Summary of the Express Pest Risk Analysis for *Toumeyella parvicornis*

PRA area: Ireland

Describe the endangered area: The wider Irish environment (outdoors)

Main conclusions

In its native North American range Pine tortoise scale, *T. parvicornis*, is considered a manageable pest with outbreaks on Pinus plantations usually controlled by natural predation. However, when introduced into new regions *T. parvicornis* has shown a remarkable level of adaptability, establishing, and thriving in new climates and on new host species. Efforts to eradicate the pest in these invaded regions have failed to date.

In the Caribbean, Pinus trees native to the Turks and Caicos Islands and Puerto Rico have been devastated by the pest. Intervention has been necessary in the Caribbean islands to prevent the total extinction of their native Pinus forests. In Italy the pest appears to have established, once again on a hew host species "stone pine" (*P. pinea*) and thrived, efforts there currently include containment in the event that eradication is impossible. This makes the recent report (December 2021) of an outbreak in France all the more concerning.

Considering the pests biology, it appears highly likely it would establish in the Irish climate, and it is already known to attack to our most abundantly grown Pinus tree species. The number of generations *T. parvicornis* could produce each year in Ireland is uncertain (likely at most two) and this characteristic would greatly influence its potential impact. Whether the natural ecosystem in Ireland has the capacity to control populations through predation cannot be determined at present. The lack of natural predators in the Caribbean islands combined with its continuous year-round breeding cycle are the two main factors contributing to this pests' devastating impacts in those regions. Should the pest come to establish in the EU it will be integral to prevent its introduction into Ireland to protect our commercial pine forestry sector and native conifer tree species Scots Pine (*P. sylvestris*).

The impact in Ireland of this new pest should be considered to be low – moderate with moderate uncertainty. The actual number of generations the pest can produce will have a significant influence on its impact as will the level of natural predation. Both of these factors are currently unknown, but it is likely that the pest will only produce 1 generation a year and at most 2.

Phytosanitary risk for the *endangered area* *(Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document***)**	High ☐	Moderate X	Low X
Level of uncertainty of assessment *(see section 17 for the justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document)*	High ☐	Moderate X	Low ☐

Other recommendations:

- Submit IE PRA to EPPO
- Produce Pest factsheet for DAFM website

Express Pest Risk Analysis:

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Toumeyella parvicornis

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Stage 1. Initiation

Reason for performing the PRA:

In November 2021 the EU commission was notified of an outbreak of the soft scale insect *Toumeyella parvicornis* attacking *Pinus pinea* on the Saint-Tropez peninsula in the Provence-Alpes-Côte d'Azur region of south-eastern France (Outbreak Number. 1640). This was only the second recorded outbreak of the pest in the EU to date. The previous known outbreak of this pest in Europe was in Italy in 2014 where it has since established and eradication programs by the NPPO are still ongoing, though the pest appears to be spreading. A presentation made by the Fr representatives in the November scoPAFF meeting indicated that the pest was causing significant damage to *Pinus pinea*. No formal PRAs for *T. parvicornis* have been produced to date although the UK produced a factsheet in 2016 (Malumphy and Anderson, 2016). The pest was shortlisted for a pest categorisation by EFSA for 2022.

Following a discussion of the Fr outbreak in the DAFM Emerging Plant Pest Review Working Group in December 2021 (DEPPR – WG) a rapid PRA was requested by the Forestry representatives along with a pest factsheet for possible circulation with the intention for raising awareness of the pest.

PRA area: *Ireland*

Stage 2. Pest risk assessment

1. Taxonomy & Nomenclature

Toumeyella parvicornis was first described in 1897 attacking Pinus species in Florida (Cockerell, 1897). The common name for the pest is "pine tortoise scale" and this has remained in constant usage throughout its history, however, several other taxonomic names have been used to classify the species (Clarke, 2013). *Toumeyella parvicornis* has been previously recorded and known as *Lecanium parvicorne* (Cockerell, 1897) and *Lecanium numismaticum* (Pettit and McDaniel, 1920) (Scalenet, 2022).

2. Pest overview

2.1 Origin

Toumeyella parvicornis is considered to be native to the North America continent (Malumphy et al., 2012). Its natural habitat is considered to span the Nearctic region ranging from Mexico, through the USA (central and eastern) and into south central Canada (Malumphy et al., 2012).

2.2 Current Distribution

In recent years *T. parvicornis* has been recorded to have spread beyond its native range on the North American mainland onto several islands in the Caribbean and into Europe (Figure 1). *Toumeyella parvicornis* was first recorded in the Turks and Caicos Islands in 2005 and Puerto Rico in 2009 and has

since become established in both territories. The first finding of the pest in Europe was in Italy in 2014 and this has since been followed by a reported outbreak in France in 2021. The current known geographical distribution of the pest and the associated climate classifications of these regions is shown in Figure 1.

The regions that the pest has successfully establish in are quite varied in their climate. The pest is capable of tolerating the cold winters in the southern Canadian provinces and northern US states, while also thriving in the tropical climates of the Caribbean.

