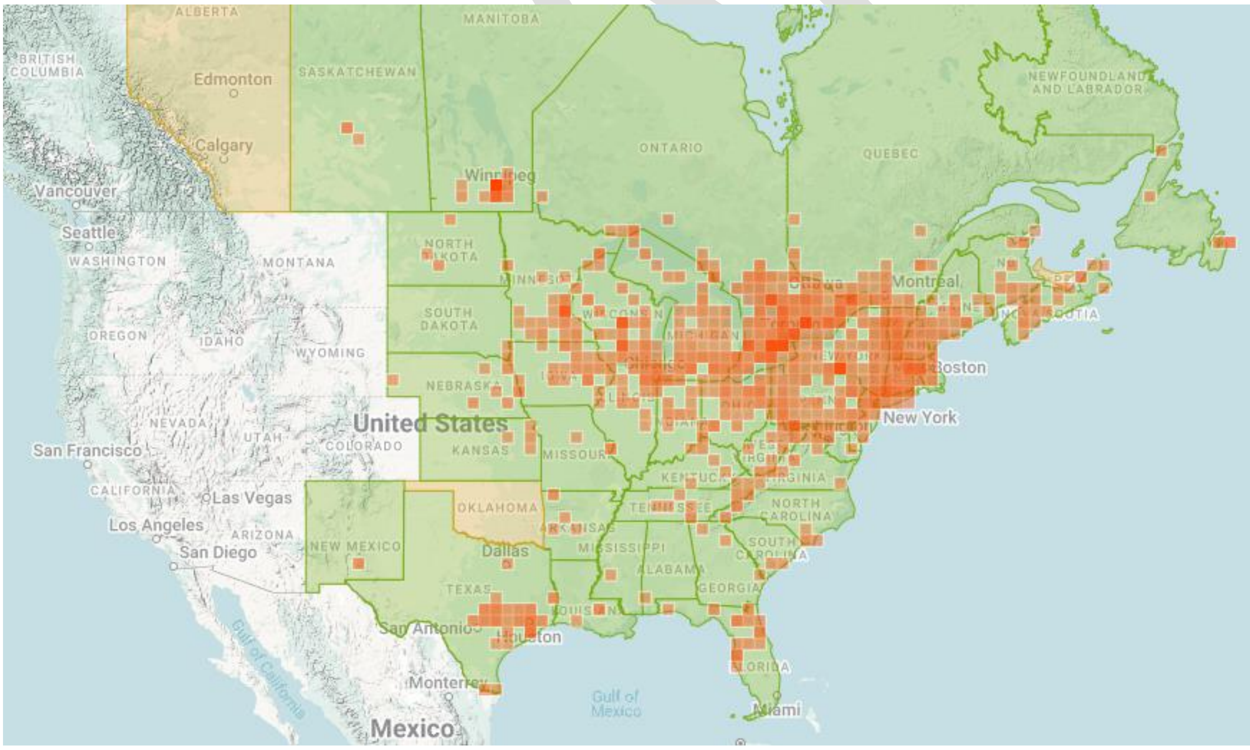

Figure 2 Records of *Ennomos subsignaria* by the iNaturalist community. Exported from https://www.inaturalist.org on 11/12/2024

Population outbreaks of *E. subsignaria* are, however, limited to the Appalachian Mountains, but have occurred as far east as St John's, Newfoundland and Labrador (Fig. 3).

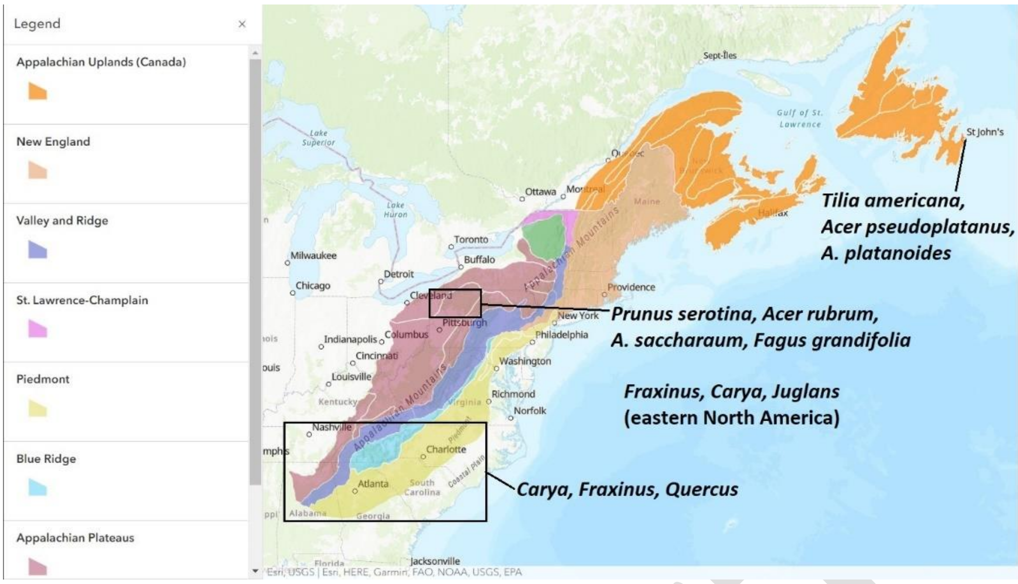

Figure 3 Appalachian Mountains of the USA and Canada © Deanrah https://commons.wikimedia.org/wiki/File:Appalachian_Mountains_of_North_America.jpg and host preferences as summarised by Ryall (2010)

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

Ennomos subsignaria is not known outside of North America.

There is a report found online of an unofficial interception made at Covent Garden market, London in April 1984; a pupa was found amongst *Asparagus setaceus* (Kunth) Jessop (recorded as *Asparagus plumosa* – asparagus fern) imported from Florida (Lowe, 1985). The adult emerged six days later. The sample was not submitted to or recorded by the Ministry of Agriculture, Fisheries and Food (MAFF).

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?

Ennomos subsignaria is highly polyphagous on deciduous trees, including trees known as forest, shade and fruit trees in North America. In areas of high larval concentrations, nearly all hardwoods except *Liriodendron tulipifera* L. (yellow poplar) and *Magnolia acuminata* (L.) L. are subject to intensive attacks (Fedde, 1971; Morin *et al.*, 2004). It has also been said that, in heavy infestations, larvae quickly spread onto practically all vegetation, stripping the timber and many understory plants (Fedde, 1971).

In a review, Drooz (1980) states that *E. subsignaria* is a serious defoliator of many broadleaved trees, particularly *Quercus* (oaks), *Carya* (hickories), *Juglans nigra* L. (black walnut) and *Acer rubrum* L. (red maple).

Fedde (1971) lists *Carya*, *Fraxinus* (ash) and *Juglans* as highly favoured hosts; *Acer*, *Aesculus* (buckeye and horse chestnut)*, Carpinus* (hornbeam), *Castanea* (chestnut), *Cornus* (dogwood), *Fagus* (beech), *Liquidambar, Nyssa, Ostrya*, *Populus* (poplar), *Prunus*, *Quercus*, *Salix* (willow)*, Tilia* (lime) and *Ulmus* (elm) as favoured hosts; *Acer pseudoplatanus* L. (sycamore), *Ailanthus*, *Catalpa, Kalmia*, *Morus* (mulberry), *Rhododendron* and *Sassafras* as less favoured hosts (attacked only in severe infestations by mature larvae); and *Liriodendron tulipifera* as a rarely attacked host. Fedde (1971) also mentions that, periodically *E. subsignaria* also causes serious damage to *Malus* (apple) crops and seriously weakens valuable shade trees. Fedde (1971) does not make clear whether the above-named species are true hosts (whether *E. subsignaria* can complete development on these species), but, as described below, Ryall (2010) successfully reared *E. subsignaria* on *Acer*, *Aesculus*, *Betula, Fagus*, *Tilia*, *Quercus* and *Ulmus* in the laboratory.

