Pest Risk Analysis for

Coleosporium asterum

STAGE 1: INITIATION

1. What is the name of the pest?

Coleosporium asterum (Dietel) Sydow & P. Sydow.

Taxonomic position:
Kingdom: Fungi
Division: Basidiomycota
Class: Pucciniomycetes
Order: Pucciniales
Family: Coleosporiaceae

Common name(s): Western pine-aster rust, needle cast of red pine, rust of *Solidago*, rust of aster.

Synonyms
C. asterum has the following synonyms (Anon., 2014):
Stichopsora asterum
Uredo solidaginis
Coleosporium solidaginis
Coleosporium solidaginis f. *solidaginis*
Peridermium montanum
Coleosporium solidaginis f. *carpesii*

Special notes on nomenclature and taxonomy:
The genus *Coleosporium* is currently comprised of >200[1] species. In the first UK Pest Risk Analysis (PRA) for *C. asterum* (Jones, 2005) species numbers were described as '*numerous*' and '*doubtfully distinct morphologically'*. The name of the pathogen and the hosts which it is reported to infect has been the subject of much debate and revision over many years (see e.g. Raabe and Pyeatt, 1990). Helfer (2013) commented that '*most authors agree that the European taxa of* Coleosporium *are indistinguishable in their morphology*'. He also stated that the taxa of *Coleosporium* are '*seriously confused*'; with host specificity appearing to restrict the host-range in some taxa, but not in others; and the use of molecular methods to define taxa being '*in its infancy*'. Because of this, there is doubt over the accuracy of some of the country and host records of *C. asterum* presented in this PRA as well as

[1]234 species records in Index Fungorum (Anon., 2014) - accessed 18 February 2014

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the current distribution of the pest. If deemed necessary, further verification (if isolates are available) would have to be undertaken using a range of methodologies (host-range studies, morphological examination and molecular techniques).

2. What is the pest's status in the EC Plant Health Directive (Council Directive 2000/29/EC[2]) and in the lists of EPPO[3]?

The pest is not listed in the EC Plant Health Directive (Anon., 2000) and it is not recommended for regulation as a quarantine pest by EPPO, nor is it on the EPPO Alert List.

However, there are some specific, detailed phytosanitary requirements for *C. asterum* or related pests for imports of plants (excluding fruits and seeds) of *Pinus* spp. Such material is normally prohibited entry into the EU when it originates in non-European countries (Anon., 2000; Annex IIIA, point 1). However, some imports of *Pinus* spp. are permitted entry from Korea and Japan under the terms of a derogation from these requirements (although for Japan the requirements are for other species of *Coleosporium*):

- Commission Decision of 26 June 2002 (2002/499/EC; most recently amended by Decision 2010/646/EU) authorises imports of naturally or artificially dwarfed plants of *Pinus* L. (specifically *Pinus parviflora* or *P. parviflora* grafted onto a rootstock of a species of *Pinus* other than *P. parviflora*), originating in the Republic of Korea, provided they are free from a list of organisms including *C. asterum*. The requirements are detailed, and are based upon frequent inspections of plants over a two-year period, removal of '*infested*' (infected) plants and, when this occurs, any remaining plants have to be '*effectively treated'.* Plants imported into the EU are also subject to post-entry quarantine. This legislation applies up until 31 December 2020.
- Commission Decision of 8 November 2002 (2002/887/EC; most recently amended by Decision 2010/645/EC) authorises imports of naturally or artificially dwarfed plants of *Pinus* L. (specifically *Pinus parviflora* or *P. parviflora* grafted onto a rootstock of a species of *Pinus* other than *P. parviflora*), originating in Japan, provided they are free of a list of organisms which does not include *C. asterum* but does include two other species of *Coleosporium* (*C. paederiae* and *C. phellodendri*). The requirements are the same as for plants of *Pinus* imported from Korea. This legislation also applies up until 31 December 2020.

For both derogations, point 8 in the Annex to these Commission Decisions refers to a general requirement for freedom from '*harmful organisms of concern'* (as laid down in Article 6 of Anon., 2000), in addition to those listed in the preceding points**.**

3. What is the reason for the Pest Risk Analysis?

As a result of the launch of the UK Plant Health Risk Register[4] in 2014, the pest has been identified as an organism that continues to pose a potential risk to the UK forestry sector. When published in January 2014, the UK Plant Health Risk Register entry, which preceded the commissioning of this new PRA, stated (under '*General comments'*): '*Dioecious rust of which the main host* [i.e. Pinus] *is prohibited, which*

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2000L0029:20100113:EN:PDF
[3] http://archives.eppo.int/EPPOStandards/PM1_GENERAL/pm1-02(21)_A1A2_2012.pdf
[4] https://secure.fera.defra.gov.uk/phiw/riskRegister/index.cfm

provides some mitigation of the risk, though additional hosts are not regulated. Cut flowers are considered to provide a greater risk of introduction'.

A UK PRA was produced in 2005 in response to interceptions of *C. asterum* on cut flowers of *Solidago* (2002) and *Solidaster* (2005) imported from Zimbabwe (Jones, 2005)[5]. Although this PRA only assessed the risk posed by imported infected cut flowers originating in countries outside of the EU where the pest was thought to occur, the conclusion suggested that the risk posed by imported infected planting material was likely to be higher than that posed by imported infected cut flowers (contrary to the recent 2014 UK Plant Health Risk Register entry). As a result, EC listing and regulation of all host plants for planting was requested by the UK Plant Health Service in 2007 (Ward, 2007). This request remains outstanding and awaits consideration by the EC Standing Committee for Plant Health (EC SCPH). To support the request the UK have suggested to the EC SCPH that EFSA (the European Food Safety Authority) could review listing of the pest. (R. McIntosh, Defra, UK, *personal communication*, February 2014).

In 2014, the 2005 UK PRA was identified as requiring the following updates in order to produce this new PRA:

- A review of literature published since the first UK PRA was produced
- Revision of the 2005 PRA to incorporate any new information
- Revision of the 2005 PRA to include risk ratings

In addition to imports of cut flowers, other potential pathways of entry have been considered (see 8. below). The UK Plant Health Risk Register entry has now been updated in line with the conclusions of this PRA.

STAGE 2: RISK ASSESSMENT

4. What is the pest's present geographical distribution?

Reports of the pest are summarised in Table 1 below.

In the 2005 UK PRA *C. asterum* was reported to occur in North America (USA, Canada and Mexico) and Asia (China, India, Japan and Korea). In addition, two interceptions of the pest had been made on cut flowers imported into the UK from Africa (Zimbabwe), first in 2002 and next in 2005. The second interception and the statutory action taken on that consignment triggered the production of the 2005 PRA. Since that time further interceptions of *C. asterum* on cut flowers from Africa have occurred in the UK (see Table 2). However, there are no published reports of *C. asterum* in Africa.

Helfer (2013) commented that the genus *Coleosporium* is '*mostly limited to the northern hemisphere, where it is widespread and common in Europe, Asia and North America*'. In updating the 2005 UK PRA, several reports of *C. asterum* in Europe have been retrieved. These are discussed below.

The United States Department of Agriculture (USDA) *'Fungal databases'* (Farr and Rossman, 2014) is cited as the primary reference for the geographic records of *C.*

[5] Hereafter referred to as the 2005 UK PRA

asterum in Table 1. Searching in the '*Fungus-Host'* section of this database yielded 755 records (for *C. asterum* and synonyms) with associated references (Redlin, S, USDA, USA, *personal communication*, March 2014). Where there are less than three references associated with the records, the original references for the records (additional to those reported in the 2005 UK PRA) retrieved from this database are cited in the text below Table 1. Where records are not reported in Farr and Rossman (2014) the references are cited in the table.

Table 1. Geographic records of *Coleosporium asterum*

Continent	Country/region (as reported)	Reference
Asia	China	Farr and Rossman, 2014
	Himalayas	Farr and Rossman, 2014
	India	Sinha and Singh, 1992
	Japan	Farr and Rossman, 2014
	Korea	Farr and Rossman, 2014
	Russia USSR	Diekmann *et al*., 2002; GBIF, 2014 Farr and Rossman, 2014
	Taiwan	Diekmann *et al*., 2002; Farr and Rossman, 2014
	Turkey	Bahcecioglu and Kabaktepe, 2012; Farr and Rossman, 2014
Africa (tentative)*	Kenya Zambia Zimbabwe	Fera (*personal communication*, 2014)
Caribbean	Cuba West Indies	Farr and Rossman, 2014
Europe (tentative)**	France	Bru-Adan *et al*., 2009
	Germany	GBIF, 2014
	Portugal	Santos and Sousa da Câmara, 1954
North America	Bermuda	Diekmann *et al*., 2002; Farr and Rossman, 2014
	Canada	Farr and Rossman, 2014
	Mexico	Farr and Rossman, 2014
	USA	Farr and Rossman, 2014
South America	Brazil Colombia	Freire and Berndt, 2013 Pardo-Cardona, 2006

*Tentative African records suspected based upon UK interceptions – see Table 2
**Tentative records in Europe – see text below

Asia

Since the 2005 UK PRA, in addition to China, India (not reported in Farr and Rossman, 2014), Japan and Korea the following records were found:

Himalayas

Farr and Rossman (2014) report the presence of *C. asterum* on species of *Aster* in the Himalayas citing Zhuang and Wei (1994).

Russia/USSR

Diekmann *et al*. (2002) refer to the presence of *C. asterum* in Russia with no further detail. GBIF (2014) refers to record GBIF93905635. This is a specimen (of unspecified material) collected from an arboretum near Gornotayozhnoe Settlement,

just west of Ussuri Reserve (*ca*. 60km north of Vladivostok), Primorye Province. Farr and Rossman (2014) report the presence of *C. asterum* in the former USSR (rather than Russia) on a number of hosts. They cite Azbukina (1984) and Kuprevich and Transhel (1957).

Taiwan
Diekmann *et al*. (2002) refer to the presence of *C. asterum* in Taiwan with no further detail. Farr and Rossman (2014) report the presence of *C. asterum* in Taiwan citing four references. Further detail can be found in the database.

Turkey
One record of *C. asterum* was recently reported in Turkey on *Solidago virgaurea* (Bahcecioglu and Kabaktepe, 2012). This reference is also cited by Farr and Rossman (2014).

Africa
The 2005 UK PRA reported interceptions of *C. asterum* on cut flowers imported from Zimbabwe in 2002 and 2005. Further interceptions have occurred since that time on cut flowers imported from Kenya, Zambia and Zimbabwe. (See Table 2). No published reports of *C. asterum* in Africa could be found. It is suspected but cannot be confirmed that *C. asterum* occurs in parts of Africa.

Caribbean
There were no reports of *C. asterum* in the Caribbean in the 2005 UK PRA. Farr and Rossman (2014) refer to three references (not obtainable) citing the presence of the pest in Cuba (on *Aster chinensis* and *Callistephus chinensis*). It was also reported on these species in the West Indies (Minter *et al*., 2001 in Farr and Rossman, 2014).