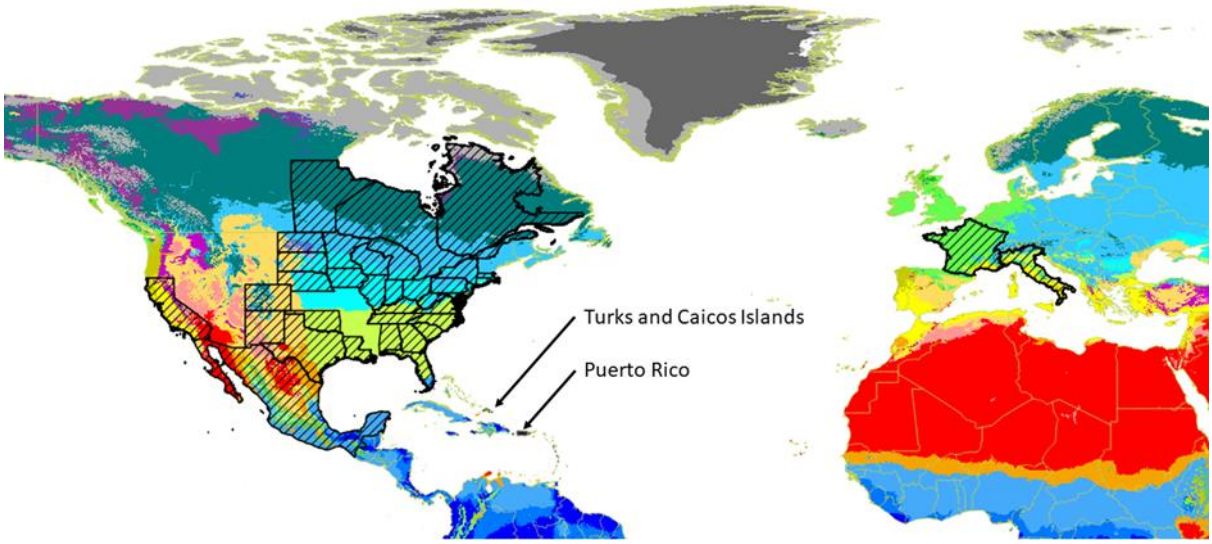

Figure 1: Current known distribution of *Toumeyella parvicornis* and the associated Koppen-Geiger climate classifications for these regions.

The pest has not yet been observed in a region with a climate zone which is representative of the Irish climate (Cfb – mild summers, cool winters). The European regions where it has currently established in France and Italy are classified as having Mediterranean climates (Csa). However, it is highly likely that the pest could establish in the Irish climate given its observed climatic tolerances in North America.

2.3 Hosts

To date, *T. parvicornis* is only reported attacking trees of the genus Pinus in the wider environment (Clarke, 2013; EPPO, 2022). *Pinus sylvestris* (Scots pine) and *Pinus banksiana* (Jack pine) are considered to be the pests primary hosts in the most northern part of its native North American range (Clarke, 2013). In the southern part of its North American range *Pinus virginiana* (Virginia pine), *Pinus elliottii* (slash pine) and *Pinus echinate* (shortleaf pine) are reported to be the pests most common hosts (Clarke, 2013).

Toumeyella parvicornis has been reported on a number of other Pinus species in North America including *P. contorta* (lodgepole pine), *P. glabra* (spruce pine), *P. mugo* (mugo pine), *P. nigra* (Austrian/black pine), *P. palustris* (Turra pine), *P. resinosa* (red pine), *P. strobus* (white pine) and *P. taeda* (loblolly pine) (Clarke et al., 2013; Malumphy et al., 2012). There is uncertainty over the genus *Cryptomeria* as a possible host, it was reported as a host plant submitted to US regional laboratories between 2005-2017 for possible *T. parvicornis* infestations (Klingeman et al., 2020). However, the study does not state that submitted plants were found/confirmed to be infested with *T. parvicornis*. There are no other studies indicating the *Cryptomeria sp.* are susceptible to infestation.

Toumeyella parvicornis populations that were introduced into the Caribbean Islands of Puerto Rico and the Turks and Caicos Islands have been found to successfully establish and complete their lifecycle on new host species of Pinus: *P. caribaea var. bahamensis and P. caribaea var. hondurensis* (Segarra-Carmona and Cabrera-Asencio, 2010; Malumphy et al., 2016).

The discovery of established wild populations of *T. parvicornis* in Italy in 2014 revealed the pest was once again successfully infesting a new host species, *Pinus pinea* (Garonna et al., 2015). Subsequently, *T. parvicornis* has also been found attacking *Pinus pinaster* and *P. nigra var. laricio* in Italy both of which have been added as new host species (Garonna et al., 2018).

It is clear that this pest is a specialist at infesting members of the genus Pinus and is highly adaptable when it encounters new Pinus species. There are currently no indications that that the pest can attack species of any other genus.

2.4 Lifecyle & Aetiology

Toumeyella parvicornis is a member of the Arthropoda order Hemiptera (Animal Diversity Web, 2021). The Hemiptera, commonly referred to as the "true bugs", share a common arrangement of features around their sucking mouthparts which they use for feeding (Johnson *et al*., 2018). *Toumeyella parvicornis* is considered a soft scale insect which has a pathogenic lifecycle which is dependent on infesting of trees of the genus *Pinus* from which it sucks sap from the trees vascular system after piercing the plants outer layer with its stylet (Clarke, 2013). An overview of the pest's lifecycle is visually depicted in Figure 2.