Summary of outbreaks described in the literature and host preferences where stated:

The earliest recorded outbreaks of *E. subsignaria* occurred in the 1800s in the New York city and Philadelphia area. Another early outbreak occurred in 1878 in the southern Appalachians (North and South Carolina, Georgia and Tennessee; Fig. 3) (Drooz, 1980 and references therein). In the early 1950s an outbreak which lasted over a decade, peaking in 1960 and affecting 607,000 ha, occurred again in the southern Appalachians (Ciesla, 1964; Fedde, 1964; Drooz, 1980). During this outbreak, *Carya* and the white and red *Quercus* groups were most heavily attacked. At least 18 major *E. subsignaria* infestations took place in the eastern USA between 1900 and 1961 (Morin *et al*., 2004 and references therein).

During an outbreak which lasted from 1991 to 1993 in the Allegheny National Forest, Pennsylvania, *Prunus serotina* Ehrh. (black cherry), *Acer rubrum* L. (red maple), *Acer saccharum* Marshall (sugar maple), and *Fagus grandifolia* Ehrh. (American beech) were noted as the preferred hosts of *E. subsignaria* (hosts ordered by basal area of plots studies, starting with the highest). In their analysis, Morin *et al*. 2004 found that the frequency of defoliation was significantly associated with the proportion of *P. serotina* and *A. rubrum* in stands (but not with other hosts). And the only significant association between *E. subsignaria* defoliation and mortality or dieback of host was with *P. serotina* and *A. saccharum*. This outbreak overlapped with outbreaks of *Rheumaptera* (formerly *Hydria*) *prunivorata* (cherry scallop shell moth) and *Lymantria dispar* (spongy moth) and affected 176,037 ha (Morin *et al.*, 2004).

At the most easterly tip of the Appalachians in St John’s and Newfoundland and Labrador, Canada, where *E. subsignaria* had previously been described as rare, the population maintained outbreak numbers from 2002 to 2006 (Fry *et al.*, 2009). In this urban environment, *Acer pseudoplatanus*, *Acer platanoides* L. (Norway maple), and *Tilia americana* L. (linden or American basswood), which are shade trees and not native to Newfoundland were the main species defoliated (Fry *et al.*, 2008a).

Host affects in the laboratory:

In a study of the life history parameters (survival, weight, development time, longevity and fecundity) of *E. subsignaria* individuals collected from and reared on various native and non-native broadleaved species, there was no clear advantageous host (Ryall, 2010). Females who had been collected as pupae from *A. pseudoplatanus* and *A. platanoides* (non-native species) produced significantly more eggs than those collected from native trees. When the fecundity of females who had been reared in the laboratory on the same range of hosts were compared, however, the females who had been reared on *Ulmus americana* L. produced significantly more eggs than those reared on the non-native *Acer* species. It is therefore difficult to gauge which hosts *E. subsignaria* is most successful on. *Ennomos subsignaria* neonate larvae were able to complete development, mate and oviposit on all species tested (*Acer pseudoplatanus*, *A. platanoides*, *Aesculus hippocastaneum* L. (horse chestnut), *Betula papyrifera* Marshall (white birch), *Fagus sylvatica* L. (var. purpurea, purple beech), *Tilia americana*, *Quercus macrocarpa* Michx. and *Ulmus americana*).

In summary, *Ennomos subsignaria* is highly polyphagous favouring different broadleaved species depending on availability and circumstance. Out of the ten principal broadleaved genera listed by growing stock for Great Britain, only *Alnus* (alder), *Corylus* (hazel) and *Crataegus* (hawthorn) are not explicitly listed as hosts in the literature. In the UK, it therefore seems likely that most broadleaved tree species in most environments (wider, urban and crop) would make suitable hosts for this pest. *Acer* spp. are commonly favoured in the more northerly parts of this pest's distribution (including *A. pseudoplatanus* which is very common in the UK) and so perhaps these species are particularly at risk.

8. Summary of pest biology and/or lifecycle

Ennomos subsignaria is univoltine (one generation / year) in its distribution across North America (Ciesla, 1964; Fry *et al.*, 2009). In the southern Appalachian Mountains, eggs laid in early July over winter and hatch in late April/early May the following year (Ciesla, 1964). Egg hatch might start as late as the third week of May in the upper slopes of the mountains of southwestern North Carolina (Drooz, 1980), and as late as early June in the northeast of North America (including Newfoundland) (Fedde, 1971; Fry *et al.*, 2009). In an outbreak in Newfoundland, eggs hatched approximately two weeks after peak budburst (Fry *et al.*, 2009).

First instar larvae do not settle to feed on the opening leaves for at least part of the day; they string down on silk and the wind commonly transports them to greater heights and distance (known as ballooning) according to Drooz (1980). This pattern was also observed in the outbreak in St John's, Newfoundland, where larvae dispersed from the lower crown to outer and upper areas of the crown as they matured (Fry *et al.*, 2009). These first instar larvae can only feed on tender foliage (Drooz, 1980). Larvae feed for six weeks, moulting four times (occasionally larvae moult five times, particularly female individuals, no explanation as to the cause of this is given in the literature). The fifth instar larva can consume a leaf equal to the size of a mature *Q. rubra* L. (red oak) leaf per day (Drooz, 1980). Mature larvae spin a loose silken cocoon on or between the remains of leaves, or, when trees are stripped, in bark fissures, on artifacts such as buildings/signposts, on exposed branch tips or in the under-growth (Ciesla, 1964; Fedde, 1971; Drooz, 1980; Fry *et al.*, 2008a). Adults emerge approximately ten to fourteen days later (in early July in the southern Appalachians and August in Newfoundland) (Drooz, 1980; Fry *et al.*, 2008a).

Laboratory rearing indicates a protandry (males emerging before females) of several days. After emergence, moths mate between evening and morning and the females oviposit in the following 24 hours. It is during this time that 'spectacular' flights of the mostly male moths (though also including some gravid females) are attracted to urban lighting. Moths can readily fly 100 to 200 km (Drooz, 1980).

'A few' to 250 eggs are laid per egg mass (on average approximately 50 to 60 eggs). Females collected from *Quercus macrocarpa* and *Acer pseudoplatanus* in St John's, Newfoundland whilst in the pupal stage went on to oviposit an average 85 to 135 eggs respectively (Ryall, 2010). In other quoted laboratory studies, however, females fed *Carya glabra* (Mill.) Sweet laid over 300 eggs (Drooz, 1970: Drooz, 1971 cited in Ryall, 2010). Whether the females lay singular or multiple egg masses was not stated in the available literature. Oviposition site preference appears to be linked to latitude and satisfies a requirement for shade, with more egg masses found on the bole in Newfoundland and Connecticut (4.6 to 12.0 m above the ground), and on the underside of branches in North Carolina (60 % were located on branches 1 to 1.5 cm in diameter) (Drooz, 1980 and references therein).

Increased population density causes a darkening of larvae and pupae and a reduction in pupal weight and fecundity among females, and the lifecycle for both sexes is prolonged (Drooz, 1980 and references therein).

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?

Plants for planting (excluding seed and pollen)

Broadleaved trees: Much of the literature published on *E. subsignaria* has concerned attacks on forest or urban trees, so the likelihood of young nursery-grown trees (those intended for export) being infested is unclear. This pest is however included on a product label for a *Bt* product meant for use by greenhouses and nurseries (on leafy and brassica vegetables, fruiting vegetables and herbs) (Nufarm, 2019). Deciduous trees and shrubs traded from this pest's distribution must be dormant and free from leaves (Phytosanitary

Conditions Regulation (assimilated regulation (EU) 2019/2072[4])). Potted trees are likely to be prohibitively expensive to transport due to weight, and so will be more likely transported as bare rooted trees. Larvae and pupae are therefore not likely to be associated with imported trees. Egg masses are laid on the bole or branches of trees. It was assumed that under outbreak conditions or in the absence of mature hosts, females would lay eggs on younger trees. These eggs, approximately 0.5 mm long, are laid in compact masses (2 to 2.5 cm wide) and appear to be quite cryptic (BugwoodWiki, no date, and references therein; Fig. 4). If trees were imported whilst dormant (during autumn/winter), assuming the eggs survived the winter (avoiding excess direct sunlight and parasitisation) and hatch was timed close enough to bud burst, the emerging larvae would be able to feed on the laves of the imported trees and transfer to new hosts by ballooning (on silk threads using wind currents). Sufficient individuals would need to survive to the adult stage to allow mating for establishment to occur.