European records
There were no reports of *C. asterum* in Europe in the 2005 UK PRA and none in Farr and Rossman (2014). However, Diekmann *et al*. (2002) stated that it is present in Europe but gave no detail. Other evidence that suggests that *C. asterum* may be present in Europe is given below:

France
This record is of *C. asterum* detected using molecular techniques to identify micro-organisms in bioaerosols emitted from a composting plant in Angers. Green waste was being composted at this site in open windrows. Air samples were collected at the final screening step at the end of the composting process. It is not possible to confirm the origin (or viability) of *C. asterum* in this study. It may have been present on infected green waste, in compost screened from other waste or in the air surrounding the site. (Bru-Adan *et al*., 2009). The origin of these sources may have been on imported plant material (cut flowers or plants for planting) or on plant material originating in France. *C. asterum* cannot be confirmed as being present in France.

Germany
There are five records of '*specimens*' of *C. asterum* collected on living plant material in Germany (4 dated October 2011, 1 dated November 2009). These are held in the herbarium of the Staatliches Museum für Naturkunde Karlsruhe (SMNK) (State Museum of Natural History) and are reported in the Global Biodiversity Information

website (GBIF; 2014; accessed 13 February 2014 and 20 November 2014). Despite the records, enquiries suggest that they are currently uncertain as to the species of *Coleosporium* as the resources needed have not been available. No further detail can be provided at this stage. (M. Scholler, SMNK, Germany, *personal communication*, April and November 2014).

Portugal

There is one report of *C. asterum* in Portugal. The record was originally reported as *C. solidaginis* (synonym of *C. asterum*) on leaf material of *Pini pinastri* (*Pinus pinaster*) dated April 1953 (Santos and Sousa da Câmara, 1954). No further detail is available. No subsequent records of *C. asterum* occurring in Portugal could be found. The only other record of *Coleosporium* occurring in Portugal on *P. pinaster* in Farr and Rossman (2014) is of *C. senecionis* – a synonym of *C. tussilaginis* (Gonzalez Fragoso, 1918).

North America

Canada, Mexico and the USA were reported as countries where *C. asterum* occurred in the 2005 UK PRA. This is supported by Farr and Rossman (2014) with numerous records for *C. asterum* and its synonyms in Canada; as well as almost every state of the USA (with the exception of Delaware, Hawaii, Kansas, Nevada, New Mexico and West Virginia); there are also a few records for Mexico.

There is one additional record for North America:

Diekmann *et al*. (2002) refer to the presence of *C. asterum* in Bermuda (offshore to North America) with no further detail. Farr and Rossman (2014) refer to the synonym *C. solidaginis* on two hosts in Bermuda citing Whetzel and Jackson (1928).

South America

There were no reports of *C. asterum* occurring in South America in the 2005 UK PRA.

The first published report was in Colombia and this states that *C. asterum* was found on a commercial crop of aster (*Solidaster*) in Antioquia in November 1999 and on wild plants of *Solidago polyglossa* in June 2001; (Pardo-Cardona, 2006).

There is also a report in Brazil referring to the synonym *C. solidaginis* infecting *Solidago canadensis*. The pest was considered to have been introduced into Ceará State through infected seedlings from the '*southeast region'*. (Freire *et al*., 2004 in Freire and Berndt, 2013).

5. Is the pest established or transient, or suspected to be established/transient in the UK? *(Include summary information on interceptions and outbreaks here).*

There is no evidence to suggest that *C. asterum* is established or transient in the UK. However, because of the difficulties of differentiating species of *Coleosporium*, the lack of official surveillance (which would face the same difficulties) and the overlapping host-range of *C. asterum* with other species such as *Coleosporium. tussilaginis*, (which is widespread in the UK), the full geographic distribution of the pest is uncertain.

Bearing this in mind, although the pest has been intercepted on cut flowers imported into the UK (see Table 2 below), no outbreaks have been reported (M. Tuffen, Fera, UK, *personal communication*, February 2014).

Table 2. Interceptions of *C. asterum* on cut flowers imported into the UK from Africa

Date	Host	Origin	Size of consignment* (no. of stems)
May 2002	*Solidago canadensis*	Zimbabwe	4500
January 2005	*Solidaster*	Zimbabwe	N/A
January 2010	*Solidago*	Kenya	N/A
March 2011	*Solidago*	Zambia	21,875
April 2011	Solidago	Zambia	31,000
May 2012	*Solidago*	Zambia	38,725
February 2013	*Solidago*	Zimbabwe	900
May 2013	*Solidago*	Kenya	600
January 2014	*Solidago*	Kenya	N/A

*N/A =data not available. Data supplied by R. Waghorn, Fera, UK, *personal communication*, April, 2014.

Statutory action was only taken on the 2005 interception, which involved destruction of the infested material. No action was taken on subsequent interceptions of *C. asterum* on cut flowers. This was as a result of a Defra decision based upon consideration of the 2005 PRA which suggested that the risk posed by this particular pathway was low or very low (but slightly higher where infected cut flowers were disposed of on compost heaps). It was also noted that infected consignments that were intercepted in January 2010 and January 2014 were ultimately destined for Barbados (thus posing a lower risk to the UK). (M. Tuffen, Fera, UK, *personal communication*, February 2014). The current interim position, pending consideration of this PRA, is that statutory action will be taken on any further interceptions on cut flowers. This will entail either destruction of the consignment, or sorting (where this is considered practical and effective, in discussion with the importer); (R. McIntosh, Defra, UK, *personal communication*, February 2014). Prior to this decision, it is possible that *C. asterum* may have entered the UK. If it has established here it remains undetected, misdiagnosed, or unreported.

The first UK PRA referred to the presence of *C. tussilaginis* in the UK. Like *C. asterum*, this rust affects pine and members of the Compositae[6] family (amongst others – see Farr and Rossman, 2014) but it was not considered synonymous with *C. asterum* in 2005 and this is still the case (Anon., 2014). Evidence given below shows this to be the only species of *Coleosporium* to be reported in the UK:

I. Forest Research (FR) has confirmed that they have only ever recorded *C. tussilaginis* on *Pinus* spp. in the UK (S. Hendry, FR, UK, *personal communication*, February 2014)
II. A search of the Fungal Records Database of Britain and Ireland (Kirk and Cooper, 2009) for the genus *Coleosporium* yielded 20 records which were either *C. tussilaginis*, synonyms of *C. tussilaginis* or synonyms of other rust genera
III. Species of *Coleosporium* reported as occurring in the UK on species of pine (references cited in Marmolejo and Minter, 2006) are:

[6] The Compositae family is also known as the Asteraceae http://compositae.landcareresearch.co.nz/Default.aspx

- *C. petasitidis* on *Pinus sylvestris* (Trotter, 1925). Note that *C. petasitidis* is synonymous with *C. tussilaginis* (Anon., 2014)
- *C. tussilaginis* on *Pinus* sp. (Saccardo, 1888)
- *Coleosporium* sp. on *Pinus austriaca* and *P. sylvestris* (Dennis and Foister, 1942)

IV. There are *ca*. 50 species of *Coleosporium* reported on *Pinus* (see e.g. Marmolejo and Minter, 2006). The Royal Botanic Gardens Edinburgh (RBGE) conducts research on rust fungi including *Coleosporium* species which occur in Europe (see Helfer, 2013). The list of specimens which have been examined and documented in the UK includes *Coleosporium senecionis* which RBGE (2014) reported as occurring on a member of the Compositae family (*Senecio vulgaris*) in 1949. This fungus is also not synonymous with *C. asterum* but it is synonymous with C*. tussilaginis* (Anon., 2014)

V. A search of Farr and Rossman (2014) for species of *Coleosporium* occurring in the UK yielded 87 records, all of which were *C. tussilaginis*, or it's synonyms (Anon., 2014). All except the synonym *C. cacaliae* were reported on *Pinus* species; *C. cacaliae* was reported on two species of *Cacalia* (now known as *Parasenecio hastatus* and *Senecio suaveolens*); both are members of the Compositae.

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

The host-range of *C. asterum* has been investigated and reported on a number of occasions including both natural observations and the results of experimental inoculation. The results can be somewhat confusing because of the difficulties in identifying the rust to species level (see e.g. discussion in Raabe and Pyeatt, 1990). In addition results of host-range testing can vary with the isolate used. However, in summary, *C. asterum* is a heteroecious rust i.e. it occurs on two different types of host. It produces five types of spore. The spermagonial and aecial stages are formed on two and three-needled pines (*Pinus* spp.). The uredial, telial and basidial stages are formed on numerous species in the family Compositae (=Asteraceae).

Table 3 lists the known genera of natural hosts of *C. asterum* in the family Compositae, along with their synonyms and common names, based largely upon Farr and Rossman (2014). Original references can be found within this database. Where three or less individual host species are given in Table 3, these are the only records of the genus in the database; otherwise only the genus is given. Host plant taxonomy in Farr and Rossman (2014) is derived from the USDA Germplasm Resources Information Network (GRIN).

Table 3a lists the known genera of natural hosts of *C. asterum* in the family Pinaceae also based largely on Farr and Rossman (2014). For most of the species, numerous synonyms and common names are recorded in the database as derived from GRIN. This is indicated in the table.

Table 3. Natural hosts of *Coleosporium asterum* in the family Compositae (based on Farr and Rossman, 2014)

Genus	Species	Synonym(s)	Common name(s)
Ainsliaea	*grossedendata*	-	-
Aster	spp.	-	Aster
Boltonia	*lautureana*	*Aster lautureanus*	Aster
Callistephus	*chinensis*	*Aster chinensis Callistemma chinense, Callistemma hortense, Callistephus hortensis*	Annual aster, China aster, Cui ju, Gartenaster, Madeleine-aster, Reine- marguerite, Satsuma-giku, Sommaraster
Callistephus	sp.	-	-
Chrysoma	*pauciflosculosa*	-	-
Chrysopsis	*oregana*	-	-
Chrysopsis	sp.	-	-
Doellingeria	*scabra*	*Aster scabra*	Chamchwi, Dong feng cai, Shirayama-giku, Strävaster
Erigeron	sp.	-	-
Gaillardia	*aristata*	-	Blanket flower, Great blanket flower, Prärie-Kokardenblume
Gaillardia	sp.	-	-
Grindelia	*integrifolia*	-	Puget Sound gumweed
Grindelia	sp.	-	-
Grindelia	*stricta*	*Grindelia stricta* var. *angustifolia*, *Grindelia stricta* var. *platyphylla*, *Grindelia stricta* var. *stricta*	Coastal gumplant, Grindelia, Oregon gumweed
Haplopappus	*lanceolatus*	*Pyrrocoma lanceolata* var. *lanceolata, Pyrrocoma lanceolata, Pyrrocoma lanceolata* var. *subviscosa, Donia lanceolata*	-
Heterotheca	*subaxillaris*	*Heterotheca subaxillaris* subsp. *latifolia*, *Heterotheca subaxillaris* subsp. *subaxillaris*	Camphor daisy, Camphorweed
Inula	sp.	-	-
Kalimeris	*spp.*	*Aster* spp.	-
*Launaea**	*sarmentosa*	-	-
*Machaeranthera***	-	-	Tansyaster
Solidago	spp.	-	Solidago, goldenrod
*Solidaster****	-		Solidaster
Solidaster	*luteus*	*Aster hybridus* var. *luteus*	-