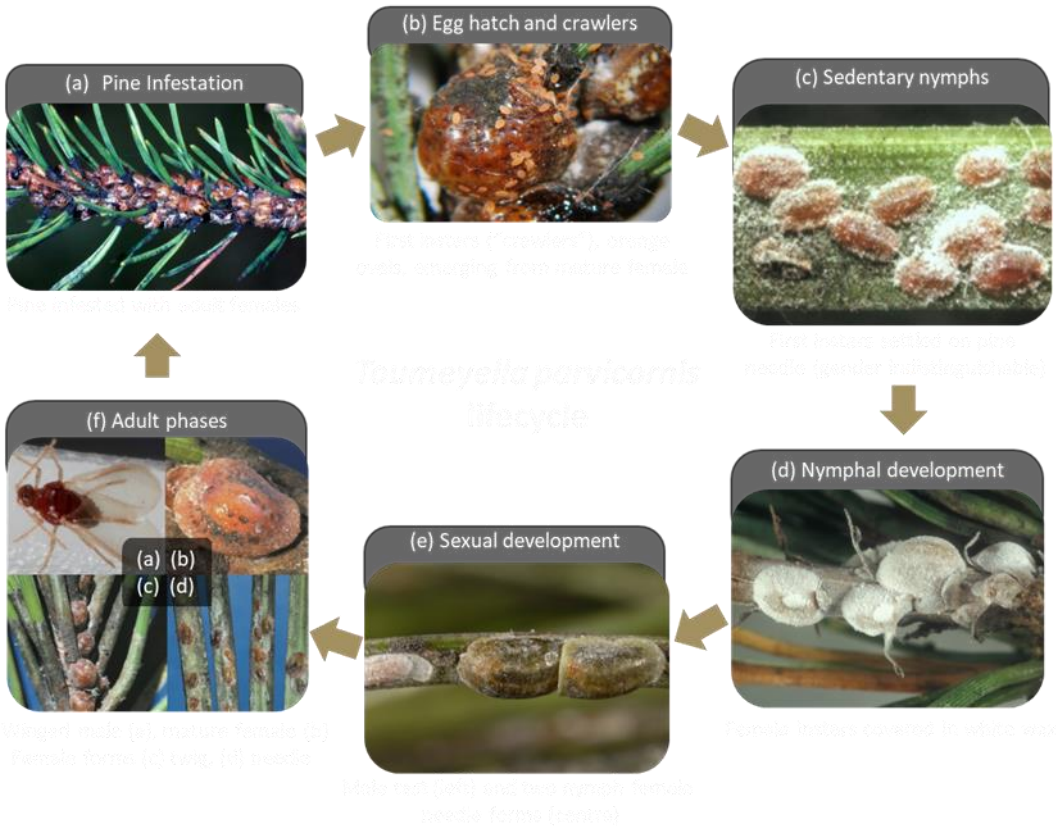

Figure 2: Lifecycle developemnt of *Toumeyella parvicornis*

Infestations of *T. parvicornis* are typically seen on the shoots/twigs or needles when attacking *Pinus* species (Figure 2 (1)). The pest has a mostly sedentary lifecycle in which it remains permanently fixed in place once it begins feeding off a host (Clarke, 2013). The sedentary stages of their lifecycle often consist of high densities of individuals congregating closely together on the host surface. These individuals each secret a powdery substance which eventually forms a waxy greenish sheath enveloping their bodies, giving the appearance of a scale (Malumphy and Anderson, 2016). The flat shape of their shells and production of this outer waxy layer gives rise to the common name for *T. parvicornis* which is "pine tortoise scale" which describes the visual symptoms on *Pinus* trees infested with the pathogen (Clarke, 2013).

Generally, the severity of scale insect infestations of pines are often linked to the nutrients in the soil and host plant, it has been noted that the abundance of *T. parvicornis* increased in pine trees after they were fertilised with urea (Camacho and Chong, 2015). *Toumeyella parvicornis* tends to favour settling on new growth when attacking *Pinus* trees (Clarke, 2013). Notably, *T. parvicornis* infestations on pine trees can take either of two different forms, those which attack the twig/shoot and those which attach the needle, shown in Figure 2(6) (Clarke, 2013). When first instars, known as crawlers, hatch from their eggs they may settle to form the sedentary stage of their lifecycle on either twigs/bark or the needles/shoots, rarely are both forms seen on the one tree (Clarke, 2013).

Generally, the twig/bark infestations occur in the northern range of their distribution while the needle/shoot form is typically observed in the more southerly ranges (Clarke, 2013). Infestations of needles/shoots have been observed the pine species loblolly, slash, longleaf, and Caribbean (Clark, 2013). Occasionally, crawlers may settle on cones, conelets or cone stems, however, only males can reach sexual maturity on the cone surface while both sexes can reach maturity on the cone stems (Clarke, 2013).

The current understanding of *T. parvicornis* lifecycle biology is mostly known from observations of the pest in its native North American range. While the *T. parvicornis* lifecycle has been relatively well characterised in its native range, novel features have been observed in newly invaded territories. A description of the lifecycle covering the egg, nymphal and adult stages is covered in detail below.

In their native range females start egg production after the first flush of new growth of the pine tree, typically in spring, although in the invaded tropical territories in the Caribbean egg production takes place throughout the full year owing to suitable climatic conditions (Clarke, 2013; Malumphy *et al*., 2016). Eggs are small (0.4 mm long), ovoid, slightly transparent with a light pinkish colouring (Clarke, 2013; Malumphy *et al*., 2012). Females have been recorded to produce around 500 eggs (534±50) which are usually laid singly or in short chains which are kept below their body until the first instar of the nymphal stage emerge, often called "crawlers" as they are the only mobile stage of nymphal development (Clarke, 2013; Malumphy *et al*., 2016; Rabkin and Lejeune, 1954). Emerging "crawlers" are shown emerging from a mature female in Figure 2(2).

The nymphal stage of the T. *parvicornis* lifecycle consists of three instars for females and two for males (Clarke, 2013). However, after the males complete their two nymphal instar stages they undergo a further two developmental stages, pre-pupa and pupa before reaching adulthood (Malumphy and Anderson, 2016). The first instar stage ("crawlers") emerges from the eggs soon after oviposition and begin searching out potential settling sites (Clarke, 2013). During this migratory stage the female and male instars are indistinguishable (Clarke, 2013; Malumphy *et al*., 2016). First instars have a body that is orange or reddish with a flat oval shape and have six legs (Anderson and Malumphy, 2016; Clarke, 2013). Crawler densities on infested trees have been recorded at >100 per inch of shoot, though overcrowding can lead to mortality for some crawlers (Clarke, 2013).

Once the crawlers find a suitable settling site they commence the sedentary stages of their lifecycle (Malumphy and Anderson, 2016). Once fixed in place the crawlers transform into the second instar stage where their legs become greatly reduced, shown in Figure 2(4) (Clarke, 2013). The sedentary instar stages produce a powdery wax coating which forms a waxy glaze over their bodies as they develop (Clarke, 2013). This powdery coating quickly disappears in wind and rain (Malumphy and Anderson, 2016). Female second and third instar stages remain fixed on the settling site, are oval in shape and slightly greenish, eventually turning reddish-brown (Malumphy and Anderson, 2016). Male sedentary instars produce an outer protective coating called a "test", generally ~3 mm long, in which the later stages develop, this is shown in Figure 2(5) (Clarke, 2013; Malumphy and Anderson, 2016). Males develop into the adult stage faster than females (Malumphy and Anderson, 2016).