The regulations for GB and NI include lists of high-risk plants which are prohibited from entering the PRA area pending a risk assessment. Many hosts of *E. subsignaria* (*Betula*, *Castanea*, *Cornus*, *Fagus*, *Fraxinus*, *Juglans*, *Populus*, *Prunus*, *Quercus*, *Salix*, *Tilia*, *Ulmus*) are listed and as such are currently prohibited from entering any part of the UK from the USA and Canada.

Other plants (those not falling into the category of broadleaved trees): In heavy infestations, *E. subsignaria* larvae are reported to spread to almost all plants in the surrounding area stripping many understory plants, and are reported to pupate almost anywhere (in the undergrowth, bark fissures, stumps, branches, buildings, etc.) (Fedde, 1971). The larval and pupal stage could, therefore, be associated with imported plants, however there are no reports of *E. subsignaria* being a pest of nurseries. Caterpillars can be vulnerable to desiccation and are easily damaged whereas the pupal stage, though delicate, might be more likely to survive the journey and go unnoticed. Again, sufficient individuals would need to survive to the adult stage to allow mating for establishment to occur.

It was assumed that the moths would fly off disturbed trees and plants and so would not be associated with plants for planting.

Table 2. Volume of outdoor trees, shrubs, plants imported from the distribution of *Ennomos subsignaria* (kg) (all values from USA, nill return for Canada). Source = HMRC

Commodity code and description / year	2019	2020	2021	2022	2023
06022080 Trees, shrubs and bushes, grafted or not, of kinds which bear edible fruit or nuts					438
06029045 Outdoor rooted cuttings and young plants of trees, shrubs and bushes	1247	17	53		10
06029050 Live outdoor plants, incl. their roots	356	1309	570	818	113

[4] https://www.legislation.gov.uk/eur/2019/2072

Total	**1603**	**1326**	**623**	**818**	**561**

*(excl. with bare roots, citrus, and vine slips)

**(excl. fruit, nut and forest trees)

***(excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants and roots, unrooted cuttings, slips, rhododendrons, azaleas, roses, mushroom spawn, pineapple plants, vegetable and strawberry plants, trees, shrubs and bushes)

The volume of trade in outdoor trees, shrubs and plants from the USA is small, and from Canada, negligible (Table 2).

No interception records for this pest were found in the electronic databases for England and Wales (Fera Plant Health Information Warehouse and Action Recs, accessed May 2024). There are, however, more than 200 interceptions and findings of other species within the family Geometridae in the same database (between 1996 and May 2024), indicating that members of this family can be moved with trade. From 1993 to 2020 there were no reports of interceptions of this pest made by EU member states (though member states only tend to report regulated pests) (Europhyt 1993-2020).No interceptions by amateur entomologists are known, e.g. within light traps (Clancy, 2024). (See one reported interception at Convent Garden market, London below.)

The probability of *E. subsignaria* entering on broadleaved trees was rated as **unlikely** with **high** confidence due to the size of the trade which is unlikely to change in the near to medium term.

Plants for planting-trees	Very unlikely	☐	Unlikely	☑	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

The probability of *E. subsignaria* entering on other plants (not broadleaved trees) was rated as **very unlikely** with **high** confidence. Other plants were considered a less likely pathway in comparison with broadleaved trees as association with these species would be reduced during non-outbreak years.

Plants for planting-non broadleaved plants	Very unlikely	☑	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☑	Medium Confidence	☐	Low Confidence	☐				

Cut parts of plants

Cut branches and foliage: Egg masses could be associated with cut branches, and if the branches are in leaf, potentially larvae and pupae too. There was a significant volume of foliage, branches and other plant parts imported from the USA in 2019 and 2020 (Table 3, note Table 3 is in tonnes not kg as Table 2). It is unknown how much of this material would have been from broadleaved trees. As this material is for ornamental purposes, it was assumed that once this material is at its final point of use, infested material would be noticed and disposed of either in general refuse or for composting. Though larvae and adults could escape open composts and spread to nearby hosts, the risk of this scenario occurring was considered low.

There was a report found online of an interception made at Covent Garden market, London in April 1984; a pupa was found amongst imported flowers - on *Asparagus setaceus* (Kunth) Jessop (recorded as *Asparagus plumosa* – asparagus fern) imported from Florida (Lowe, 1985). The adult emerged six days later. It was assumed that that the imported *Asparagus* was foliage only.

Table 3. CN 06042090 Foliage, branches and other parts of plants, without flowers or flower buds, and grasses, fresh, suitable for bouquets or ornamental purposes (excl. Christmas trees and conifer branches), imported from the distribution of *Ennomos subsignaria* (tonnes) (nill return for Canada). Source = HMRC

Year	2019	2020	2021	2022	2023
United States	59	21	7	0	0

Despite the one interception from the 1980s, cut branches and foliage were considered an **unlikely** pathway. If the pest was associated with these commodities, it would be in low numbers, and these products are perishable. This rating was made with **medium** confidence due to the lack of discrimination with the trade data and predictability with future trade.

Cut parts of plants-branches & foliage	Very unlikely ☐	Unlikely ✓	Moderately likely ☐	Likely ☐	Very likely ☐
Confidence	High Confidence ☐	Medium Confidence ✓	Low Confidence ☐		

Cut flowers: Because the aesthetics of cut flowers are so important to their value, and pesticide use is high, the risk of *E. subsignaria* being associated with outdoor grown cut flowers was considered low.

Table 4. Sum of fresh cut flowers* imported from the distribution of *Ennomos subsignaria* (tonnes) Source = HMRC

Year	2019	2020	2021	2022	2023
Canada & United States	340	174	29	112	20

* Commodity codes:

06031100 Fresh cut roses and buds, of a kind suitable for bouquets or for ornamental purposes

06031200 Fresh cut carnations and buds, of a kind suitable for bouquets or for ornamental purposes

06031400 Fresh cut chrysanthemums and buds, of a kind suitable for bouquets or for ornamental purposes

06031970 Fresh cut flowers and buds, of a kind suitable for bouquets or for ornamental purposes (excl. roses, carnations, orchids, gladioli, ranunculi, chrysanthemums and lilies)

Ennomos subsignaria is not reported to be a pest of cut flower production and there have been no interceptions on this material, so despite trade volumes being high (Table 4), cut flowers were considered a **very unlikely** pathway with **high** confidence.

Cut parts of plants- cut flowers	Very unlikely	✓	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	✓	Medium Confidence	☐	Low Confidence	☐				

Wood in the rough / Roundwood

(Wood in the rough / Roundwood as per the definitions https://www.gov.uk/guidance/classifying-wood#rough-wood and https://knowledge4policy.ec.europa.eu/glossary-item/roundwood_en)

Host wood with retained bark has the potential to be infested with egg masses, if felled and exported between August and May, or pupae, if felled and exported during the summer.

Table 5. Wood in the rough imported from the distribution of *Ennomos subsignaria* (tonnes). Source = HMRC

Commodity code and description / yr	2019	2020	2021	2022	2023
Canada					
44039100 Oak "*Quercus* spp." in the rough*					2
44039900 Wood in the rough**	0		2	0	8
United States					
44039100 Oak "*Quercus* spp." in the rough*		72	3		
44039700 Poplar and aspen "*Populus* spp." in the rough***			22	12	
44039900 Wood in the rough**	93	106	160	86	0
Total	**93**	**178**	**187**	**98**	**11**

* whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood in the form of railway sleepers; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives)
** whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives, coniferous and tropical wood, oak, beech, birch, poplar, aspen and eucalyptus)
*** whether or not stripped of bark or sapwood, or roughly squared (excl. rough-cut wood for walking sticks, umbrellas, tool shafts and the like; wood in the form of railway sleepers; wood cut into boards or beams, etc.; wood treated with paint, stains, creosote or other preservatives)
0 = less than 1 tonne

There has been a small volume of non-coniferous wood in the rough imported from the USA each year in the last five years, though the market is quite unstable (Table 5). It is not known how much of this wood would have been de-barked. Wood of *Quercus* from parts of Canada and the USA within the distribution of *Agrilus bilineatus* (two lined chestnut borer, Buprestidae), *Bretziella fagacearum* (oak wilt, Ascomycota) or *Phytophthora ramorum* (Oomycota) must be bark free or have undergone another specified treatment.