Hosts in the Compositae not listed in Farr and Rossman (2014):
**L. sarmentosa* was previously classified as *Launaea pinnatifida* and was referred to as such in Sinha and Singh (1992). Reclassification noted at www.theplantlist.org
** *Machaeranthera* was listed as a host genus in Sinclair *et al.* (1989)
***Intercepted on imported cut flowers of *Solidaster* in the UK

Table 3a. Natural hosts of *Coleosporium asterum* in the family Pinaceae (based on Farr and Rossman, 2014)

Genus	Species	Synonym(s)	Common name(s)
Pinus	*armandii*	-	Numerous including Armand pine
Pinus	*banksiana*	-	Numerous including Jack pine
Pinus	*contorta;* var *contorta*; var *latifolia*	Numerous	Numerous including lodgepole pine
Pinus	*densata**	-	Gao shan song
Pinus	*densiflora*	-	Numerous including Japanese red pine
Pinus	*echinata*	-	Numerous including Arkansas pine
Pinus	*koraiensis*	-	Numerous including Korean pine
Pinus	*massoniana*	*P. sinensis*	Numerous including Chinese red pine
Pinus	*nigra*	Numerous	Numerous including Corsican pine
Pinus	*palustris*	*P. australis*, *P. longifolia*	Numerous including pitch pine
Pinus	*pinaster***	*P. maritima*	Maritime or cluster pine
Pinus	*ponderosa*	*P. ponderosa* var. *ponderosa*, and *var. scopulorum*	Numerous including Ponderosa pine
Pinus	*radiata*	-	Numerous including Monterey pine
Pinus	*resinosa*	-	Numerous including American red pine
Pinus	*rigida*	-	Numerous including pitch pine
Pinus	*strobus*	*P. strobus* f. *prostrata*	Numerous including white pine
Pinus	*sylvestris*	Numerous	Numerous including Scots pine
Pinus	*tabuliformis*	Several	Several including Chinese pine
Pinus	*taeda*	-	Numerous including loblolly pine
Pinus	*taiwanensis*	-	Numerous including Taiwan pine
Pinus	*thunbergii*	*P. thunbergiana*	Numerous including Japanese black pine

Hosts in the Pinaceae not listed in Farr and Rossman (2014):
*IMI culture collection 356437; cited by Marmolejo and Minter, 2006
***Pinus pinaster* is recorded as *Pini pinastri* in Santos and Sousa da Câmara,1954

The economically-important hosts of *C. asterum* include *Pinus* species as well as ornamental plants in the Compositae family. In addition to having economic value, some members of this family are now considered to be invasive in parts of Europe and they are commonly found in the UK as ornamentals and weeds as well as being invasive species (ornamentals that have *'escaped'* into the wider environment).

Pinus species

Pinus sylvestris (Scots pine) is native to the UK (Preston *et al*., 2002) and according to the Forestry Commission (FC) it is the only native conifer to be grown commercially for timber (FC, 2014). Data from the National Forestry Inventory (FC, 2012, 2012a) shows that it is the second most important conifer species grown for timber in Great Britain (GB); Sitka spruce - *Picea sitchensis* is considered to be the most important. Two other species of *Pinus*, *P. contorta* (lodgepole pine) and *P. nigra* (Corsican pine) are also economically significant for timber production. Table 4 shows the most recent statistics for stocked area and timber volume of FC and non-FC woodland combined for *Pinus* species and for all conifers in GB.

Table 4. Total stocked woodland area and timber volume of conifers and significant *Pinus* spp. in GB up to April 2012.

Common name	Species	Area (thousand ha)*	Standing timber volume (million cubic metres)**
Scots pine	*Pinus sylvestris*	241	50.7
Lodgepole pine	*Pinus contorta*	106	18.3
Corsican pine	*Pinus nigra*	49	12.0
All conifers	-	1357	335.7

*FC, 2012
**FC, 2012a

Susceptible trees in the genus *Pinus* are also grown as ornamental species in the UK and can be purchased for planting in public and private gardens. No data were available on the value of this sector.

Pines are also grown as Christmas trees in the UK[7]. Although there are no reliable statistics on the area or number of trees of the species grown for this purpose, pines represent only a very small percentage of the totals; *Abies* and *Picea* spp. are more commonly used. *Pinus* species grown as Christmas trees in the UK are Lodgepole pine (*P. contorta* var. *latifolia*) and Scots pine (*P. sylvestris*); both are recorded as hosts of *C. asterum* and of the two, *P. sylvestris* is a natural host of *C. tussilaginis*. No rust diseases (including *C. tussilaginis* which occurs in the UK) have been detected on pines grown as Christmas trees. (C. Palmer, Crop Protection Adviser to the British Christmas Tree Growers Association - BCTGA; and J. Allen, ADAS, UK; *personal communications*, May 2014).

Compositae

There are numerous species of plants in this family which are reported as natural hosts of *C. asterum*. The genera *Erigeron, Aster* and *Solidago* are amongst these. The 2005 UK PRA highlighted blue fleabane (*Erigeron acer*), alpine fleabane (*Erigeron borealis*), goldilocks aster (*Aster linosyris*) and sea aster (*Aster tripolium*) as native perennial herbs that might be susceptible to *C. asterum*. These species are not specifically named as natural hosts in Farr and Rossman (2014). Nevertheless they have the potential to become infected.

Aster and *Solidago* spp. are cultivated as ornamentals and are commonly planted in gardens in the UK. Enquiries to various organisations did not yield any production statistics. Interflora comment[8] that *Aster* and *Solidaster* are amongst the main '*crops*' of plants (and cut flowers) that the UK grows, located all around the UK but mainly in Lincolnshire and on the south coast.

With respect to cut flower production, information supplied by the National Cut Flower Centre (NCFC) showed that the majority of known hosts of *C. asterum* that are used in the UK are imported; with *Aster ericoides* and *Solidago* being used as fillers in mixed bunches. Of the known hosts, the only species that is grown on a commercial scale for cut flowers in the UK is China aster (*Callistephus chinensis*) (*ca.* 20ha outdoors, 1ha under protection). There is also *ca*. 1 ha in total of *Solidago* and *A. ericoides* (grown both under protection and outdoors). (L. Mason, NCFC, UK, *personal communication*, April 2014).

Perversely, following introduction as ornamental plants from North America, *Solidago gigantea* and *Solidago canadenis* have spread from gardens and according to CABI (2014) they are now considered to be invasive species in a number of European countries. In this context they are described as present (with no further details) in the UK. *Grindelia stricta* is also considered to be an invasive species and is similarly-described (but see the apparent limited presence recorded in Figure 3 below). These are all reported as natural hosts of *C. asterum* (Farr and Rossman, 2014).

[7] http://www.bctga.co.uk/images/Poster%20Easy%20Xmas%20Trees%20Poster%202012.pdf - accessed 8 May, 2014.
[8] http://www.flowers.org.uk/a-z/where-your-flowers-come-from/ - accessed 28 April 2014.

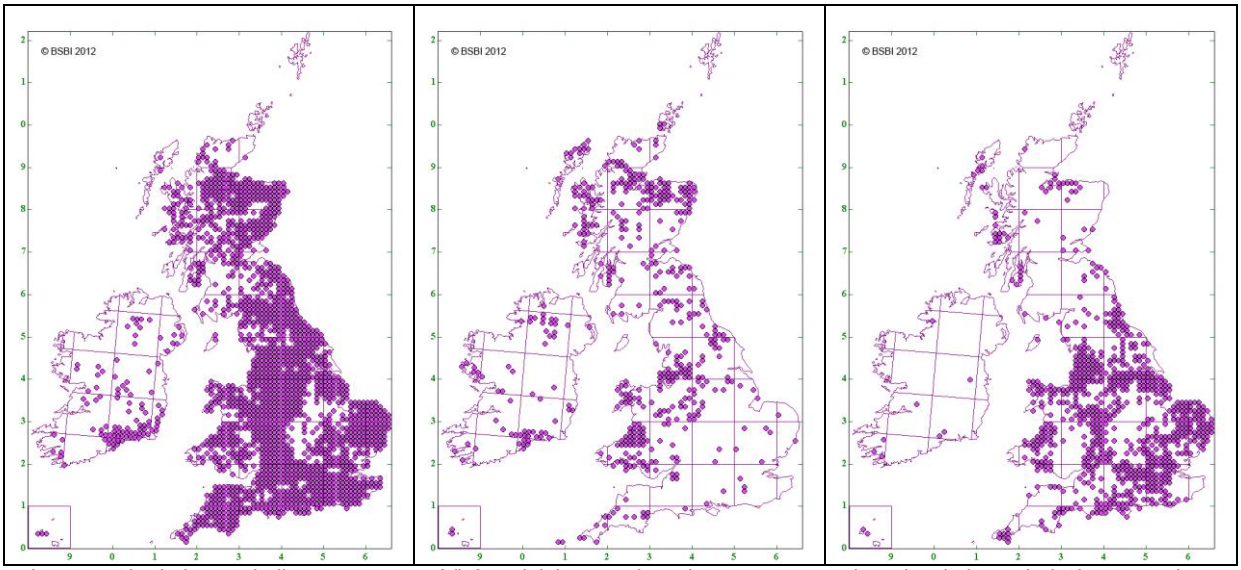

Figure 1. Shaded areas indicate presence of (left to right) : *P. sylvestris*, *P. contorta* and *P. nigra* in hectads (10km square) over the British Isles recorded in the period 2000-2009. Source – British Isles Maps Scheme. http://www.bsbimaps.org.uk/atlas/main.php - accessed 13 March 2014.