The lifecycle of male and female *T. parvicornis* differs substantially. Females are immobile throughout the adult stage, while males emerge from their tests winged and immediately seek out fertile females, Figure 2(6a) (Clarke, 2013; Malumphy and Anderson, 2016). The females which have settled on needles/shoots differ morphologically in colour and shape from those which settle and feed on twig/bark, Figure 2(6c&d) (Malumphy *et al*., 2012). Adult females feeding on twig/bark tend to turn reddish-brown as they mature from their yellowish/pinkish nymphal colouring (Clarke, 2013). Female twig/bark feeders are generally convex and hemispherical in shape, with flattened edges which resembles tortoises chich gave rise to the common name (Figure 2(6b), while those that feed on needles/shoots are more elongated (Chris, 2013; Malumphy *et al*., 2012). Females feeding on needles/shoots tend to be slightly elongated (up to 4.4 mm long and 4 mm wide) with black marking on their shell backs (Clarke, 2013; Malumphy and Anderson, 2016). Adult females extrude a honeydew substance which is rich in sugars and this tends to attract other insects such as ants, wasps and bees (Clarke, 2013). This honeydew tends to coat the pine needles and branches, the honeydew then serves as a substrate which fungal moulds grow giving it a blackened, often described as "sooty" appearance which is shown in Figure 3 (Clarke, 2013). The sooty appearance is a useful marker when surveying for the pest. Females over-winter on pine trees as fertilised, immature "scales" and commence egg production in the spring (Clarke, 2013).

When males complete their pupa stage the adult emerges from their "test" and takes flight in search of fertile females (Clarke, 2013). The adult males that emerge from their "tests" are short lived, tending to survive for only one or two days (Clarke, 2013). The adult males' body is brown, they have one pair of white wings, and their posterior is covered in a pointed sheath (Clarke, 2013). Males are smaller than females (typically about 1.5 mm in length) and are rarely seen due to their small size (Clarke, 2013; Malumphy and Anderson, 2016).

The number of generations which *T. parvicornis* can produce each year is dependent on the region's climate. In its most northern range (such as Colorado and Nebraska) the pest only produces one generation per year (univoltine), further south two generation per year (bivoltine) are possible in the temperate to sub-tropical states such as Maryland, Virginia and North Carolina (Clarke, 2013). In the southern USA the pest is multivoltine and has been recorded producing up to four generations in the humid sub-tropical climate of Georgia (Clarke, 2013). In the Caribbean islands no seasonality (no over-wintering stage) has been observed in the pest's lifecycle and five generations are possible throughout the year (Malumphy and Anderson, 2016). In Italy, it also appeared that the population of the pest established around Rome could produce up to three generations per year (Garonna *et al*., 2018).

Dispersal of *T. parvicornis* beyond its native range has been generally associated with international trade (Malumphy and Anderson, 2016). The introduction of *T. parvicornis* into the Caribbean islands from the US has been linked to the importation of live cut pine for use as Christmas trees (Malumphy *et al*., 2012). The recent introductions into Italy and France are also likely to be the results of trade. The only stage of *T. parvicornis's* lifecycle cycle that can spread naturally is the first instar stage of females, as adult females are immobile and flying males cannot start new populations by themselves. The natural capacity for crawlers to travel via crawling is not considered to be extensive, medium to long-range dispersal between trees is primarily via wind and possibly hitchhiking on birds, insects or mechanical equipment (Clarke, 2013; Malumphy and Anderson, 2016).

2.5 Management, Monitoring and Control Options

3. Is the pest a vector? **Yes** ☐ **No** **X**

If the pest is a vector, which organism(s) is (are) transmitted and does it (do they) occur in the PRA area?

4. Is a vector needed for pest entry or spread? **Yes** ☐ **No** **X**

If a vector is needed, which organism(s) serves as a vector and does it (do they) occur in the PRA area? Consider both the pest and the vector in the assessment.

5. Regulatory status of the pest

Trade in Live Plants of *Pinus spp*. other than fruit and seeds is prohibited with certain "third countries" outside of the EU under Regulation 2016/2072 Annex VI. This prevents trade in live PfP and cut foliage of *Pinus spp.* with Canada, Mexico and the USA, as well as Puerto Rico and the Turks and Caicos Islands where the pest is well established. This limits the potential for entry of the pest into Ireland from these regions.

Pinus spp. can generally be traded freely between EU countries and certain other third countries listed in Regulation 2016/2072. At present the pest is being and under eradication in France and contained with the goal of eradication in Italy. These eradication program should prevent the movement of infested host material outside of the afflicted regions and limit the potential for introducing the pest into Ireland via this route. However, should the programs fail to eradicate the pest and it comes to establish within the EU *Pinus* commodities could serve as pathways for introducing the pest into Ireland along with hitchhiking on machinery such as vehicles arriving via ferries from the continent.

Already Ireland maintains a protected zone for the pest *Thaumetopoea pitycampa* (the pine processionary moth) which mainly attacks *Pinus* species, along with several other PZs for pests that attack multiple hosts genera that include *Pinus*, such as *Dendroctonus micans, Gremmeniella abietina, Ips amitinus, Ips sexdentatus, Ips typographus* and *Ips duplicatus.* These protected zones require Official Statements that any *Pinus* exported to Ireland has been produced in areas free of the PZ pests. EU exporters of *Pinus*

commodities to Ireland therefore must ensure good levels of biosecurity on their premisses, therefore these PZ's should provide a degree of protection against the introduction of *T. parvicornis* on these commodities. However, the spread of *T. parvicornis* throughout the EU should be continually monitored and particular attention should be undertaken on checks on *Pinus* PfP or cut foliage arriving from Italy or France.

6. Distribution

Continent	***Distribution*** *(list countries, or provide a general indication, e.g. present in West Africa)*	*Provide comments on the pest status in the different countries where it occurs e.g. widespread, native, introduced….)*	***Reference***
America	*USA; Mexico; Canada*	Native	*Clark et al (2013)*
Caribbean	*Puerto Rico; Turks and Caicos Islands*		*Malumphy and Anderson, 2016*
Europe	*Italy; France*		*Garonna et al (2018); Fr NPPO*

7. Host plants /habitats* and their distribution in the PRA area

The NFI (2017) report stated that there was 7,700 ha of *P. sylvestris* and 64,900 ha of "other Pine" species planted in Ireland in 2017. This accounted for a combined 9.4% of the total forestry area in Ireland (10.7% of stocked area). The DAFM Forest Statistics Ireland 2021 indicated that there were 3,421,000 *Pinus contorta* and 630,000 *Pinus sylvestris* trees planted in Ireland in 2020 (DAFM, 2022). This accounted for ~47.5% of the conifer species sown in Ireland that year (Table 1). This was considerably higher than that planted in previous years, however, they generally account for ~ >8% of sown conifers since 2017. *Pinus sylvestris* is considered one of *T. parvicornis*'s primary hosts in its native North American range (Clarke, 2013). *Pinus cortorta* is also a known host for *T. parvicornis* in its native range. Both of these commercially planted trees are widely distributed throughout Ireland and therefore at considerable risk should a *T. parvicornis* outbreak occur on the island.