Populus from the Americas must also be bark free or kiln dried. De-barking or treating wood would likely be effective at removing this pest which only resides on the surface of the timber. The specified hosts within Table 5, would therefore be very unlikely to harbour this pest. Similar restrictions apply to some other hosts (e.g. *Betula*, *Fraxinus* and specified *Acer* species).

It was assumed that for the majority of imports, the wood would be squared as this makes for more efficient packing, and may be seasoned as this would reduce the weight, but these were uncertainties. As mitigations only apply to some hosts, wood in the rough was rated as a **moderately likely** pathway with **medium** confidence due to the lack of detail in the trade data - including information about processing, and variation in volumes traded.

Non-squared wood / Roundwood	Very unlikely ☐	Unlikely ☐	Moderately likely ☑	Likely ☐	Very likely ☐
Confidence	High Confidence ☐	Medium Confidence ☑	Low Confidence ☐		

Fuel wood

Though the commodity code for fuel wood does not distinguish between tree species, all imports of fuel wood to GB must now be notified under the firewood statutory notification scheme. The purpose of this is to allow the Forestry Commission to monitor the extent of trade and carry out risk based and random inspections of consignments. As a proportion of the total amount of fuel wood imported from third countries, import volumes from North America are very small (Table 6). To put into context, the mean amount of non-coniferous solid firewood imported per year for the period in Table 6 was over 94,000 tonnes from all countries (HMRC), with most imports originating from the Baltic states (Morgan, 2019; 2022). Fuel wood must meet the same requirements (measures on certain hosts) as wood in the rough (see above).

Table 6. CN 44011200 Fuel wood, in logs, in billets, in twigs, in faggots or in similar forms from the distribution of *Ennomos subsignaria* (tonnes). Source = HMRC

Year	2019	2020	2021	2022	2023
Canada				72	27
United States	6	9	3	30	2
Total	**6**	**9**	**3**	**102**	**29**

Because the mitigations on fuel wood are the same as wood in the rough, entry on this pathway was considered **moderately likely** with **medium** confidence. A medium confidence rating was given again because of the lack of detail on the trade from North America - including information about processing, and variation in volumes traded.

Isolated bark	Very unlikely ☐	Unlikely ☐	Moderately likely ☑	Likely ☐	Very likely ☐

Confidence	High Confidence	☐	Medium Confidence	✓	Low Confidence	☐

Isolated bark / bark chips

The isolated barks of some hosts (e.g. *Castanea*, *Populus*, *Quercus*, *Acer saccharum, A. macrophyllum* Pursh, *Aesculus californica* (Spach) Nutt.) are prohibited from either North America or just the USA. Isolated bark and wood chips of *Juglans* from the USA has measures concerning *Geosmithia morbida* (thousand cankers disease, Ascomycota) and its vector. Isolated bark and wood chips of *Fraxinus* and specified *Juglans* and *Ulmus* species from any third country also have measures concerning *Agrilus planipennis* (emerald ash borer, Buprestidae). There is no commodity code for isolated bark. The definition for 'wood shavings and waste' includes 'bark and shavings' (https://www.gov.uk/guidance/classifying-wood). References to wood waste/bark/chips in the tariff descriptions are materials destined for use as fuel wood or to be used for dyeing purposes. Much of the bark chip/wood chip used outdoors in the UK comes from coniferous trees. Imported wooden ornaments could potentially contain pieces of bark.

Larger pieces of isolated bark, for example on wooden ornaments, are likely to be seasoned and/or egg masses would be noticed by wood workers. Bark chips are not generally considered to carry Lepidopteran pests. Whether the egg stage of *E. subsignaria* could survive the bark chipping process is not certain as no information on insect egg survival on bark chips could be found in the literature. It was considered, however, that the buffeting and friction of the chips post chipping would likely damage some eggs. Stored wood chip piles can also reach temperatures over 60°C at the centre (Wästerlund *et al.*, 2017). This is above the required temperature of some insect-killing treatments, so would also kill off some eggs. This pathway was therefore rated as **very unlikely** but with **medium** confidence due to lack of clarity on the trade and uses of bark.

Isolated bark	Very unlikely	✓	Unlikely	☐	Moderately likely	☐	Likely	☐	Very likely	☐
Confidence	High Confidence	☐	Medium Confidence	✓	Low Confidence	☐				

Contaminating pest (hitchhiking)

When populations are high, vehicles, buildings and other objects can become covered in larvae (Fig. 5), and larvae will pupate on artifacts such as buildings/signposts, on exposed branch tips or in the under-growth (Fedde, 1971). Hitchhiking on vehicles and other outdoor machinery and goods was therefore considered a pathway worth assessing. As well as being easily damaged, and unlikely to survive lengthier journeys by sea, larvae would need to find foliage immediately to complete their development, so were not expected to arrive in large enough numbers to potentially establish. Goods like vehicles/machinery imported in mass are likely to be stored in large outdoor spaces i.e., not near trees, so it was thought that any pupae arriving on vehicles etc., would be on one off imports and in very small numbers. Females were not reported to lay eggs on anything but trees. Hitchhiking has therefore been rated as **very unlikely** with **medium** confidence due to lack of data.

Hitchhiking	Very unlikely ✓	Unlikely ☐	Moderately likely ☐	Likely ☐	Very likely ☐
Confidence	High Confidence ☐	Medium Confidence ✓	Low Confidence ☐		

Figure 4 *Ennomos subsignaria* egg mass on a branch © Heidi Fry, Bugwood.org https://www.ipmimages.org/browse/detail.cfm?imgnum=5445622

Figure 5 *E. subsignaria* larvae on a car © Heidi Fry, Bugwood.org https://www.ipmimages.org/browse/detail.cfm?imgnum=5563736

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

This pest is a free-living organism with no need for a vector.

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

Hosts: As broadleaved trees are well distributed throughout the UK (Fig. 6) and many of these species are within the preferred host genera of *E. subsignaria*, hosts were not considered to be a limiting factor to the establishment of this pest.