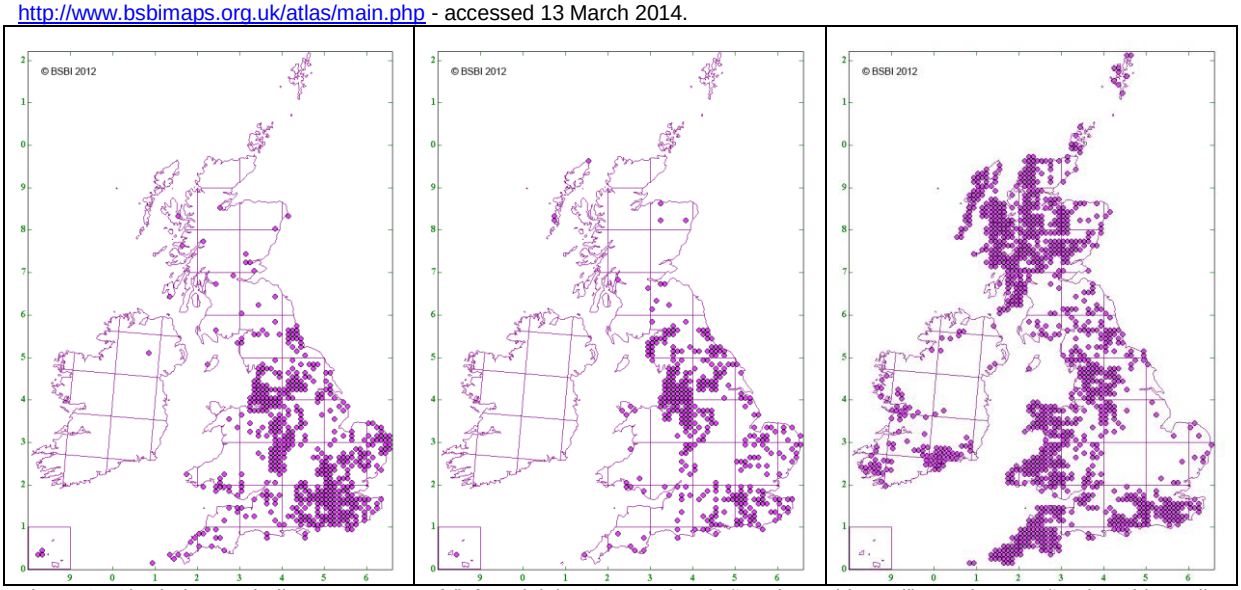

Figure 2. Shaded areas indicate presence of (left to right) : *S. canadensis* ('garden goldenrod'), *S. gigantea* ('early goldenrod) and *S. virgaurea* (goldenrod) in hectads (10km square) over the British Isles recorded in the period 2000-2009. Source – British Isles Maps Scheme. http://www.bsbimaps.org.uk/atlas/main.php - accessed 13 March 2014

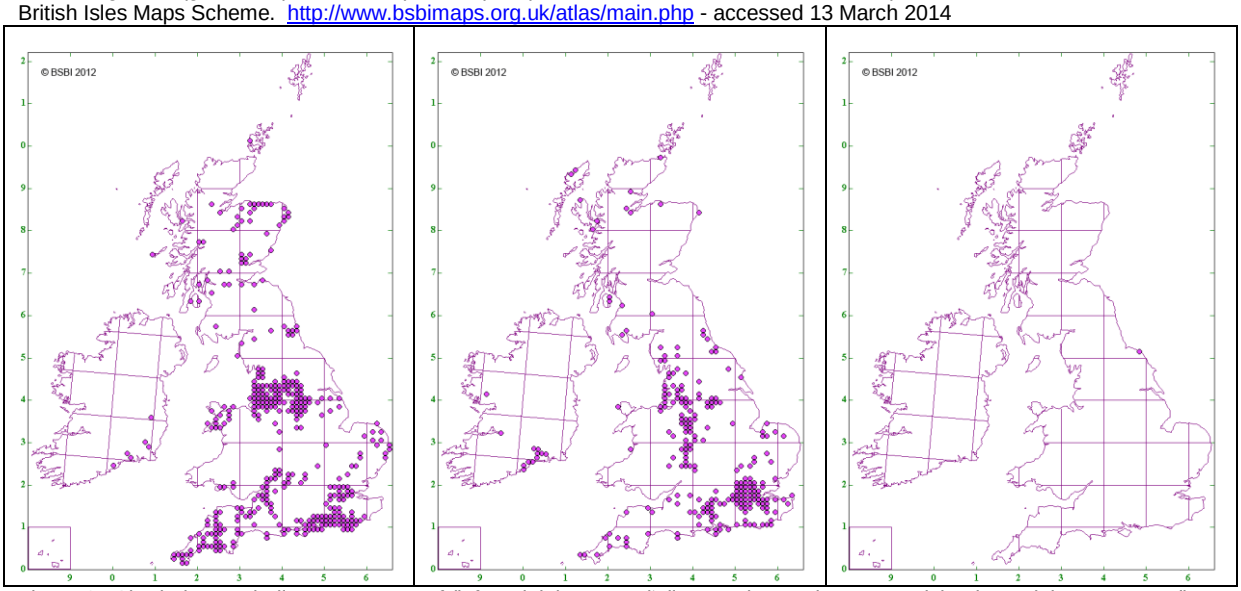

Figure 3. Shaded areas indicate presence of (left to right) : *Aster* ('alien North American taxa Michaelmas daisy aggregate'), Aster X salignus (*A. lanceolata* x *novi-belgii* –' common Michaelmas daisy') and *G. stricta* ('coastal gumplant') in hectads (10km

Figures showing the distribution of host records of the three most important species of *Pinus* grown for timber in GB as well as the most commonly-recorded species of *Solidago* and *Aster*, alongside (for comparison) *G. stricta* for the British Isles are given above (note these maps indicate presence rather than full distribution).

7. If the pest needs a vector, is it present in the UK?

C. asterum is a rust fungus which disperses naturally via aerial dispersal of spores. Vectors are not required to disperse the spores. However, various invertebrates, especially larvae of flies in the cosmopolitan genus *Mycodiplosis* are known to feed on rust spores. Their role in the ecology of the rust fungi is not known but the adult flies have the potential to disperse spores of *C. asterum* (Henk *et al.*, 2011).

8. What are the pathways on which the pest is likely to move and how likely is the pest to enter the UK? (*By pathway*):

Factors taken into account for entry, as set out by ISPM 11, are the probability of the pest:

- *being associated with the pathway at origin,*
- *surviving during transport or storage,*
- *surviving existing pest management procedures*
- *transferring to a suitable host.*

There are four main pathways all originating in areas where the pest occurs or may occur (see Table 1); namely parts of Asia, Africa (tentative), the Caribbean, Europe (tentative), North America and South America thus:

- Cut flowers of Compositae
- Foliage of *Pinus* spp.
- Plants for planting of Compositae
- Plants for planting of *Pinus* spp.

<u>Cut flowers of Compositae</u>

C. asterum has been intercepted in the UK on cut flowers of *Solidago*, *S. canadensis* and *Solidaster* imported from Africa (Kenya, Zambia and Zimbabwe) on a number of occasions between 2002 and 2014 (see Table 2). There are no records of the pest in these countries but it is suspected that it occurs there. *C. asterum* has a wide host-range but the main genera (other than *Pinus* spp.) upon which it has been recorded are *Solidago* and *Aster*. Figures for UK imports of cut flowers of these genera for 2011, 2012 and 2013 from third countries (those outside the EU) are shown in Tables 5 and 6 below (data supplied by R. Waghorn, Fera, UK, *personal communication*, April 2014). These data show that a number of countries where *C. asterum* is suspected to occur (Kenya, Zambia and Zimbabwe) or is reported to occur (Canada, Columbia and India) export mostly large quantities of cut flowers of host genera to the UK. There are no data for imports from countries within the EU and it is not known whether such a trade exists, however reports of the pathogen in the EU remain unconfirmed.

Table 5. UK imports of consignments of cut flowers of *Solidago*; 2011, 2012 and 2013

Country of origin*	2011			2012			2013		
	No.	Total weight (kg)	Total stems	No.	Total weight (kg)	Total stems	No.	Total weight (kg)	Total stems
Colombia	42	724	12273	70	956	19725	85	963	18525
Ecuador	6	23	730	3	41	506	2	17	310
India	0	0	0	0	0	0	1	38	1188
Israel	219	17122	366550	126	5210	134425	23	690	16950
Kenya	621	55263	3594816	858	142260	5728147	838	88993	3779946
Malaysia	0	0	0	1	790	27300	0	0	0
South Africa	0	0	0	1	334	19200	4	33	1000
Thailand	0	0	0	0	0	0	1	2	30
Zambia	107	54083	2337715	68	66893	2797825	0	0	0
Zimbabwe	155	134007	5839045	191	69175	3040075	30	1,341.00	38350
Total	1150	261222	12151129	1318	285659	11767203	984	92077	3856299

*Blue indicates countries where *C. asterum* has been reported or is suspected to occur

Table 6. UK imports of consignments of cut flowers of *Aster*; 2011, 2012 and 2013

Country of origin*	2011			2012			2013		
	No.	Total weight (kg)	Total stems	No.	Total weight (kg)	Total stems	No.	Total weight (kg)	Total stems
Ajman	1	100	2	0	0	0	0	0	0
Bhutan	0	0	0	0	0	0	1	1000	100000
Canada	1	1234	234	0	0	0	0	0	0
Colombia	19	125	680	13	387	8270	6	749	26184
Ecuador	5	1045	6541	13	218	5000	0	0	0
Israel	18	326	5475	9	164	2650	1	39	500
Kenya	2	284	8100	2	833	24730	3	2592	138600
Morocco	2	9340	266864	0	0	0	0	0	0
Nepal	1	110	730	0	0	0	0	0	0
Thailand	12	162	5639	6	111	2462	5	5	596
Zimbabwe	43	981	45000	2	81	3225	0	0	0
Total	104	13707	339265	45	1794	46337	16	4385	265880

*Blue indicates countries where *C. asterum* has been reported or is suspected to occur

Although there are no phytosanitary requirements for this trade in relation to *C. asterum*, imports of cut flowers of *Aster* and *Solidago* from outside of the EU have to be accompanied by a Phytosanitary Certificate (PC) and must fulfil the following requirements (Anon., 2000):

That either:

- They originate in a country free from *Bemisia tabaci* Genn. (non-European populations)

Or that:

- Immediately prior to export, they have been officially inspected and found free from *Bemisia tabaci* Genn. (non-European populations)

Cut flowers of *Solidago* also have to fulfil the following requirements:

That either:

- They originate in a country free from *Liriomyza sativae* (Blanchard) and *Amauromyza maculosa* (Malloch)

Or that:

- Immediately prior to export, they have been officially inspected and found free from *Liriomyza sativae* and *Amauromyza maculosa*

Sixty-five per cent of these consignments are subject to inspection at the point of entry into the UK and the aim is to inspect 200 stems per consignment (G. Nettleton, Fera, UK, and R. McIntosh, Defra, UK; *personal communications*, April 2014). Because of the phytosanitary requirements for invertebrate pests, detection of *C. asterum* at export and at the point of entry is possible but only if rust pustules are present. Latent infections would not be detected. However, the number of stems imported is high and the number of stems inspected is relatively low so the potential for detection is limited. The 2005 UK PRA illustrated how it might be possible for *C. asterum* to enter (entry includes transfer to a susceptible host) the UK on this pathway. This is quoted verbatim (but annotated) below:

> *Sinclair* et al*., (1989) state that uredinial pustules, which are initially bright orange and then fading to yellow, develop 10 to 15 days after infection of wild or cultivated species of a range of hosts including* Aster *and* Solidago*. The temperature at which these develop is not specified. Provided the pathogen has developed these obvious pustules by the time an infected shipment arrives at the port of entry then exclusion may be possible. However, if undetected, or if the pathogen enters* [is present] *as a latent infection, entry of the rust on cut flowers could mean that infected batches may be distributed widely before precautions can be taken. Commercially imported cut flowers would probably be sorted by the importer on arrival and those regarded as unsightly with rust would most likely be discarded on a compost heap where they could potentially pose a danger to susceptible ornamentals and pine species growing nearby. Similarly, cut flowers with latent infections may go on to develop uredinial pustules post-sale and may also be discarded in this way. Cut flowers have a limited life and although rusts need a living host to complete their lifecycle, the pathogen could in theory overwinter as teliospores on infected tissue* [of Compositae] *or may, depending upon the time of year at which they are discarded go on to infect hosts growing nearby in the same season. Establishment* [this should in fact be '*transfer*'] *would depend on the diseased cut flowers with viable rust pustules being discarded, possibly on a compost heap near to susceptible species in the garden* [gardens]*,* [wider] *environment or glasshouses under the right environmental conditions for spread* [spore dispersal] *and infection.*

The 2005 UK PRA went on to say '*This is not an impossible scenario'*. The detection of *C. asterum* by molecular methods in bioaerosols emanating from windrows at a composting site in France also supports this perspective, albeit viability of the pest was not proven (Bru-Adan *et al*., 2009).