Table 1: Proportions (%) conifer trees sown in Ireland between 2016-2020 (DAFM, 2022)

	2016	**2017**	**2018**	**2019**	**2020**
Larix decidua	0.00	0.04	0.04	0.04	0.18
Picea abies	8.83	10.80	10.70	8.84	0.22
Picea sitchensis	86.13	75.09	72.50	80.79	40.06
Pinus contorta	0.40	5.45	5.82	4.78	40.30
Pinus sylvestris	3.38	7.20	9.39	3.90	7.42
Pseudotsuga menziesii	1.16	1.31	1.41	1.59	11.82
Tsuga heterophylla	0.10	0.10	0.13	0.06	0.00

8. Pathways for entry

Toumeyella parvicornis is currently only known to infest species of the genus *Pinus*. The trade in live trees of *Pinus* (Christmas trees) with the US is considered to have been the pathway which introduced the pest into the Caribbean islands (Malumphy and Anderson, 2016). Therefore, all live *Pinus* commodities (PfP; cut foliage) originating from areas where *T. parvicornis* is present should be regarded as potential entry pathways that could introduce the pest into Ireland.

A review of the consignments listed on TRACES for 2021 found 23 unique listed imports of *Pinus* species from third countries into Ireland (Table 2). *Toumeyella parvicornis* is not known to be currently present in any of the countries of origin for these consignments. However, a number of these imports were live plants such as plants for planting from the UK and "living plants" such as cut flowers and branches with foliage from China and India. Such imports of live pine tree material could serve as pathways for pine scale insect pests should the pest expand its current distribution to these locations where trade is currently occurring.

Toumeyella parvicornis is also considered to be possibly spread by machinery. Hitchhiking on vehicles and forestry machinery is another route by which the pest could be spread between forests and over long distances.

The route by which the pest was introduced into Italy and subsequently into France is still unknown. Whether the outbreak in France was introduced from Italy or represents another sperate introduction into the EU has yet to be determined, howwver, it is likely linked to the Italian outbreak.

For Ireland there is a threat that the species could be introduced on trade or hitch hike from Italy or France into Ireland. Control measures being undertaken in both these countires should reduce the likelihood of its spread in the short term. However, if the species is not regulated at an EU level and allowed to spread it will eventually pose a threat to Ireland.

Table 2: Listed consignments of *Pinus* imports into Ireland from third countries

Country Of Origin	**Country Of Dispatch**	**Latin Name**	**Product Type**
United States	United Kingdom	*Pinus*	Others
United Kingdom	United Kingdom	*Pinus*	Others
United States	United States	*Pinus*	Plant products: sawn wood
United Kingdom	United Kingdom	*Pinus sylvestris*	Intended for planting: seeds
United Kingdom	United Kingdom	*Pinus sylvestris*	Intended for planting: seeds
United States	United Kingdom	*Pinus taeda*	Plant products: sawn wood
United States	United Kingdom	*Pinus taeda*	Plant products: sawn wood
Russian Federation	United Kingdom	*Pinus*	Plant products: others
Belarus	Belarus	*Pinus*	Others
Russian Federation	Russian Federation	*Pinus sylvestris*	Others
Russian Federation	United Kingdom	*Pinus; Pinus sylvestris*	Plant products: others
United States	United Kingdom	*Pinus*	Plant products: sawn wood
Russian Federation	Russian Federation	*Pinus sylvestris*	Others
Russian Federation	Russian Federation	*Pinus sylvestris*	Others
United Kingdom	United Kingdom	*Pinus sylvestris var. aquitana*	Intended for planting: not yet planted
Russian Federation	United Kingdom	*Pinus sylvestris*	Plant products: others
United Kingdom	United Kingdom	*Pinus*	Plant products: logs
United States	United Kingdom	*Pinus taeda*	Plant products: sawn wood
United Kingdom	United Kingdom	*Pinus; Picea abies*	Plant products: logs
Russian Federation	United Kingdom	*Pinus sylvestris*	Plant products: others
Russian Federation	Russian Federation	*Pinus sylvestris*	Others
China	United Kingdom	*Pinus bungeana*	Other living plants: cut flowers and branches with foliage
India	United Kingdom	*Pinus*	Other living plants: cut flowers and branches with foliage

Rating of the likelihood of entry	*Low* ☐	*Moderate* ☐	*High* X
Rating of uncertainty	*Low* X	*Moderate* ☐	*High* ☐

9. Likelihood of establishment outdoors in the PRA area

No experimental work has been published investigating *T. parvicornis*'s baseline temperatures for its lifecycle development stages. However, an app called "Pest Prophet" has been developed in the US which indicated that lifecycle development starts at around 50F (10°C) and it takes about 450 GDD F (Growing degree days) (232°C) for crawlers to emerge. This app is designed to inform growers when to spray for crawlers. The basis for the Pest Prophet app is not known.
The likelihood is that *T. parvicornis* could establish in the Irish climate based on observation data and climate matching. The pest has been found to be capable of establishing in a wide range of climates from the Nearctic regions of North America, to the tropical climates of the Caribbean islands, and the Mediterranean region (Malumphy and Anderon, 2016). It is unknown if the pest would have a univoltine or bivoltine lifecycle on the island of Ireland. It is considered to produce up to three generations per year in Italy (Garonna et al., 2018). It has a bivoltine lifecycle in US states that have temperate – sub-tropical climates (Maryland, South Carolina and Virginia), therefore we consider it unlikely for *T. parvicornis* to have more than two generations at most in the Irish temperate climate. Therefore, the potential risk of establishment for this pest should it arrive is considered high.

As regulatory prohibitions are in place on trade in live Pinus tree commodities from counties outside the EU where the pest is present this should reduce the likelihood of the pest entering Ireland from outside the EU. However, this has not prevented the pest's introduction into the EU. As the pest is known to have established in two separate regions in the EU the risk of introduction into Ireland is increasing. The possibility of the pest (1) permanently establishing in the EU is increasing if the eradication programs fail and (2) subsequently reaching Ireland via trade or hitchhiking on vehicles entering Ireland is possible.