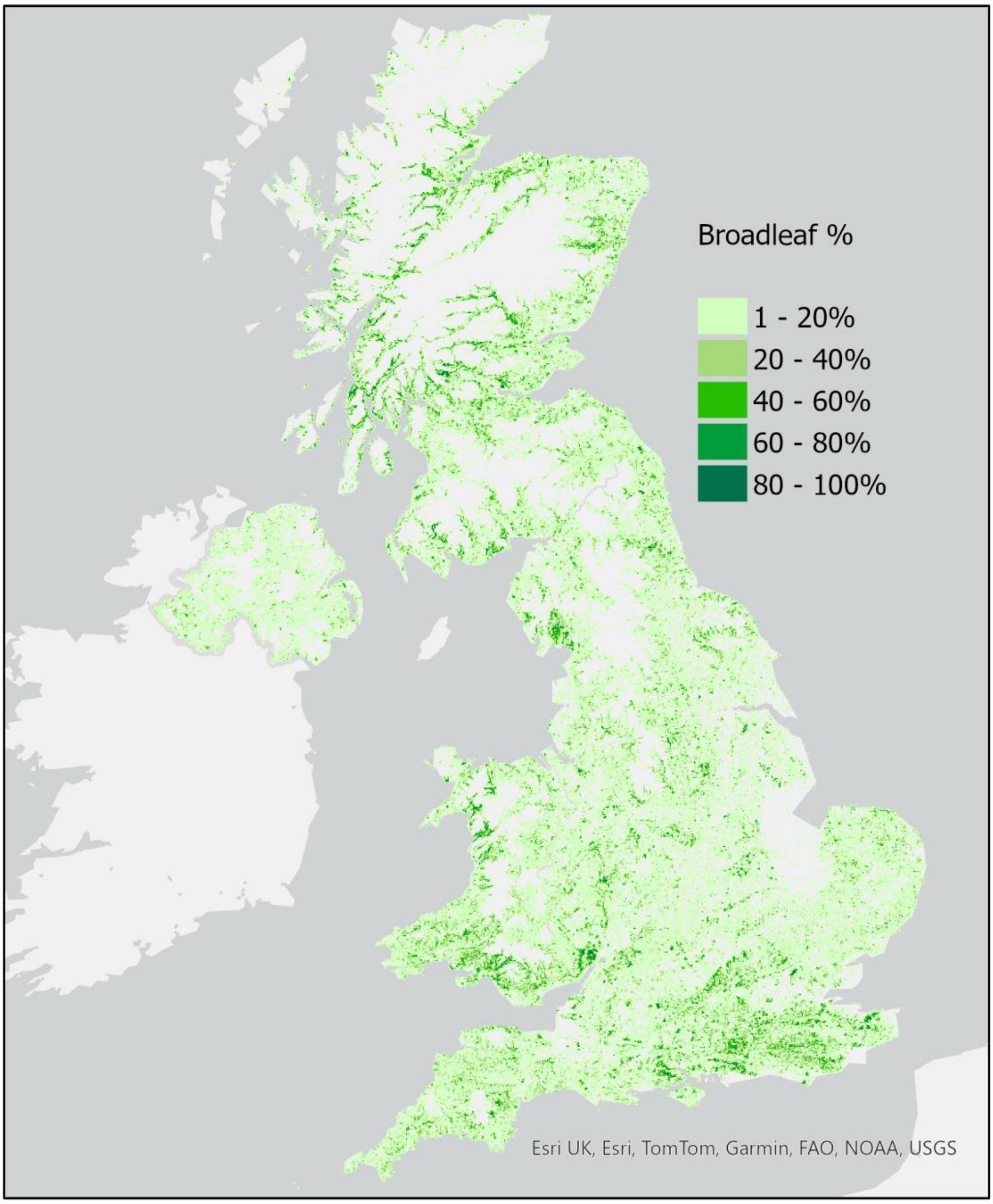

Figure 6 Distribution of broadleaf woodland by percentage cover (UK CEH Land Cover classification 2021) Data: Marston *et al.* (2022)

Climate: Latitudinally *E. subsignaria* is distributed across much of North America; from Newfoundland and Labrador, Canada to Florida, USA. This distribution covers four Köppen-Geiger climate classifications (Fig. 7). *Ennomos subsignaria* populations are highest in the mountainous parts of the more southerly states of the USA, however, where night temperatures will be lower than those at lower altitudes. The Köppen-Geiger climate classification for the UK is different to the four classifications within the distribution of *E. subsignaria*, however, it does have some similarities and lies within the temperature extremes of these four classifications (Fig. 7).

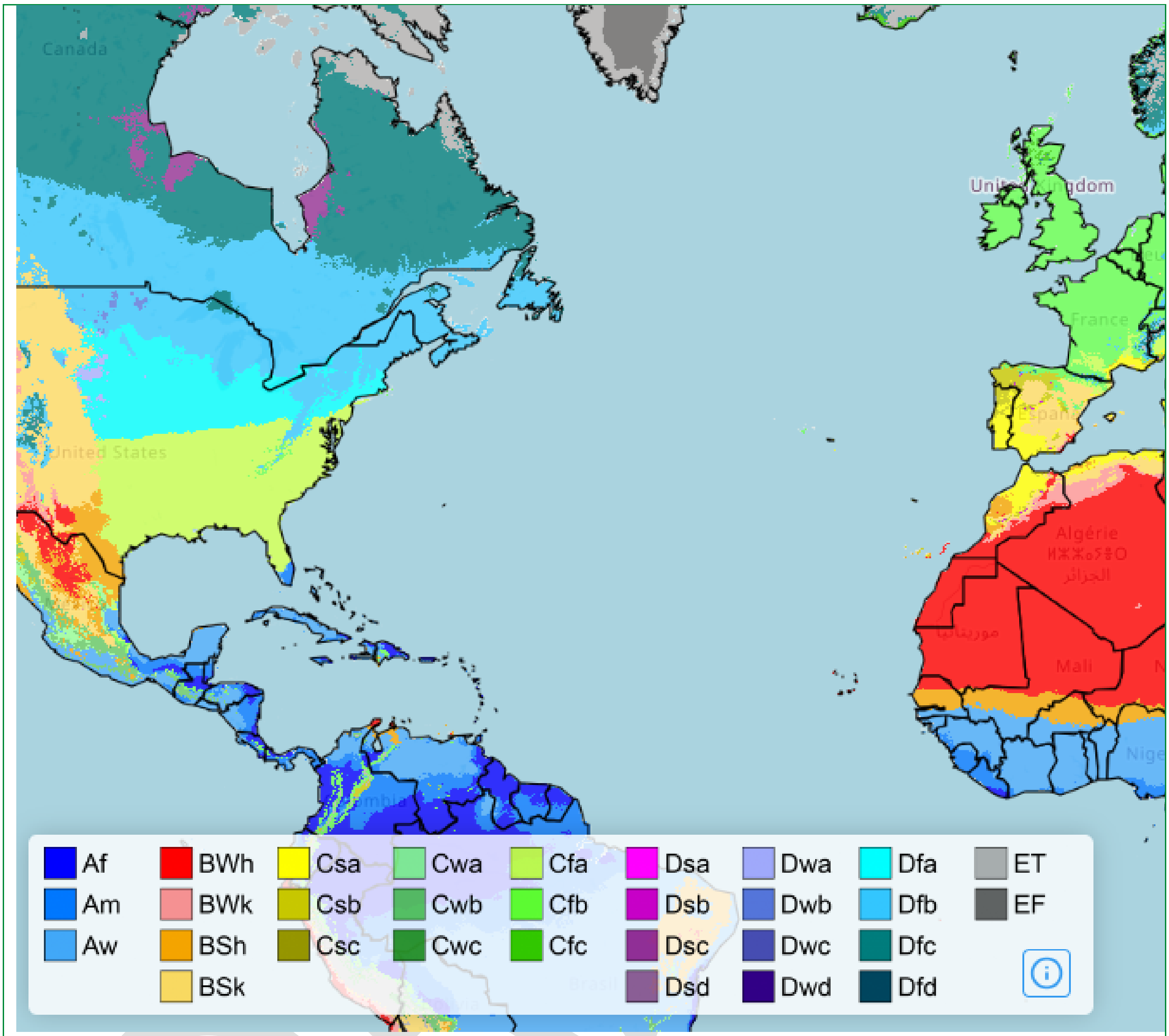

Figure 7 Köppen-Geiger climate classifications for North America and the UK
Dfc = Cold, No Dry season, Cold summer (N. Canada inc. St John's)
Dfb = Cold, No Dry season, Warm summer (S. Canada & N.E. USA)
Dfa = Cold, No Dry season, Hot summer (N. E. USA)
Cfa = Temperate, No Dry season, Hot summer (S. & E. USA)
Cfb = Temperate, No Dry season, Warm summer (UK)
Historical period range: 1991-2020, Source: https://koppen.earth/
After Beck *et al.* (2023)
https://creativecommons.org/licenses/by/4.0/

Figure 8 shows a comparison of annual growing degree days (over a threshold of 5°C) in the more northerly part of the current distribution of *E. subsignaria* with annual growing degree days in the UK. Many of the locations where *E. subsignaria* can be found have a similar number of degree days as found in parts of the UK. St John's in Newfoundland and Labrador, where outbreaks have occurred on city trees, accumulates a similar number of degree days as central Wales, northern England and a large part of Northern Ireland (Fig. 8).