However, although not impossible, the scenario is unlikely. There are two major spore types produced by *C. asterum* on *Compositae* that could enter on cut flowers: urediospores and basidiospores. The urediospores are capable only of infecting other *Compositae* hosts whereas the basidiospores only infect the *Pinus* hosts.

If *Compositae* cut flowers were to enter with basidiospores, they would have to be disposed of or left near suitable *Pinus* hosts for transfer to occur. In addition the teliospores (which germinate and eventually give rise to the basidiospores) are also killed by frosts (Nicholls et al 1965), and basidiospores are described by Lowe (1972) as "small and delicate and cannot survive even a short period of temperature extremes or drought. Unless they land on susceptible pine needles shortly after dissemination and unless climate conditions are favourable, the basidiospores will perish".

Urediospores could enter on cut flowers and infect other *Compositae* hosts. Studies on field infections of *C. asterum* on the *Compositae* host *Euthamia graminifolia* (syn of *Solidago graminifolia*) found most urediospores fall within 1 metre of source plants (Price et al 2004). Infested cut flowers producing urediospores would need to be disposed of outdoors relatively close to potential *Compositae* hosts in order for the spores to transfer. In addition, the seasonality of the interceptions could also influence the transfer of the pathogen to other *Compositae* hosts. Many of the potential *Compositae* hosts in the UK such as members of the *Solidago* genus are herbaceous, and have foliage that dies back over winter (Levine 1995), but there are records of the pest overwintering in the uredinial stage on Compositae hosts (Sinclair et al 1989, Back et al. 2014).

The UK Plant Health Risk Group reviewed this PRA and considered it to be **unlikely** (**with medium uncertainty**) that *C. asterum* could enter the UK on this pathway. This is because cut flowers present a relatively **low risk of transfer** to suitable hosts, and, despite multiple interceptions on cut flowers where no statutory action was taken, the pathogen is not known to have established in the UK.

Foliage of *Pinus* spp. from non-EU European countries and EU countries

In addition to cut flowers of *Solidago* and *Aster*, imports of other genera of cut flowers or parts of plants for decorative purposes have restricted entry to the UK. In this respect the importation of such plant material (e.g. foliage) of *Pinus* spp. from non-European countries is prohibited and from non-EU European countries a PC is required. Imports from within the EU are permitted.

There are no import data available for this trade.

Non-EU European countries

Although there are no records of *C. asterum* in non-EU European countries it may be present, but, as appears to be the case with other countries (e.g. Kenya, Zambia and Zimbabwe), remains undetected, misdiagnosed, or unreported. However, given the

requirement for a PC and a lack of interceptions of *C. asterum* on imported foliage of *Pinus* with this origin it is considered by the Plant Health Risk Group that the pest is **very unlikely** to enter on this pathway (with **low uncertainty**).

EU countries
C. asterum has not been confirmed as present in the EU but there are some tentative records for France (bioaerosols), Germany (molecular sequence records from plant specimens – recorded as *C. asterum* but still pending confirmation of the species of *Coleosporium* in November 2014) and Portugal. Only the latter record is on a species of pine (*P. pinaster*) but the publication is relatively old (Santos and Sousa da Câmara, 1954) and no further records have been made for this country. As stated previously, differentiation of *Coleosporium* species is difficult and no official surveillance is in place for this pest in the EU. No interceptions of *C. asterum* have been made on this pathway although this may relate to the level of inspection on this pathway which is unregulated. Without further evidence of its presence in the EU, entry of *C. asterum* into the UK on this pathway is considered by the UK Plant Health Risk Group to be **very unlikely**. It is given a **medium uncertainty** score due to the tentative EU records of the pest.

Plants for planting of Compositae
Infected plants intended for planting originating in countries or areas where *C. asterum* occurs have the potential to be a direct pathway of entry of this pest into the UK due to the intended use. This is illustrated by the following examples:

- The genus *Coleosporium* is considered to be mostly limited to the northern hemisphere (Europe, Asia and North America). Thus, records of the genus in the southern hemisphere (e.g.) New Zealand are considered to have occurred there because infected hosts originating in the northern hemisphere were '*planted-out or intercepted*'. Helfer (2013).

- In Brazil, four rust species including C. *solidaginis* (synonym of *C. asterum*) were considered to have been introduced into Ceará State through infected seedlings brought in from the southeast region (Freire *et al*., 2004 in Freire and Berndt, 2013).

Enquiries to trade bodies and to the UK Plant Health Service did not yield any data on imports of plants intended for planting of members of the Compositae family to the UK, either from within the EU or from third countries. In some cases (including the UK Plant Health Service), this was because no data were available. However not all organisations responded. Since *Aster* and *Solidago* spp. are popular garden plants in the UK it is likely (as is the case for cut flowers) that some level of import occurs to satisfy demand. The origin of such material is unknown.

There are currently no phytosanitary requirements for *C. asterum* on plants for planting of Compositae entering the UK; however there are some requirements related to insect pests on herbaceous perennials which may facilitate detection of the rust if it is actively sporulating when such plants are inspected but this also depends on the level of inspection. See:
http://www.fera.defra.gov.uk/plants/plantHealth/documents/additionalDeclarations201311.pdf

In general terms, plants for planting of any species originating outside the EU have to be accompanied by a PC which is issued by the exporting country's National Plant Protection Organisation (NPPO) following inspection to indicate that the plants are free from quarantine (listed) organisms and practically free of other injurious pests and diseases. Such plants will receive an inspection at the point of entry in the UK and thus it may be possible to detect sporulating rust infections on import if they were not detected pre-export. Again, this depends on the level of inspection. Plants originating from within the EU which require further growing-on before sale, require a plant passport related to the health of the plants to be issued by the grower (who is authorised to do so by the NPPO). Thus, there is potential for some level of detection in such material if *C. asterum* is already present in the EU. However, plants which are ready to plant out can be moved between EU Member States without a plant passport. (G. Nettleton, Fera, UK, *personal communication*, April 2014).

See: http://www.fera.defra.gov.uk/plants/plantHealth/plantPassporting.cfm

If plants are infected, *C. asterum* could enter the UK on this pathway.

Wise *et al*. (2004) commented that trade in ornamental crops has made the exclusion of rust pathogens difficult because plant parts may be symptomless. Rusts can be detected where sporulating lesions are present, but young non-sporulating lesions may be small and can go undetected if only a few pustules are present in large shipments of plants. Repeated entry of rust pathogens to new areas may occur without detection until such times as the organism becomes endemic.

As imports of plants of members of the Compositae are not regulated with respect to *C. asterum* it is considered that the pest is **moderately likely** to enter the UK on this pathway where such plants originate in areas where *C. asterum* occurs or is suspected to occur. Because of the lack of import data (thus not allowing determination of the origin of imports), this risk of entry is rated with **high uncertainty**.

Plants for planting of *Pinus* spp.

Imports from countries outside of the EU
The EC Plant Health Directive (Anon., 2000) prohibits the imports of plants of *Pinus* spp. into the EU with some exceptions:

- Imports of bonsai *Pinus* from Korea and Japan are permitted under the terms of two derogations (see 2. above)
- Imports of *Pinus* spp. from non-EU European countries are permitted if they are accompanied by a PC

C. asterum is known to occur in Korea and Japan but has not been reported in non-EU European countries.

The strict phytosanitary requirements of the derogations for the importation of bonsai *Pinus* relate to pests which include *C. asterum* (for Korea) and for Japan - other rust species - including two species of *Coleosporium*. In recent years, imports of bonsai *Pinus* all originated in Japan and were quarantined and inspected post-entry on at least three occasions by the PHSI during active growth and found '*free from pests and diseases*'. The number of plants imported is relatively low and is summarised in Table 7 (M. Tuffen, Fera, *personal communication*, April 2014).

Table 7. Imports of bonsai *Pinus* from Japan

Period	No. of importers	Material imported	No. of plants
1 August 2009 – 31 July 2010	3	*Pinus pentaphylla*	134
		Pinus sp.	71
1 August 2010 – 31 July 2011	4	*Pinus pentaphylla*	340
1 August 2011 – 31 July 2012	3	*Pinus pentaphylla*	87
		Pinus sp.	85
1 August 2012 – 31 July 2013	1	*Pinus pentaphylla*	190

Pinus pentaphylla (a synonym of *Pinus parviflora* var. *pentaphylla*[9]) is not recorded as a host of *C. asterum* and as it is a five-needled pine it is not likely to become infected in the exporting country since the named *Pinus* hosts are two- and three-needled pines. *P. pentaphylla* has some susceptibility to other species of *Coleosporium* (Saho, 1972). The remaining imports are of unspecified *Pinus* but are likely to be *P. pentaphylla* or *P. pentaphylla* grafted onto the rootstock of another species of *Pinus*. They are not likely to be infected with *C. asterum* pre-export due to this and the other strict phytosanitary requirements for imports of bonsai *Pinus*. It is considered to be **very unlikely** with **low uncertainty** that *C. asterum* would enter the UK on imports of bonsai *Pinus* from Japan or Korea.

The requirement for imports of *Pinus* from non-EU European countries into the EU to be accompanied by a PC also make the risk of entry on this pathway **very unlikely** but with **medium uncertainty** due to the requirements being less stringent than those for Korea and Japan.

Imports from the EU
Imports of *Pinus* plants for planting are permitted entry into the UK from within the EU (see Table 8.). Four species have been imported in the last ten years as plants for planting for forestry purposes: *P. contorta*, *P. nigra*, *P. pinaster* and *P. sylvestris*.

[9] http://www.theplantlist.org accessed June 24th 2014

All of these are reported to be hosts of *C. asterum*. However, there has only been one published record on *Pinus* in the EU, in Portugal on *P. pinaster*; Santos and Sousa da Câmara, 1954, and no further records have been made for this country, so it may have been a misdiagnosis. As stated previously, it is not confirmed that *C. asterum* is present in the EU but there is also a tentative record in France (bioaerosols) from which relatively high numbers of *Pinus* spp. have been imported (see Table 8). Although Germany is reported to have records of *C. asterum* the species of *Coleosporium* has yet to be confirmed (November 2014). Due to the difficulties involved in identifying findings of *Coleosporium* to species and the tentative records it is possible that *C. asterum* may already be present in the EU. Findings of *Coleosporium* on *Pinus* spp. in the EU may not be documented, may be misdiagnosed, or may be presumed to be species that are already present (e.g. *C. tussilaginis*). There are no official surveys for *C. asterum* and there are no specific measures in place that would prevent entry of *C. asterum* into the EU on members of the Compositae other than a requirement for a PC. For these reasons it is possible that *C. asterum* may already be present in the EU and that imports of *Pinus* spp. from the EU into the UK may harbour infection, but the lack of any firm evidence means uncertainty regarding this pathway is high.