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ☐	*High* X
Rating of uncertainty	*Low* X	*Moderate* ☐	*High* ☐

10. Likelihood of establishment in protected conditions in the PRA area

No known hosts of *T. parvicornis* are cultivated, at least widely, under protected cultivation in Ireland.

Rating of the likelihood of establishment in protected conditions	*Low* X	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* X	*Moderate* ☐	*High* ☐

11. Spread in the PRA area

Populations of the pest are only mobility transferrable to new areas during the crawler stage of its lifecycle. The pest can easily spread locally between adjoining trees by crawling or wind. Wind dispersal has been recorded dispersing crawlers up to a distance of 2-3 miles (4.8 km) from a severe infestation site (Rabkin & Le Jeune, 1954). To spread further distances to new tree stands the pest would most likely need to hitchhike on machinery, other insects and birds. As *Pinus* forestry is commercially cultivated monocultures (Table 1) the pest would likely be easily spread in these areas. The capacity and rate at which the pest may spread naturally if it entered and established in Ireland is therefore considered to be low as it cannot spread very far by its own means. Spread would be greater if the pest produced several generations per year, as the number of generations the pest may produce is unknown there is still moderate uncertainty regarding its ability to spread. However, in Italy spread as been observed to be along road side trees indicating possible Hitchhiking as a means of spread. Hitchhiking could facialitate long distance spread to new hosts. If the pest were to arrive and etablish forestry machinery could easily be a means of long distance spread if it were not appropriately disinfested.

Therefore spread is considered to be possibly low-moderate with a moderate level of uncertainty for the lack of information on potetnail hitchiking.

Rating of the magnitude of spread	*Low* X	*Moderate* X	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

12. Impact in the current area of distribution

12.1 Economic Impact

The severe impacts *T. parvicornis* has had on Pinus species in newly invaded regions has attracted considerable international attention and concern. Yet in its native North American range, the pest is not considered to present a considerable threat to natural Pinus forests with natural predation capable of controlling population levels. The pest has been mostly prevalent on young trees where it has been known to kill or severely damage these (Rabkin and Lejeune, 1954). Economically, infestations in North America are mostly associated with impaired tree growth and appearance, often "cosmetic" levels of damage, however, in some circumstances heavily infested trees may be killed, particularly seedlings and saplings (Clarke, 2013; NC State University, 2022).

On the north American mainland, the pest has co-evolved with a wide range of native predators which effectively control populations from over whelming trees and forestry (Clarke, 2013). Additionally, it is only in the southern most US states that the pest displays a multivoltine lifecycle. In most US states and Canadian provinces, the pest produces only one-two generations per year. Since the number of generations produced each year influence how destructive the pest can be, this uni/bivoltine development lifecycle capacity greatly reduces the damage the pest can inflict.

The pest has inflicted considerable damage in newly invaded regions. In the Turks and Caicos Islands and Puerto Rico the climatic conditions have allowed the pest to reproduce continually, achieving up to 5 generations throughout the year (Sanchez *et al*., 2019). All stages of the pest's development lifecycle have been observed throughout the year in the invaded Caribbean islands indicating no seasonal affects (e.g. over-wintering stages) in its reproductive cycle (Sanchez *et al*., 2019). The combination of continuous reproduction and the lack of natural predators present in these islands has led populations of *T. parvicornis* to grow unchecked on the widely available host *Pinus* species (Malumphy and Anderson, 2016).

Toumeyella parvicornis was first introduced into the Turks and Caicos Islands sometime prior to in 2005 (Sanchez *et al*., 2019). Within just six years after the pest was first recorded an estimated 97.6% decline in the number of mature pine trees (Green, 2011). It has taken a sustained and coordinated efforts to try repopulate the islands wild areas with nursery grown pine saplings to regenerate the forestry ecology (Sanchez *et al*., 2019).

Toumeyella parvicornis was first reported in Puerto Rico in 2010 causing extensive damage to young Honduran Pine (*Pinus caribaea* var. 'honduras') seedlings (Segarra-Carmona & Cabrera-Asenico, 2010). There appears to be little recent information available on the current status of the pest and its host plants in Puerto Rico.

The first report of the pest in Europe was in Italy in 2014 (Garonna *et al*., 2015). The pest has caused considerable damage (decline and dieback) to *Pinus pinea* trees in several Italian regions (Garonna *et al*., 2018). Interestingly, while *P. pinaster* had been shown to be a viable host for *T. parvicornis* in Italy, to date no dieback has been observed (Garonna *et al*., 2018). It has also been noted that *Pinus halepenis* (Aleppo pine) appears to be resistant to *T. parvicornis* (Garonna *et al*., 2018). In 2021 the NPPO declared the pest was under containment, in case eradication was impossible (EPPO, 2022).

The Irish forestry sector is highly valuable, in 2012 it was calculated that forestry was worth ~ €2.3 billion to the wider Irish economy when direct and indirect induced effects are considered (DAFM, 2022). In 2019, forestry product exports accounted for €467 million of the total agri-food exports valued at €14.5 billion ~ 3% (DAFM, 2020). When non-plant-based exports are removed from this figure the value stands at €2.276 billion of which forestry accounts for 18.9% and wood-based products account for 1.59% (combined 20.49%).

The introduction of a new pest would negatively impact the pine forestry sector. Eradication programs may lead to early tree felling and reduce or completely eliminate the commercial viability of infested stands of pine trees and limit the potential future use of *Pinus* species. However, pine trees currently represent just ~10% of the current total Irish forestry cover. Despite this, the grouping of "Other pine spp." in the NFI (2017) report is the second largest tree category recorded in Ireland (Table 3). Given the pest is potentially a threat to all of these species the value of the pine sector should be considered as moderate – high. However, pine forestry is secondary to spruce (Picea) in Ireland.

The impact in Ireland of this new pest should be considered to be low – moderate with moderate uncertainty. The actual number of generations the pest can produce will influence its impact as will the level of natural predation. Both of these factors are currently unknown.