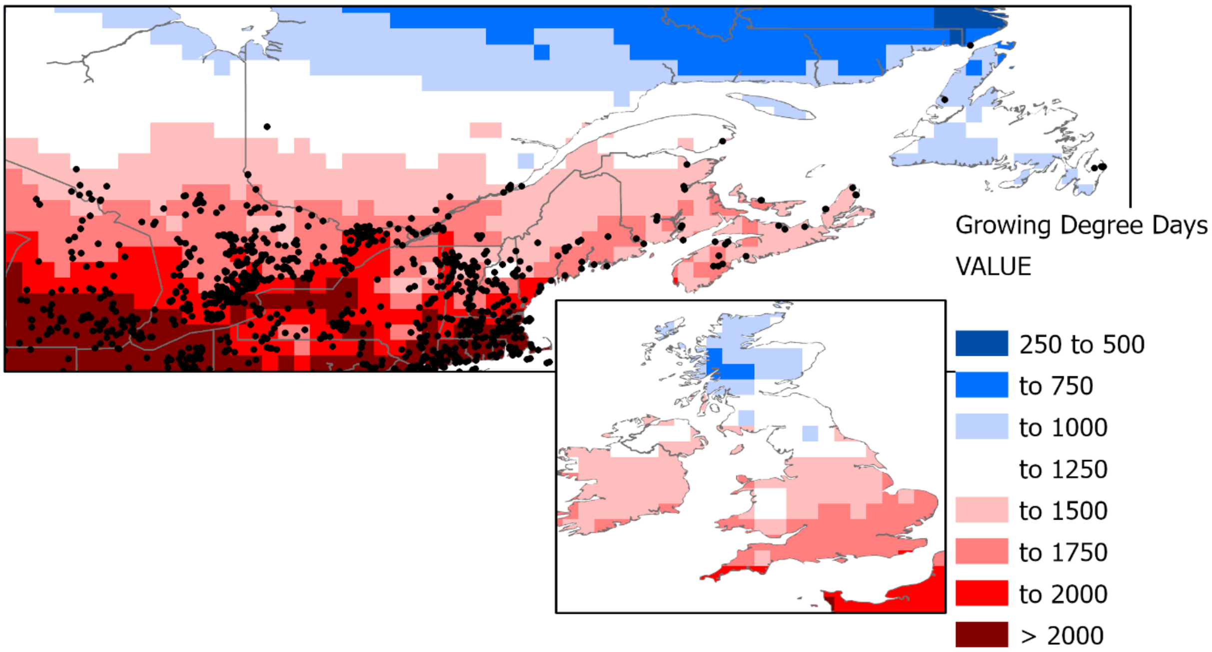

Figure 8 Annual Growing Degree Days in Canada and northern USA, and the UK (inset). Black dots occurrence records for *Ennomos subsignaria* (note that some may be records of migrated adults), exported from GBIF.org on 16/12/2024 https://www.gbif.org/occurrence/search?taxon_key=1957870
Growing Degree Days data from Climate Research Unit, Univ. of East Anglia, and used by permission of The Center for Sustainability and the Global Environment (SAGE), Nelson Institute for Environmental Studies, University of Wisconsin-Madison. Available at https://sage.nelson.wisc.edu/data-and-models/atlas-of-the-biosphere/mapping-the-biosphere/ecosystems/growing-degree-days/ after New *et al.* (2000)

Phenology and egg temperature requirements: Throughout its distribution *E. subsignaria* is univoltine. This is due to the relatively long period of time spent in the egg stage (approx. nine months). Egg hatch is correlated with latitude, occurring earlier in the spring the further south you go (section 8). In St John's, Newfoundland, the peak period of egg hatch (first week of June) occurred two weeks after the peak period of *A. pseudoplatanus* budburst (Fry *et al.*, 2009). This meant that egg hatch was closely synchronised with the availability of the most suitable leaves for development.

The mean daily temperatures in St John's, Newfoundland in June are min 5.9°C and max 15.9°C (data range = 1971 to 2000 https://worldweather.wmo.int/en/city.html?cityId=642). The mean daily temperatures in Asheville, North Carolina (situated in the Blue Ridge Mountains, 650 m elevation) in April (when *E. subsignaria* is reported to hatch in the southern Appalachians) are min 7.3°C and max 19.7°C (data range = 1981 to 2010 https://worldweather.wmo.int/en/city.html?cityId=717).

In the wild the eggs experience roughly 'three months of summer, five months of winter and one and a half months of spring' (Drooz, 1980). The requirements of the egg stage in the laboratory for efficient hatch are described as: 75% RH, three months of warmth (20 to 23°C) followed by three months of chill (approx. 5°C), then at 22°C, hatch will occur in 14-

16 days (Drooz, 1970a cited in Drooz, 1980). Eggs kept for five months at 24°C and four months at 4°C (75% RH), were reared at a range of constant temperatures in order to determine some temperature-dependent developmental parameters by Drooz and Screuder (1972). Of the models tested, two estimated lower developmental thresholds of 9.1°C and 6.5°C, and upper thresholds of 28.3°C and 32.8°C, 34% and 10% RH respectively.

Winter temperatures within the UK will be within the extremes of those at the northern and southern boundaries of the distribution of *E. subsignaria*. The budburst of many broadleaved trees including *A. pseudoplatanus* occurs in the first half of April (Met Office, 2016). For much of the UK, average mean temperatures are between 6 to 10°C in April and 9 to 13°C in May (Fig. 9). These temperatures seem favourable for egg hatch to coincide with the availability of new leaves.

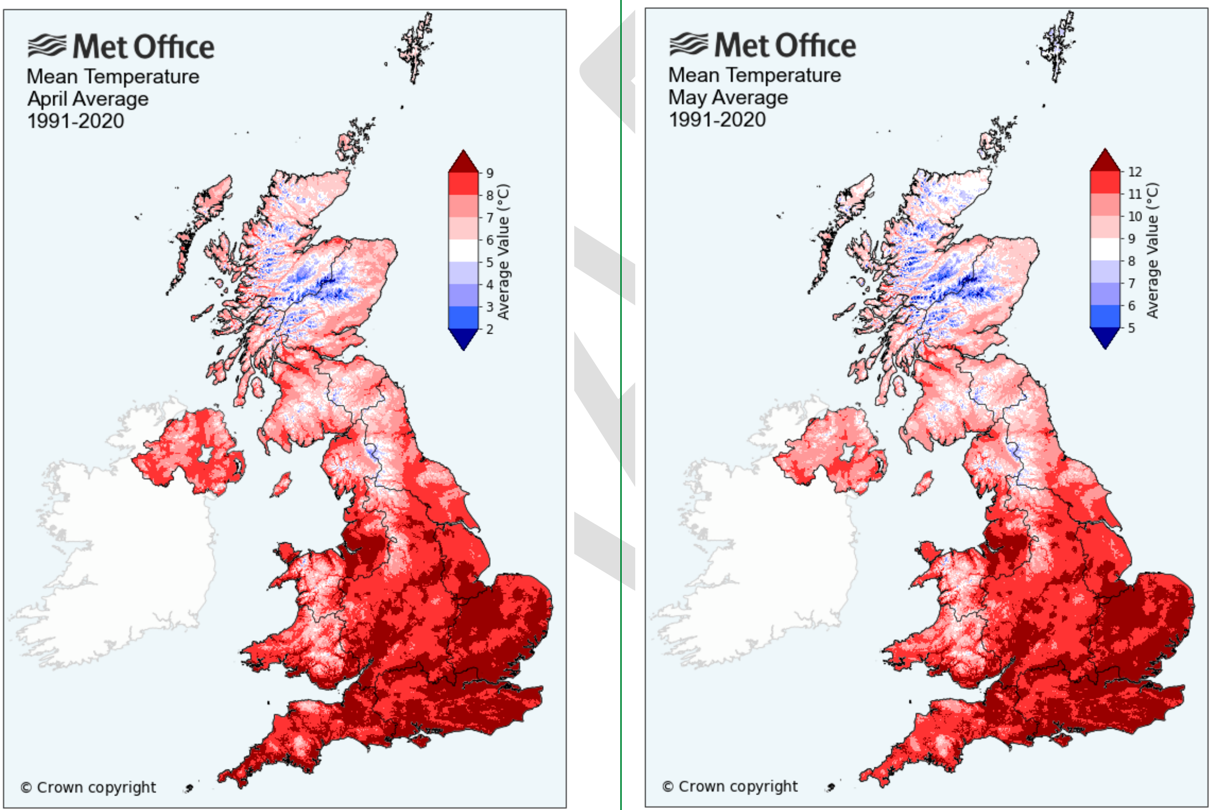

Figure 9 Mean temperatures in April (left map) and May (right map) in the UK (average period 1991-2020)
Source: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages

No temperature parameters for the other stages of *E. subsignaria* were found. Given the available information, the UK's climate was not considered a limiting factor for the establishment of this pest. Establishment outdoors was therefore considered **likely** with **medium** confidence.

Ennomos subsignaria is not known as a pest of plants under protection, therefore, the risk of establishing in this environment is rated as **very unlikely** with **high** confidence.