Table 8. Number of plants of *Pinus* species imported into the UK from EU countries

Year	Country	*Pinus* species				TOTALS
		P. contorta	*P. nigra*	*P. pinaster*	*P. sylvestris*	
2003	Belgium				200	200
2003	France				9,000	9,000
2004	France				6,500	6,500
2005	Denmark		500		400	900
2007	Czech Republic				30,000	30,000
2009	Belgium				250	250
2009	France				20,700	20,700
2010	Ireland				400	400
2011	Germany				5,000	5,000
2011	Ireland	100			22,800	22,900
2012	Belgium			4200	150	4350
2012	Denmark				2,500	2,500
2012	France			11,384		11,384
2012	Ireland				18,300	18,300
2013	Germany		125			125

*Blue indicates countries where *C. asterum* has been reported or is suspected to occur but note comments on Germany above

Without any additional evidence that *C. asterum* is present in the EU, entry on planting material of *Pinus* spp. from the EU is considered by the UK Plant Health Risk Group to be **very unlikely**, but with **high uncertainty** related to the possible records of the pest's presence in certain EU Member States.

Summary of risk of entry of C. asterum *to the UK* (modified by the Plant Health Risk Group, November 2014)

Pathway		Likelihood of entry										Uncertainty
Cut flowers of Compositae		Very unlikely		Unlikely	✓	Moderately likely		Likely		Very likely		Medium
Foliage of *Pinus* spp.	From non-EU European countries	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely		Low
	From EU countries	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely		Medium
Plants for planting of Compositae		Very unlikely		Unlikely		Moderately likely	✓	Likely		Very likely		High
Plants for planting of *Pinus* spp.	Bonsai *Pinus* from Japan and Korea	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely		Low
	Pinus spp. from non-EU European countries	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely		Medium
	Pinus spp. from the EU	Very unlikely	✓	Unlikely		Moderately likely		Likely		Very likely		High

9. How likely is the pest to establish outdoors or under protection in the UK?

Establishment of *C. asterum* is very likely to occur both outdoors and under protected conditions in the UK. The related fungus *C. tussilaginis* has a similar lifecycle and has wide distribution in the UK with numerous records (contributed by a large number of organisations) on the National Biodiversity Network's Gateway website (NBN, 2014) and displayed below (Figure 4).

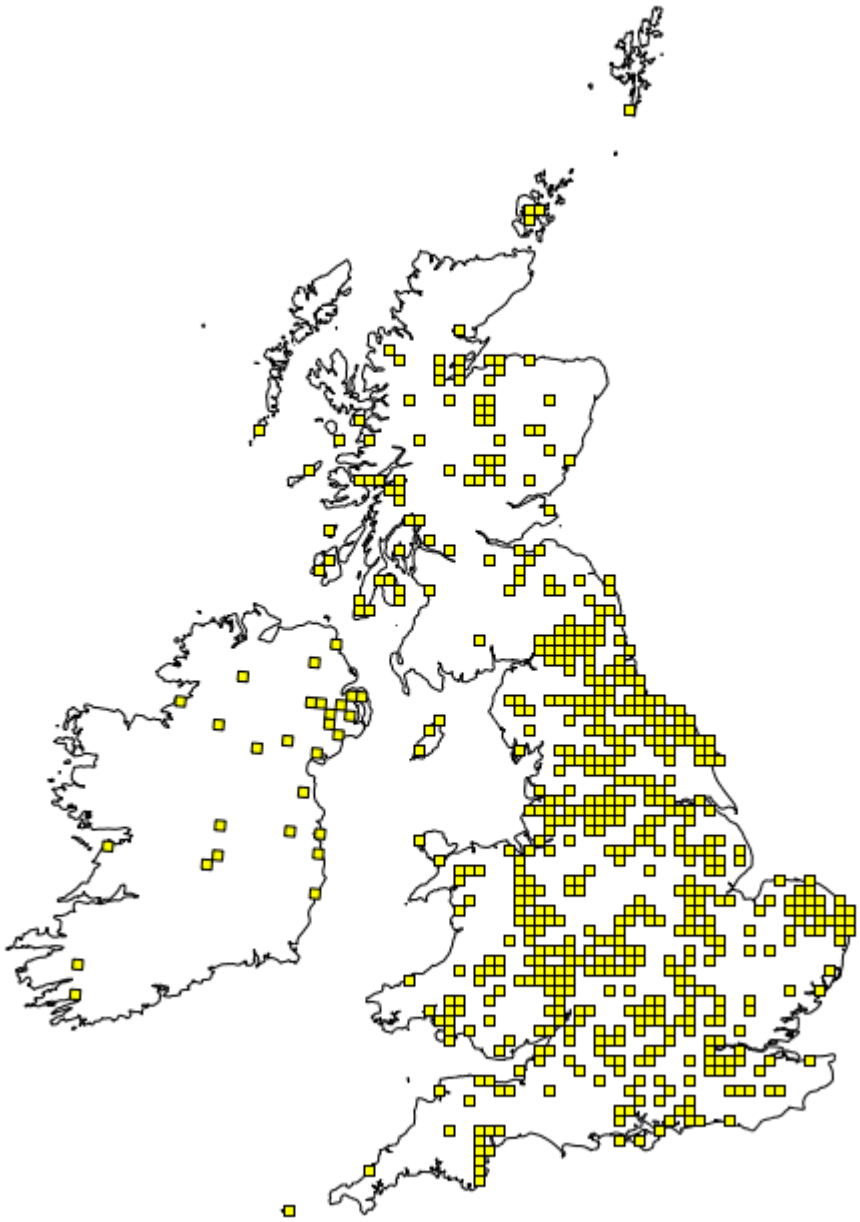

Figure 4. Grid map for records of *Coleosporium tussilaginis* (Pers.) Kleb (source NBN Gateway: https://data.nbn.org.uk/Taxa/NHMSYS0001478207/Grid_Map - accessed 10 April 2014). © Crown copyright and database rights 2011 Ordnance Survey [100017955][10]

For establishment to occur, completion of the lifecycle of *C. asterum* requires the presence of at least one susceptible pine species and at least one susceptible herbaceous host (the alternate host) in the family Compositae. Such species are common outdoors in the UK and their range overlaps (see Figures 1, 2 and 3 above).

Host species may also be grown under protected conditions albeit pines and alternate hosts may not necessarily be in close proximity.

[10] The information (map) used here was sourced through the NBN Gateway website and included data from numerous sources. http://data.nbn.org.uk - accessed 10 April 2014. The data providers and NBN Trust bear no responsibility for the further analysis or interpretation of this material, data and/or information.

The pest is known to occur across the USA and Canada which includes areas with climates comparable to the UK so climate is unlikely to be a limiting factor in establishment of *C. asterum*.

A summary of the year-long lifecycle of *C. asterum* is given below. This has been compiled from the 2005 UK PRA, Anon. (undated), Sinclair *et al*. (1989), and Sinclair and Lyon (2005).

Lifecycle

In late summer or early autumn susceptible pine species are infected by wind-borne short-lived (longevity unspecified) basidiospores produced on herbaceous alternate hosts (members of the Compositae). These spores germinate and produce germ tubes which grow into pine needles where *C. asterum* overwinters; however, symptoms of infection do not appear until the following spring when the needles exhibit yellow spots. Fruiting bodies (spermagonia) develop beneath these spots, followed by white, '*tongue-like*' fruiting bodies (aecia). The aecia burst and release wind-borne bright orange spores (aeciospores) which infect the alternate hosts during the summer. The aeciospores are no longer visible on pine hosts at the end of the summer but they leave tiny scars on yellow-brown spots/bands on partly-yellowed needles.

On alighting upon the herbaceous alternate hosts, the aeciospores germinate in moisture on the leaves and stems leading to infection and the development of bright orange uredinial pustules. The time taken for these pustules to appear varies with the host and the local climatic conditions. On hosts grown on commercial premises symptom development is also dependent upon whether the plants have been treated with fungicides, which, if fungistatic, may suppress symptom development. Sinclair and Lyon (2005) suggest that the time between infection and the appearance of visible pustules is 10-15 days for the genus *Coleosporium*. The pustules produce uredospores which are long-lived and infect more alternate hosts thus building-up inoculum over the summer. Spread of these spores between herbaceous alternate hosts occurs by wind or by water-splash. In late summer/early autumn, long-lived dark-coloured telia develop on the margins of the uredinial pustules. Basidiospores develop from the telia and these are wind-blown from the alternate hosts. If they land upon a susceptible pine host the needles may become infected and the lifecycle is completed, however it should be noted that basiodspores are described by Lowe (1972) as "small and delicate and cannot survive even a short period of temperature extremes or drought", and thus, "unless they land on susceptible pine needles shortly after dissemination and unless climate conditions are favourable, the basiospores will perish".

In overwintering herbaceous host plants (or discarded infected cut flowers) *C. asterum* can survive as telia as well as uredinial mycelium, although teliospores may be killed by frosts (Nicholls et al 1965). *C. asterum* can also survive for >1 year as mycelium in the living tissue of the pine host on which it can produce aecia for 2-3 summers. An early report (Lowe, 1972) suggests that *C. asterum* is perennial in pine needles and as the needles usually live for at least 3 years the rust can also live for 3 years in the needle or until it dies. Thus, the rust can survive for a long period even if conditions for spread are unfavourable.

All spore types of *C. asterum* germinate most rapidly at 20°C. The spores that lead to infection are able to start new infections within 24hrs under wet conditions at this optimal temperature. (Sinclair *et al*., 1989).

There is evidence to suggest that the frequency of infection of pines increases with closer proximity to the alternate hosts and also with the abundance of these hosts (see review in Milhail *et al*., 2002). This multi-factorial Ontario study (host competition x pathogen x soil type interactions) showed that in 1996 very few trees of *P. banksiana* were found beyond 50m of infected *Aster macrophyllus* plots. However, by 1997 the level of disease had built up to such an extent on the alternate host to result in uniform levels of disease on pine trees located at up to 140m from this source.

In outdoor situations infection of pine hosts would be most likely to occur if diseased alternate hosts (either ornamental or wild species) with telia present were growing in close proximity to susceptible pines. Given the invasive nature of some of the herbaceous species that are known to occur in the UK as well as the fact that *Aster* and *Solidago* are commonly planted in gardens this scenario is very likely. However, under some circumstances the risk of establishment may be lower since alternate hosts may be controlled. An example of this is the management of weeds in UK Christmas tree plantations as described below:

The main Compositae weed problems that occur in UK Christmas tree plantations are ragwort (*Jacobaea vulgaris*) and groundsel (*Senecio vulgaris*) (C. Palmer, Crop Protection Adviser to the BCTGA, *personal communication*, May 2014). These species are hosts of *C. tussilaginis* (including in the UK) but are not recorded as having been infected by *C. asterum* (Farr and Rossman, 2014). Various thistles are also weeds in these plantations and as members of the Compositae are potentially susceptible to both species of *Coleosporium*. Rosebay willowherb (*Epilobium angustifolium*) is also a weed problem but it is a member of the family Onagraceae and is not a host of any species of *Coleosporium* (Farr and Rossman, 2014). In these plantations, ragwort may be controlled using herbicides or by roguing; groundsel is not specifically targeted but will be controlled by some residual herbicides used for annual willowherb control. Growers use herbicides against rosebay willowherb (the latter is controlled as an alternate host of another rust – *Pucciniastrum epilobii*, which affects other species of Christmas tree but not pines). Thistles are controlled using herbicides. (C. Palmer, Crop Protection Adviser to the BCTGA; and J. Allen, ADAS, UK; *personal communications*, May 2014). Although pines grown as Christmas trees in the UK are potential hosts of *C. asterum* it may be that because of the control of weeds they would not become infected (as evidenced by the apparent absence of *C. tussilaginis* in this sector).