Table 3: Tree Species Composition in Ireland (NFI, 2017)

Rank	Tree category	Area (ha)	%
1	Other conifers	3,030	0.4
2	Scots pine	7,660	1.1
3	Beech	10,030	1.5
4	Sycamore	10,100	1.5
5	Douglas fir	10,380	1.5
6	Other long living broadleaves	11,820	1.8
7	Pedunculate and sessile oak	17,880	2.7
8	Alder spp.	17,910	2.7
9	Larch spp.	24,490	3.6
10	Ash	25,280	3.8
11	Norway spruce	25,770	3.8
12	Birch spp.	47,270	7
13	Other short living broadleaves	53,280	7.9
14	Other pine spp.	64,900	9.6
15	Sitka spruce	343,310	51.1

Rating of the magnitude of spread	*Low* X	*Moderate* X	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

Management, Monitoring and Control Options

There are currently 25 known scale pests recorded in Ireland, though none are known to attack *Pinus* species (O'Connor *et al*., 2013). All previous records of scale pests attacking *Pinus* species have been removed from Irish records as there have been no recent findings and the original records were considered errors, these include *Leucaspis lowi* and *Kermes corticalis* (O'Connor *et al*., 2013). An outbreak of a pine scale pest on *Pinus* would be unprecedented in our recent history but probably easy to detect visually as it is unlikely to be confused with another pest species.

Infestations of the pest can be surveyed for visually by looking for needle loss, white coatings of needles and the characteristic "sooty" appearance given by the honeydew produced by females which coat pine needles, branches and objects below the tree in a white coating which black fungal moulds then grow upon (Figure 3). Symptoms produced by certain pine aphids may be mistaken for *T. parvicornis* as they share some similar visual qualities. A record of pine aphids and their symptoms are available at: https://influentialpoints.com/Gallery/Aphids_on_pine_Pinus_in_Britain.htm.

Figure 3: Visual symptoms of *T. parvicornis* infestations of *Pinus* trees

Chemical control for scale insects is often difficult, particularly in forest and urban environments (EPPO, 2022[b]). Outbreaks of *T. parnicorvis* on Christmas tree plantations in the US are difficult to control using insecticides as the mature female's outer shell is largely impenetrable (NC State University, 2022). When using insecticides for controlling scale pests such as *T. parvicornis* the optimum time to apply these chemicals is considered to be when the susceptible crawlers emerge (NC State University, 2022). Monitoring the lifecycle stages of the pest is therefore critical when applying conventional pesticide-based control strategies. Cooper and Cranshaw (1996) found certain and a horticultural oil to be effective as foliar applications. Insecticidal *soaps and horticultural* oils can also be used to treat over-wintering females and have the additional benefit being less impacts on non-target organisms (NC State University, 2022). A study conducted by Clarke et al. (1992) found pyrethroids were toxic to *T. parvicornis*, though less so than organophosphorus insecticides. There is a wider range of insecitcides avialable forestry nureries (https://teagaschorticultureportal.ie/table-view/forest-nurseries/) for conrolling aphids, black vine weevil,caerpillaers, mites and white flies which may prove effective.

In its native North American range, *T. parvicornis* is controlled by a wide range of natural predators including coccinellids (ladybirds), larvae of certain moths, particularly *Laetilia coccidivora*, and chalcidoid wasps (Malumphy *et al*., 2012). Predators appear to respond to heavy infestations and have been shown to

reduce overwintering females by up to 50% in certain cases in the US state of Michigan (Clarke, 2013). A combination of ladybirds and *L. coccidivora* attacking outbreaks in the US has been shown to reduce damaging infestations to non-outbreak status within a year (Clarke, 2013). Numerous other organisms have also been reported as predators such as lacewings, mirids, spiders, and birds (Clarke, 2013).

Coccinellids that consume the eggs and young scales of *T. parvicornis* in North America include *Brachyacantha ursina, Chilocorus bivulnerus, C. stigma Coccinella novemnotata, C. transversoguttata, C. trifasciata, Hyperaspis binotata, H. congressis, H. signata* and *Scymnus lacustris* (Clarke, 2013; Malumphy *et al*., 2012). None of the species of predatory ladybirds from North America are registered as present in Ireland with the NDBC. However, there are members of the genera *Chilocorus* and *Hyperaspis* present in Ireland, though whether they would prey on *T. parvicornis* is unknown.

The larvae of scale-feeding snout moth, *Laetilia coccidivora*, has been recorded to severely reduce heavy infestations of *T. parvicornis* (Clarke, 2013). The larvae of dipteran moths of the genus *Leucopis* have also been found to develop beneath the settled *T. parvicornis* females, ingesting their body contents (Clarke, 2013; Malumphy *et al*., 2012). No species of the genera *Laetilia* or *Leucopis* are currently registered as present in Ireland with the NDBC.

Chalcidoid parasitoid wasps recorded to attack *T. parvicornis* include aphelinids of the genus *Aphytis*, and the species *Coccophagus albicoxa, C. lycimnia, C. immaculatus* and *C. quaestor* as well as the encyrtid *Microterys fuscicornis* (Malumphy *et al*., 2012). There are no known members of the genera *Aphytis, Coccophagus* and *Microterys* recorded with the NDBC in Ireland.

In Italy there was a recorded shift in natural predators feeding habits towards outbreaks of *T. parvicornis*, however, the level of predation has not been enough to prevent the spread or proliferation of the pest (Garonna *et al*., 2018). One species of parasitoid wasp, *Metaphycus flavus*, was shown top prey upon *T. parvicornis*, particularly immature males (Garonna *et al*., 2018).

There appears to be no known natural predators of *T. parvicornis* in Ireland. However, the parasitoid wasp species *M. flavus* is used as a biological control agent for scale insects by European countries. *Metaphycus flavus* is listed in the EPPO PM 6/3(5) standard "Biological control agents safely used in the EPPO Region" in Appendix 1-3. Use of *M. flavus* in the UK requires a licence as it is considered non-native (Defra, 2022). An Irish eradication program could therefore possibly be complemented with the use of *M. flavus* in combination with restricted movement of host material from the site of an outbreak site, controlled felling and burning, and if possibly conventional insecticides. However, it should be highlighted that the efficacy of *M. flavus* for controlling *T. parvicornis* in Ireland is untested and entirely unpredictable.