Outdoors	Very unlikely		Unlikely		Moderately likely		Likely	✓	Very likely	
Confidence	High Confidence		Medium Confidence	✓	Low Confidence					

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?

Fedde (1971) states that *E. subsignaria* moths are nocturnal and superficially do not appear to be strong flyers. He then goes on to describe the occasional mass flights of males being drawn from surrounding countryside to the lights of towns and cities. Drooz (1980) states that moths readily fly 100-200 km, and then goes on to mention a report of a male found on Big Pine Key, Florida, 1100 km from the nearest outbreak (the original source of this report could not be accessed and is therefore not taken into consideration). Drooz (1980) then goes on to explain that flights are made up of mostly males, but at times gravid females 'go along'. Another source states that no females had been caught in light traps despite hundreds of males being caught (https://auth1.dpr.ncparks.gov/moths/view.php?MONA_number=6798). It is therefore very unclear just how far females can fly.

The wingspan of both sexes is between 35 to 40 mm. If a female could manage just half of the distance a male could fly (~100 km), then this pest could spread quickly.

Newly emerged larvae disperse by ballooning on the wind, and later instars may disperse locally by looping across the ground (Fry *et al.*, 2008a). One reason given as to why egg mass densities were not a good predictor of end of season defoliation was because the larvae are so mobile (Fry *et al.*, 2008a).

In a news article reporting on an unusually large population of *E. subsignaria* larvae in Winnipeg, Canada, a worker in insect-control said that the larvae had been concentrated along the riverways and had not appeared in the suburban areas of the city (Kives, 2017). No reason was given for this preference in location. Once a good host resource or preferable environment is found by individuals, there might be limited spread from that population.

Natural spread was rated as **quickly** as a precaution, but with **low** confidence.

This pest could be introduced to new areas in the UK on potted trees and possibly via vehicles and objects as pupae. It was assumed that female moths would be attracted to mature trees over traded trees unless populations were high. So spread with trade might be long distance, but occasional to begin with. Spread with trade was therefore rated **moderate** pace with **low** confidence. The low confidence rating was to reflect that rate of spread with trade would very much depend on the location of initial outbreak sites.

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

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?

Most of the impacts recorded in the literature from this pest are those that occur as a result of outbreaks. The term outbreak in this pest's case was understood to mean when a population becomes so numerous that the defoliation of trees becomes noticeable to the casual observer. Fedde (1971) describes *E. subsignaria* as a native pest that intermittently causes serious damage to trees in the USA and Canada. It was assumed that impacts during non-outbreak years or low population years are similar to those of other foliage-feeding non-pest moths.

In a review of North American outbreak folivores, Mattson *et al.* (1991) concluded that there are around 85 species of Lepidoptera and Hymenoptera which periodically cause serious widespread defoliation (to broadleaved and coniferous species). The authors classify the plant systems that hosts these folivores into 39 categories based on the dominant tree species and list the plant system's main folivores. *Ennomos subsignaria* is only listed in the *Carya* spp. plant system, but as the only main folivore. In the appendix listing folivore species and their outbreak areas over a 28 year period in the United States (1957 to 1987), *E. subsignaria* is placed 14th for maximum outbreak area and average area affected per episode (infestation area / frequency).

Economic and environmental impacts: In St John's, Newfoundland, completely defoliated trees are reported to often refoliate in late summer (Fry *et al.*, 2008a). After two or more successive summers of complete defoliation, however, limbs can dieback and trees can die (Fedde, 1964 cited in Fry *et al.*, 2008; Fedde, 1971). This occurred in the southern Appalachians in the late 50s and early 60s where yearly larval defoliation of trees in the uplands caused mortality and stand deterioration (Fedde, 1964). Radial growth loss is evident after initial defoliation by *E. subsignaria* (Fedde, 1971). Trees weakened from *E. subsignaria* attack, oaks in particular, are subject to attack by other insects such as *Agrilus bilineatus* (two-lined chestnut borer: Buprestidae) which can lead to widespread host mortality. Periodically, *E. subsignaria* causes serious damage to apple crops and seriously weakens valuable shade trees (Fedde, 1971).

Fedde (1971) notes that severe infestations have occurred in cities near sea level and in hardwood (broadleaved) swamps, but that typically, the most intensive feeding occurs on the wooded ridgetops of mountainous areas (most of Fedde's published work concerns the southern Appalachians).

Outbreaks may also negatively impact local economies as many historic city parks, which are frequented by tourists, are infested with larvae during peak tourist season (Fry *et al.*, 2008a).

Social impacts: Fedde (1964) states that besides timber losses, the spanworm adversely affected forest recreation, hunting, fishing, and the summer tourist business during the outbreak which lasted a few years.

In urban areas, during outbreaks, *E. subsignaria* is a considerable nuisance and sometimes a safety hazard for citizens because masses of larvae, as well as their silk strands and frass, can cover houses, sidewalks, driveways and cars (Fry *et al.*, 2008a) (Fig. 5). The flight of moths is described like snow in summer.

Three news articles from Winnipeg, Canada cover an increase in the *E. subsignaria* population across a few years. The term 'outbreak' is not used at any point (though, to note, these are not scientific sources) and only social impacts are documented. In 2019, a worker in insect-control states that it is the third year that the infestations have been 'noticeable', that the pest had been spreading along the city's rivers moving westwards and northwards, and that the population was at the peak of its five or six-year cycle, adding that he expected the next year's population (2020) to be less noticeable (Kives, 2017; 2019). In 2020, the population was still causing a nuisance to the public and the city was looking to change how it sprayed (*Btk – Bacillus thuringiensis* subsp. *kurstaki* – a bacterium that kills Lepidoptera larvae) for the caterpillars in the future, because the population was not following the multi-year cycle it had in the past. Delays to spraying due to weather conditions and residents requesting that the city not spray trees on their property meant that controls were also not as effective. Other members of the public complain about the larvae 'raining down' on them and slipping on frass-covered pavements (Stackelberg, 2020).

Ratings:

Economic impacts were rated as **large** with **high** confidence due to loss to timber, replacement of urban trees, cost of control methods (spraying), loss to local economies due to lower tourist numbers and reduced activity of residents. It should be noted that these impacts are large but occasional. And also, that control methods of more serious pests (e.g. *Lymantria dispar*) will probably be providing some protection from increases in *E. subsignaria* numbers.

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

Environmental impacts were rated as **large**. If trees were defoliated and left weakened, this would have reduced food resources for other foliage feeding invertebrates, and the wildlife (birds, bats and other mammals) that might have relied on these other invertebrates as a food source. If trees were killed in forests and the wider environment, this is likely to have had a negative impact not only on wildlife but also the ecosystem services the trees were providing. In urban environments, killed trees were probably replaced by smaller less effective trees. Wide scale spraying of *Btk* will have affected non-pest Lepidoptera. These impacts were rated with **medium** confidence. This was due to the lack of documented environmental impacts and the question of whether North American ecosystems are well adapted to the less sustained outbreaks of this native pest. Increases in *E. subsignaria* larvae would have been beneficial to some parasitoids and are documented to have increased the numbers of some species of birds (Haney, 1999).

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

This pest can be a serious nuisance. Residents need to clean their properties and cars at the end of a high-population season. They also need to clean their car windscreens before driving, and this pest can affect how and where people travel to and how they choose to spend their leisure time for at least a few weeks of the year. Larvae on pavements can be a safety issue, causing slips and falls. Social impacts were therefore rated as **large** with **high** confidence.

Social 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?

One aspect that is key to consider is why there are outbreaks of this pest. At present in the literature the exact factors seem to be unknown, but are probably a mixture of abiotic and biotic factors, with parasitoid populations being important and being stated to significantly affect *E. subsignaria* populations. Many outbreaks of this pest overlap with others, so the causes are difficult to tease apart. Morin *et al.* (2004) mentions speculation that an increase in tree mortality observed in the Allegheny hardwood forest (Pennsylvania) between 1985 and 1995 was due to extensive forest defoiliator outbreaks (five Lepidoptera are mentioned including *E. subsignaria*), but they note that droughts occurred in the late 1980s and early 1990s, and that there is some indication that *Acer saccharum* is undergoing a poorly understood general decline in the region.