In protected environments *C. asterum* could also establish where susceptible hosts are grown.

Summary of risk of establishment of *C. asterum* in the UK

Establishment area	Likelihood of establishment										Uncertainty
Outdoors	Very unlikely		Unlikely		Moderately likely		Likely		Very likely	✓	Low
Under protection	Very unlikely		Unlikely		Moderately likely		Likely		Very likely	✓	Low

10. How quickly could the pest spread in the UK?

Once present in the UK, *C. asterum* could spread quickly over the spring, summer and early autumn via aerial dispersal of spores between susceptible hosts whose distribution is not limited (see lifecycle, under 9. and selected host distribution maps – Figures 1, 2 and 3).

Spread in trade of planting material of infected hosts is also likely to be quick.

Movement of infected cut flowers could also facilitate spread. *Solidago* and *Aster* are commonly used in the floristry trade. Recycling of green waste by composting is now common practice in the UK, both by members of the public in garden compost heaps/bins as well as in public gardens or by local authorities, often in open-air windrows. Disposal of diseased cut flowers with viable rust pustules in this manner near to susceptible species in gardens, the wider environment or near glasshouses during the summer and autumn, when conditions are favourable for movement of spores and infection of hosts, could result in spread; or, spread may occur the following year if the rust overwinters as telia in such material. The detection of *C. asterum* in bioaerosols from windrows in France using molecular techniques (Bru-Adan *et al*., 2009) does not prove that viable spores were present, but it does support the view that this potential mode of spread is not impossible.

Summary of likely rate of spread of C. asterum *in the UK*

Mode of spread	Rate of spread										Uncertainty
Natural spread	Very slowly		Slowly		Moderate pace		Quickly		Very quickly	✓	Low
In trade	Very slowly		Slowly		Moderately pace		Quickly		Very quickly	✓	Low

11. What is the area endangered by the pest?

The area endangered by *C. asterum* is all areas of the UK where host plants in the Compositae and Pinaceae co-exist. The pest could potentially become established throughout the range of its known hosts.

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

The 2005 UK PRA commented solely on the impact in North America where needle rusts of pine were not regarded as significant diseases of older trees but might cause defoliation and stunting of young pines (derived from Sinclair *et al*., 1989). *C. asterum* was described as occasionally causing severe browning and loss of needles on low branches of young trees. The effect of the rust on ornamentals e.g. *Aster* and *Solidago* was considered to be difficult to determine, but like other rusts of ornamentals could be severe if left uncontrolled. The strict phytosanitary requirements for the derogations that allowed imports of bonsai *Pinus* from Japan and Korea arose from the view of the UK Plant Health Service in 1999-2000 (as stated in the 2005 UK PRA) that *C. asterum* had the potential to cause damage to susceptible forest trees in the UK if such a trade was allowed.

In producing this new PRA, with few exceptions, much of the literature for *C. asterum* is dated (published before the 2005 UK PRA although not referred to in that document) and centres on reports of new findings and on '*races*' with differing host specificity rather than impact. Little new information could be gleaned but an

overview of the impact and examples of impacts by continent and host (*Pinus* spp. and alternate hosts in the family Compositae) are given below:

Overview

In a revised edition of Sinclair *et al*. (1989), Sinclair and Lyon (2005) repeated that needle rusts of pines occasionally destroy enough foliage to disfigure or retard growth of young trees but usually cause little damage.

Milhail *et al*. (2002) summarised the impact of *C. asterum* on two- and three-needled pines as causing needle browning and defoliation of the lower branches of young trees. The effect of *C. asterum* on susceptible pine species was considered to vary according to the age of the tree; on mature trees it was not considered to be lethal. In reviewing the early literature (e.g. Baxter *et al*., 1931) it was noted that trees of *P. resinosa* (red pine) less than 1m tall became severely infected but those ≥2m tall were virtually unscathed. Severe infection on young red pine seedlings killed the lowest branch whorls. Once the canopy was closed, or the lower branches shaded, *C. asterum* had virtually no effect. Alternate hosts such as *Aster* spp. and *Solidago* spp. suffer from leaf blisters and when severely affected, symptoms of leaf blight occur.

Asia

The most recent report from Asia (Back *et al*., 2014) describes the effect of *C. asterum* on *Solidago virgaurea* var. *gigantea* (Korean goldenrod). This plant is cultivated as a '*culinary vegetable*' and is used in Korean folk medicine. In Ulleong-do (a South Korean island off the east coast of the Korean Peninsula) it is the third most cultivated crop, with 72.3 ha being planted. This species was valued at 2.7 billion Won (£1.5 million). From June to October 2012 severe outbreaks of *C. asterum* were observed in all areas of cultivation in Ulleong-do and production of *S. virgaurea* var*. gigantea* was estimated to be significantly reduced by >10% due to disease on the leaves.

Sinha and Singh (1992) reported severe infection of *Launea pinnatifida* (now known as *L. sarmentosa*) in a village in India with heavily infected leaves being distorted and crimpled, dwarfing of plants and suppressed flowering.

Africa

There are no reports of *C. asterum* in Africa despite the pest being intercepted on cut flowers imported into the UK from Kenya, Zambia and Zimbabwe so no impact can be described. However, management of cut flower crops to avoid infection or the development of disease symptoms to ensure good quality will incur a cost to the industry.

Caribbean

The records for the Caribbean on *A. chinensis* and *C. chinensis* were obtained from Farr and Rossman (2014) but the original references were not available so the impact cannot be described.

Europe (tentative)

Records in Europe are tentative with only one clear record on plant material; *Pinus pinaster* in 1953 (Santos and Sousa da Câmara, 1954), however this is a very old record pre-dating molecular techniques and given the difficulties in distinguishing species of *Coleosporium* morphologically, in particular the European *C. tussilanginis*

from *C. asterum,* this record is highly uncertain. No impact was described. The records of *C. asterum* in Germany are molecular sequences from living plant material but the researchers have yet to confirm the species of *Coleosporium* involved. The record in France was detected in bioaerosols at a composting plant so cannot be directly attributed to infected plant material growing in France.

North America

Most of the reports on impacts caused by *C. asterum* in North America pre-date the 2005 UK PRA. However, this does not mean that impacts do not occur. Indigenous species that are widespread and have been well-studied are not always of continuing interest to the research community and those that provide research funding. As described above, the 2005 PRA concluded that needle rusts of pine were not causing significant damage but the main impact was defoliation and stunting of young pine trees.

This is further borne-out by recent correspondence with the plant health authorities in North America as described below.

The Canadian Food Inspection Agency (CFIA) Plant Health Risk Assessment Unit supplied the following information (S. Gulden, CFIA, *personal communication*, April 2014); summarised in quotes below:

C. asterum *is native to North America and is one of the most common needle rusts in Canada. However, it rarely causes serious damage to a tree. The disease is widespread in Canada and has been reported from the native ranges of its host species (*Aster*,* Callistephus, Erigeron, Grindelia, Pinus *and* Solidago*) from all provinces and territories. No control measures are required in industrial forests.*

The national Canadian Forest Service's Forest Insect and Disease Survey (FIDS) 1984 report suggested that the disease has been significant in some years, with infection levels varying in plantations from as low as 1% to as much as 72% of the needles (in a jack pine plantation in Nova Scotia) being affected by the rust. Another FIDS report from 1994 described the presence of the rust in Ontario from jack pine in two small pockets with defoliation from 35 to 75%. Widespread incidence was reported. Incidence of 100% occurred in several townships. On red pine (also in Ontario from 1984) the survey reports foliar damage as averaging from 20% on 83% of the 1.4-m trees in one township.

The rust causes minor needle cast and discolouration of needles of pine and, in cases of severe infection, some reduction in terminal growth, but only rarely does it kill trees. Damage can be light to severe on pines. Although it is widespread, damage has not been great. Generally, only relatively small trees, less than 8 to 10 feet in height, are affected, and only heavily infected older needles are cast prematurely, resulting in lowered food production, consequent growth reduction, and reduced value for Christmas trees. However, death of seedlings could result from a combination of rust attack and insect attack fatal to the new shoots. In cases of severe infection, all needles except those of the current growing season may be affected.

The Canadian Forest Service (B. Callan, CFS, Canada, *personal communication*, April 2014) summarised responses from regional specialists in British Columbia (BC) and commented that there is no recent information on *C. asterum*, and, that it is viewed as a minor problem with '*scattered*' historical reports in FIDS reports from

natural forests where no control measures would be applied. FIDS ceased forest health surveillance in the mid-1990s when it was shut-down, devolving responsibility to provincial agencies. One respondent to B. Callan stated that the disease is viewed as a '*minor problem'* and '*with the diagnostics available to the specialists it hasn't been recorded'*. (This illustrates the issues with reporting of findings). No information could be obtained from the BC Christmas tree Council. However, the CFIA commented that for Christmas tree growers the disease is a problem from '*time to time'* but growers have more recently shifted away from growing pine to growing spruce and fir; this is not because of the disease but because of pines being less popular (as is the case in the UK – see 13). Cultural controls have been applied in this sector. (S. Gulden, CFIA, *personal communication*, April 2014).

One example of early reports of damage include that by Lowe (1972) who described light to severe attacks annually from BC and western provinces of Canada. Although widespread, damage was not considered to be great with only small pine trees (<8 to 10 feet) being affected, and only heavily infected older needles being cast prematurely. This led to a reduction in growth and reduced value for affected Christmas trees. Lowe considered that seedlings might die from a combination of rust infection and insect attack to new shoots. Needles on severely affected young trees may all be affected apart from those in the current growing season.

The impact of *C. asterum* on valuable ornamental plants grown for planting or as cut flowers has rarely been described. However, rusts are always disfiguring and have to be controlled using an integrated approach with some species being managed by imposing quarantine restrictions (e.g. historically in the UK - chrysanthemum white rust – *Puccinia horiana*) (see e.g. Wise *et al*., 2004). Raabe and Pyeatt (1990) described the impact of what was presumed (and debated) to be *C. asterum* infection on *Callistephus chinensis* (China aster) in California as being '*so severe as to threaten the production of cut-flower asters as a commercial enterprise'*.