12.2 Ecological Impact

Pinus sylvestris is considered to be one of the few native coniferous tree species to the island of Ireland, though it is often debated whether there are any truly native stands left after the last glacial maximum (Futureforests, 2022). However, the tree is now currently widespread throughout the country (Figure 4) and plays an important ecological role in the Irish natural woodland ecosystem (Roche, 2010). As this species can be commercially cultivated it is an attractive ecological alternative to *Pinus* species which are considered non-native and often attract negative attention when used in commercial forestry.

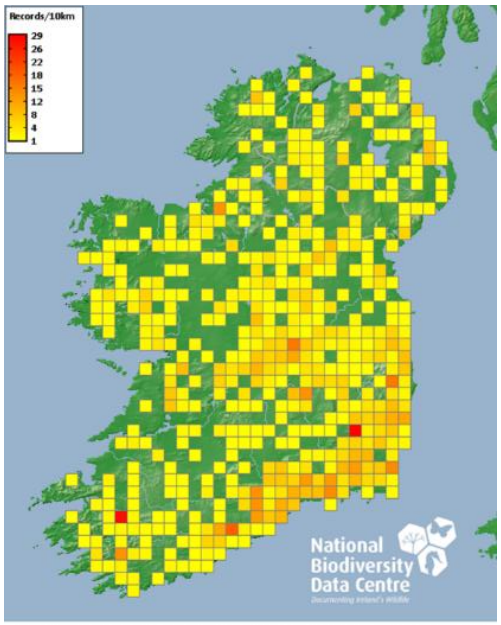

Figure 4: Distribution of *Pinus sylvestris* in Ireland as recorded with the NDBC

Should the pest enter and establish the addition of another pest could be quite damaging to this native tree species. In the invaded territories of Puerto Rico and the Turks and Caicos Islands native natural stands of *Pinus* trees have been devastated. Similarly in Italy the pest is considered a major threat to the iconic pine trees of Rome and it is unknown if the pest can be contained and eradicated. The threat to our native tree *P. sylvestris* should be considered to be low - moderate though with moderate uncertainty. The threat depends on how many generations the pest could produce in any given year and whether there is an abundance of generalist predators which would control populations of the pest. These are big unknowns regarding the pest biology and possible impacts.

Figure 4: *Pinus sylvestris* distribution as recorded by citizen scientists in Ireland.

Rating of the magnitude of impact in the current area of distribution	*Low* X	*Moderate* X	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

12.3 Sociological Impact

Pine species are widely present in national parks and *P. sylvestris* is highly prised as it is considered native. The impact of having to destroy trees in an eradication program would have a social impact in parks and recreational areas. The threat to a native species would also attract public attention. The social impact of an outbreak and eradication program is therefore considered low - moderate with moderate uncertainty.

Rating of the magnitude of impact in the current area of distribution	*Low* X	*Moderate* X	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

The rating chosen should be based on the highest type of impact.

13. Potential impact in the PRA area

The impact of this pest in Ireland appears to be low-moderate given the low economic importance of Pine to the overall forestry sector which is domianted by spruce (Picea). The pest will likely not produce more than 1-2 generations a year in Ireland limiting the impacts on pine species.

Rating of the magnitude of impact in the current area of distribution	*Low* X	*Moderate* X	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

14. Identification of the endangered area

Irish pine forestry.

15. Overall assessment of risk

In its native North American range *T. parvicornis* is considered a manageable pest with outbreaks on *Pinus* plantations usually controlled by natural predation. However, when introduced into new regions *T.*

parvicornis has shown a remarkable level of adaptability, establishing and thriving in new climates and on new host species. Efforts to eradicate the pest in these invaded regions have failed to date. In the Caribbean, *Pinus* trees native to the Turks and Caicos Islands and Puerto Rico have been devastated by the pest. Intervention has been necessary in the Caribbean islands to prevent the total extinction of their native *Pinus* forests. In Italy the pest appears to have established, once again on a hew host species (*P. pinea*) and thrived, efforts there currently include containment in the event that eradication is impossible. This makes the recent report of an outbreak in France all the more concerning. Considering the pests biology, it appears highly likely it would establish in the Irish climate and it is already known to attack to our most abundantly grown *Pinus* trees. The number of generations *T. parvicornis* could produce each year in Ireland is uncertain (likely at most two) and this characteristic would greatly influence its potential impact. Whether the natural ecosystem in Ireland has the capacity to control populations through predation cannot be determined at present. The lack of natural predators in the Caribbean islands combined with its continuous year-round breeding cycle are the two main factors contributing to this pests' devastating impacts in those regions. Should the pest come to establish in the EU it will be integral to prevent its introduction into Ireland to protect our commercial pine forestry sector and native conifer tree *P. sylvestris*.

However, the actual level of impact on the pine sector will likely be low should the pest arrive. Early detection and eradication may prove effective as has been should for previously for pine scale pest introductions. An introduction of *Chionaspsis pinifoliae* (a similar) pine scale pest of north American origin was detected early in the 1980s and eradicated from a nursery.

Stage 3. Pest risk management

16. Phytosanitary measures

Efforts should be made to prevent the entry of *Toumeyella parvicornis* into Ireland. Should the pest establish in the EU as appears likely to be the case in Italy, a protected zone should be sought to add further regulation to the movement of *Pinus* trees (PfP, cut foliage) into Ireland from other EU states. An associated factsheet should be produced for raising awareness of the threat this pest poses to Irish biosecurity. A contingency plan should be drafted to provide clear instruction for how to respond to an outbreak of this pest should wild populations be detected in Ireland.

17. Uncertainty

- The number of generations the pest could produce each year in the Irish climate is unknown. Whether the pest is univoltine or bivoltine is would greatly influence the impact it may have on Irish pine trees.
- It is unknow to what extent natural predation would help control *T. parvicornis* populations should they enter and establish.
- If the risk of entering has been underestimated the risk rating scoring for this pest rises substantially.

18. Remarks

- A summary factsheet will be prepared on the pest and added to the Irish plant pest risk register.
- Request update of EPPO Cryptophlebia ombrodelta database in line with PRA information.

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Appendix 1. Relevant illustrative pictures (for information)