Natural enemies:

More than forty different parasites and predators (wasps, parasitic flies, birds, spiders, true bugs and ground beetles) are known to attack *E. subsignaria* larvae, pupae and adults. Fedde (1971) considered the effects of these to be less significant than the parasitoid *Telenomus alsophilae* which parasitizes overwintering spanworm eggs in the early spring. This parasitoid was thought to contribute substantially to the decline of past outbreaks.

The following species have been recorded as parasites of *E. subsignaria* (Anderson & Kaya, 1974; 1976; CABI, 2019a) - this list is not comprehensive:

- Diptera: Tachinidae: *Ceromya ontario* (reported as *Actia ontario*)
- Hymenoptera: Aphelinidae (reported as Eulophidae): *Ablerus clisiocampae* (not considered an important parasitoid of *E. subsignaria*, but was introduced to France (< 1953) and Italy according to Rasplus *et al*. (2010 and references therein).
- Hymenoptera: Encyrtidae: *Ooencyrtus ennomophagus* Yoshimoto, *Ooencyrtus clisiocampae*
- Hymenoptera: Scelionidae: *Telenomus alsophilae*, *Telenomus droozi*

Drooz (1980) states that of all the egg parasitoids studied, *Telenomus droozi* (which parasitised up to 89% of eggs in a southern Appalachian outbreak), and *Ooencyrtus ennomophagus* (probably accidentally introduced from Asia) are considered to be the most effective.

Neither the *Ooencyrtus* nor the *Telenomus* species mentioned above are present in the UK (CABI, 2019 b; c; d; e; NHM UK Species Inventory). All four hymenopteran parasitoids attack other Lepidopteran species, so similar generalist parasitoids that are present in the UK may provide some control. Assuming *E. subsignaria* did establish, a time lag between *E. subsignaria* colonising new areas and the generalist parasitoids learning to locate and recognise *E. subsignaria* eggs as suitable hosts would be expected.

Frosts:

Drooz (1980) mentions that late spring frosts (which are common in the Appalachians from Pennsylvania to Georgia) can be a limiting factor to *E. subsignaria* outbreaks and ended an expanding outbreak in Pennsylvania in 1977. When the statement is repeated there is mention that these late frosts destroy foliage, so the effect is likely indirect – affecting the food source of larvae rather than the larvae themselves.

In a typical April across the UK, the Met Office states that there are approximately 12 days of grass frost, and on an average of just over four days, temperatures fall to 0°C or below creating an air frost (< 4 days in England; ~ 6 days in Scotland) https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/your-home/gardening/5-gardening-tips-for-april#:~:text=In%20a%20typical%20April%20across,below%2C%20creating%20an%20air%20frost.. By May, it is unusual for there to be more than a couple of nights of frost even in Scotland https://www.metoffice.gov.uk/weather/warnings-and-advice/seasonal-advice/your-home/gardening/gardening-tips-for-may#:~:text=Establish%20a%20weekly%20mowing%20routine,lawn%20in%20the%20best%20condition..

This pest has been able to outbreak in a wide variety of climates and environments (in urban areas as far north as St John's, Newfoundland and as far south as the southern Appalachians; at sea level and on forested mountain slopes). In the UK, there will be a lag time for present parasitoids to exploit new populations of *E. subsignaria.* The main means of control in North America is *Bt* spraying. This kind of control would be controversial in the UK, and if employed, would take some time to implement.

Most broadleaved commercial forest stands and most urban trees were assumed to be at risk from this pest and so the potential economic impact was rated as **large** with **low** confidence due to the unknown triggers for outbreaks.

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

If an outbreak of *E. subsignaria* occurred in the wider environment, this could impact woodland and forest ecosystems severely. Native species of tree, particularly mature trees may be less adapted to the need to refoliate in the same season in comparison with North American tree species. *Operophtera brumata* (winter moth) is a polyphagous UK species which occasionally reaches pest numbers, defoliating small trees (UKMoths, 2024), but not to the extent of some North American species of Lepidoptera including *E. subsignaria*. Potential environmental impacts were therefore rated as **large**, again with **low** confidence due to the unknown triggers for outbreaks.

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

Potential social impacts were rated as **large**. If this pest were able to outbreak in the UK, the public are not used to dealing with nuisance pests on the same scale. Impacts on garden, street or park trees would be keenly felt. This was again rated with **low** confidence.

Social 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?

There is no mention of pathogens vectored by this pest in the available literature.

16. What is the area endangered by the pest?

Broadleaved trees in urban and rural environments across the UK.

Stage 3: Pest Risk Management

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

Exclusion:

Measures on plants for planting?: Of the hosts listed as favoured in the literature (Fedde, 1971; Drooz, 1980), *Carya*, *Carpinus*, *Liquidambar*, *Nyssa* and *Ostrya* are not listed as high-risk plants in the regulations which are prohibited from entering GB and NI pending a risk assessment.

Measures on wood (wood in the rough and fuel wood[5])?: A narrowed down list of hosts could be created for the consideration of measures.

Given that there have been no recorded interceptions of this pest in the last 30 years and that this pest can feed on many different plants (and could therefore enter the PRA area on many different plants or wood with bark), regulating certain hosts for the sole purpose of excluding this pest might be difficult to justify.

Eradication:

Once established this pest would be very difficult to eradicate because of the pest's high fecundity, polyphagy, and ability to spread in the larval and adult stage.

[5] https://www.gov.uk/guidance/classifying-wood

Containment and control:

Chemical insecticides: There are papers from the 1970s investigating the efficacy of various chemical controls on *E. subsignaria* (Doane & Dunbar, 1973; Dunbar & Doane, 1973; Robertson & Lyon, 1973). A factsheet from the University of Massachusetts contains a list of 14 chemical pesticides that might be used against *E. subsignaria* in the USA - acephate, acetamiprid, azadirachtin, bifenthrin, carbaryl, chlorpyrifos, cyfluthrin, deltamethrin, dinotefuran, emamectin benzoate, methoxyfenozide, permethrin, pyrethrins and piperonyl butoxide, and tebufenozide. A handful of these chemicals can be applied systemically (as tree injections) (Fry *et al.*, 2008b; Anon, no date) and a couple can be used as a soil drench. Some of these active substances (e.g. acetamiprid, azadirachtin, deltamethrin and pyrethrin) are registered for use in the UK, but their use is restricted to certain crops, and none could be used for forestry applications.

Bacterial insecticides: *Bacillus thuringiensi* (*Bt*) appears to be the most commonly used control treatment, with *Bacillus thuringiensis* subsp. *kurstaki* being mentioned in most sources of information, though *Bacillus thuringiensis* subsp. *aizawai* can also be used (Anon, no date). *Bt* is available for use in the UK, but aerial spraying or large scale spraying of trees is not common practice and would likely cause some controversy due to its impact on other Lepidoptera.

Chromobacterium subtsugae, which is effective against some beetle larvae and adults, stink bugs, and mites, is listed as a treatment for *E. subsignaria* (Anon, no date). This bacterium was only discovered in 2007 and products containing this bacterium are not available in the UK.

Parasitoids: *Telenomus droozi* and *Ooencyrtus ennomophagus* are very important natural enemies of *E. subsignaria* (see section 14). Both are capable of destroying more than 80% of eggs during outbreaks, however, neither are present in the UK and they are not licensed for use here. There are parasitoids available for use in England which attack a wide variety of pest moths (*Trichogramma brassicae* – under licence, *T. evanescens* and *Bracon hebetor*) (Defra, no date). It is not clear whether these would use *E. subsignaria* as a host and their use might have similar drawbacks to the use of *Bt* in that non-target Lepidoptera may be impacted.

IPM and cultural management: Egg masses can be pruned from hosts before they hatch (Anon, no date).

Fry *et al.* (2008a) describes methods to predict end of season defoliation of individual trees to aid pest managers in deciding whether to apply treatments to trees in urban areas.

Successful attempts have been made to synthesise the sex pheromone of *E. subsignaria* (Magee *et al.*, 2011; Zhou *et al.*, 2024) in order to trap males (Ryall *et al.*, 2010), but as yet trapping does not appear to have been put into practice.

18. References

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This publication is available via the UK Plant Health Information portal https://planthealthportal.defra.gov.uk/

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 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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