Tucker *et al*. (1999) commented that only a few of the *ca*. 72 species of *Solidago* native to North America were cultivated as ornamental species but *S. odora* (sweet goldenrod) was valued for its anise-like fragrance by perfumers and flavorists being used by Native Americans for medicinal purposes, exported in the 19th century as a tea, and, proclaimed as the state herb of Delaware (in 1996). Although not proven, *C. asterum* infection of *S. odora* was blamed for causing acute toxic anaemia in horses that had consumed infected plants in 1891. Abortion in cattle in the 1940s was also linked with ingestion of *Solidago speciosa* infected with a rust fungus tentatively identified as a species of *Coleosporium*. It is not clear whether the rust was the cause of the health problems, or the essential oils in the plants. However, it can be assumed that rust infection of *Solidago* species grown for economic purposes would have a detrimental effect on yield and quality.

<u>South America</u>

In Brazil the pest was reported to occur on *Solidago canadensis* having been introduced to Ceará State via infected seedlings (Freire and Berndt, 2013). Although no impacts were described the authors commented that '*due to the frequent introduction of contaminated or infected plant parts into Ceará State a strict eradication and control campaign must be implemented aiming to protect the fruit and the ornamental industries. However, all efforts by the Federal Plant Health*

Inspection may fail if the trade and sell [sic] *of these materials continue without curtailment'*.

In Columbia (Pardo-Cardona, 2006) *C. asterum* is reported to have affected a commercial crop of *Aster* in Antioquia and it was also detected on a wild species of *Solidago*. No details of impacts were given.

Overall it has been difficult to collect data on impacts but these will vary with the sector as summarised below.

Summary of impact of C. asterum *in the current area of distribution*

Host	Impact										Uncertainty
Mature forestry pines	Very small	✓	Small		Medium		Large		Very large		Low
Nursery pine stock including forestry, ornamental and Christmas trees	Very small		Small	✓	Medium	✓	Large		Very large		Medium
Cultivated Compositae	Very small		Small		Medium		Large	✓	Very large		Low

13. What is the pest's potential to cause economic, environmental or social impacts in the UK?

The impact of *C. asterum* in the UK is considered likely to be similar to that where it currently occurs.

Mature forestry pines

C. asterum is not considered to be a major problem in mature forestry plantations in its current area of distribution, thus, the impact on mature forestry pines in timber plantations in the UK is considered likely to be very small with low uncertainty.

Nursery pine stock including forestry, ornamental and Christmas trees

The 2005 UK PRA commented that *C. asterum* was expected to cause damage similar to that caused by *C. tussilaginis*, a rust which is widespread in the UK. At that time, *C. tussilaginis* was considered to be a cosmetic problem on young susceptible pines such as those grown as Christmas trees and *C. asterum* was considered likely to have a similar effect.

Only a small percentage of the area devoted to Christmas tree production in the UK is planted with pines. The main rust affecting conifers grown as Christmas trees is *Pucciniastrum epilobii* which does not affect *Pinus* spp. Although *C. tussilaginis* is common and widespread in the UK, it has not been detected in Christmas tree plantations on *Pinus* spp. This may be because of the control of weeds that are alternate hosts. Consequently, it may be the case that *C. asterum* does not pose a threat to pines grown as Christmas trees.

Forest Research (S. Hendry, FR, UK, *personal communication*, April 2014) advised that forest nurseries would have a greater concern about *C. tussilaginis* than Christmas tree growers because '*heavy infection of very young trees might actually compromise production (more likely as a result of poorer growth than outright mortality of affected trees)*'. Also that '*if older stock became infected in the nursery during the final year of production, plants would be asymptomatic when supplied for spring planting but quickly develop overt symptoms of rust infection thereafter*'. However, FR considered that weed control programmes on forest nurseries would make such occurrences highly unlikely, if not impossible. If this is the case, then *C. asterum* is likely only to be a problem if weed hosts are not controlled on such nurseries; or if ornamental plants such as *Aster* spp. and *Solidago* are growing nearby and become infected.

Intensive horticultural nurseries growing *Pinus* spp. also impose strict control of weeds (I. Willoughby, FR, UK, *personal communication*, May 2014) and thus may

also be inadvertently protecting *Pinus* spp. against infection by *Coleosporium* species including *C. asterum*.

Because of the weed control that is undertaken which effectively removes alternate hosts, the potential impact of *C. asterum* on nursery stock of susceptible pine species is considered to be small with medium uncertainty. However, if weed control is not undertaken the risk increases to medium.

Overall therefore, the potential risk to this sector is considered to be small to medium with medium uncertainty.

Regeneration of young trees in forests

In addition to young pine trees in nurseries, the UK also has areas of pine forest where natural regeneration occurs and is encouraged. Of particular concern would be any threat to endangered habitats such as native pine forests. Figure 2 shows that the UK does have Solidago species growing throughout the UK, including across northern Scotland, but weed control in native pinewoods may be limited. Understanding the potential impact of the pest to these wild environments is difficult, but in North America [in pine forests] where *C. asterum* is common it rarely causes serious damage. The closely related *C. tussilaginis* which is widespread in the UK, also rarely causes serious damage.

On this basis the potential risk to endangered habitats from *C. asterum* is considered to be small – medium, but with high uncertainty.

Cultivated Compositae

In 2005, the potential threat that *C. asterum* posed to ornamentals such as *Aster* and *Solidago* was considered likely to be severe if precautions were not taken. *C. asterum* is still considered to have the potential to cause large impacts on cultivated ornamentals of susceptible species with low uncertainty if controls are not implemented by growers.

Summary of potential impact of C. asterum *in the UK*

Host	Impact										Uncertainty
Mature forestry pines	Very small	✓	Small		Medium		Large		Very large		Low
Nursery pine stock including forestry, ornamental and Christmas trees	Very small		Small	✓	Medium	✓	Large		Very large		Medium
Regeneration of young trees in forests	Very small		Small	✓	Medium	✓	Large		Very large		Medium
Cultivated Compositae	Very small		Small		Medium		Large	✓	Very large		Low

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

The pest is a primary pathogen of plants which does not act as a vector of other plant pathogens.

STAGE 3: PEST RISK MANAGEMENT

15. What are the risk management options for the UK?

Exclusion

Exclusion of *C. asterum* from the UK depends upon detection of the pest on the pathways of entry either prior to export or at the point of entry into the UK.

As with any fungal disease, the time it takes between infection and development of obvious symptoms will vary with the host and the climatic conditions in the area where the host is being grown. Fungicides that suppress symptom development (fungistats) will also influence whether infection is detected.

If *C. asterum* has developed obvious symptoms either pre-export or at the time an infected shipment arrives at the point of entry, then exclusion may be possible. However, this depends upon the efficacy of unofficial controls such as growers, exporters or importers inspecting and sorting consignments; as well as whether official controls are in place, such as requirements for generic or specific pest-freedom, inspection and the level of inspection.

If undetected, or latent (which could occur if fungistatic treatments have been applied pre-export), entry of the rust on the pathways identified as posing the greatest risk could result in widespread distribution of *C. asterum* in the UK.
Management options for exclusion include the application of phytosanitary controls to those pathways of entry which are currently not subject to regulation and for those pathways that are controlled to be amended to account specifically for the pest (see 8.).

There is some uncertainty over the current distribution of *C. asterum*; in particular the records in the EU and the lack of records in Africa, despite UK interceptions on imports of cut flowers from Kenya, Zambia and Zimbabwe. For this reason it may be necessary for the UK NPPO to correspond with the NPPOs of those countries where the status of the pest is uncertain, if it is decided to try to prevent entry of the pest via changes to phytosanitary legislation at the UK or EU level. UK surveillance would also help determine whether *C. asterum* is already present here. The potential measures for exclusion on the pathways of entry are described below.

Plants for planting of Compositae – risk of entry moderately likely – high uncertainty
There are no data available on the level of imports of plants for planting of Compositae into the UK but if such imports exist (and it seems probable that they do since host species are popular garden plants in the UK and demand may exceed UK supply) then *C. asterum* has the potential to enter on this pathway. The same uncertainty with respect to geographic distribution of *C. asterum* applies to this pathway; nevertheless the suggested phytosanitary requirements for cut flowers (pest-free areas or places of production) could also be applied to prevent entry of *C. asterum* to the UK on imports of plants for planting of host species in the family Compositae.

Cut flowers of Compositae – risk of entry - unlikely – medium uncertainty
C. asterum could enter on imports of cut flowers of Compositae; mainly *Aster* spp., *Solidago* spp., and *Solidaster* from countries or areas where *C. asterum* occurs, however the pathway is considered unlikely due to the low chance of transfer to suitable hosts. Since 2002, *C. asterum* has occasionally been intercepted on UK imports of cut flowers of *Solidago* and *Solidaster* from Kenya, Zambia and Zimbabwe. However, there are no published records of *C. asterum* in these or other African countries. Although the full geographic distribution of *C. asterum* is uncertain it has increased since the 2005 UK PRA and it remains uncertain as to whether it is already in Europe (e.g. France, Germany and Portugal). Options for managing this pathway would be for *C. asterum* to become listed as a quarantine

pest in Anon. (2000; as amended). The most appropriate Annex to list it in would depend upon presence or absence in the EU and whether all hosts or just major hosts require regulation. Requirements for imports of cut flowers of Compositae; mainly *Aster*, *Solidago* and *Solidaster* would be for them to originate in a pest-free area or pest-free place of production for *C. asterum*. This could be determined by meeting certain requirements. For example, the growing crop would have to be inspected and found free of symptoms and/or the crop has been subject to appropriate treatments; albeit some fungicides suppress symptoms rather than eradicate infections.

Plants for planting of Pinus *spp. from within the EU – risk of entry very unlikely – high uncertainty*
Currently the status of *C. asterum* in the EU is highly uncertain and the only record on *Pinus* in the EU is from Portugal (published 1954). The UK does import plants for planting of *Pinus* spp. from EU Member States including those where there are tentative records of *C. asterum.* As with plants for planting of Compositae, if *C. asterum* is confirmed as present in the EU then requirements for *Pinus* spp. imported into the UK from the EU to originate in a pest-free area or place of production could reduce the potential risk of entry.

Foliage of Pinus *spp. from EU countries – risk of entry very unlikely – medium uncertainty*
Foliage of *Pinus* spp. is permitted entry from within the EU without the need for a PC. For foliage originating in the EU the only record of *C. asterum* on *Pinus* is that from Portugal (1954). Entry of *C. asterum* on this pathway is very unlikely with medium uncertainty, compared to the high uncertainty associated with the rating for plants of *Pinus* spp., because of the intended use and lack of interceptions on this unregulated trade. However, this depends on the status of *C. asterum* in the EU (including the UK). If it is considered that measures are required, foliage would have to originate in pest-free areas or places of production in the countries from which such imports (if they exist) arise.

Plants for planting of Pinus spp. from non-EU European countries – risk of entry very unlikely – medium uncertainty
As imports of these plants into the UK require a PC, the uncertainty associated with this pathway is less than that for plants of *Pinus* from the EU. If deemed necessary, the requirements would be the same as for plants for planting of Compositae (pest-free area or place of production).

Foliage of Pinus *spp. from non-EU European countries – risk of entry very unlikely – low uncertainty*
Foliage of *Pinus* spp. is permitted entry from non-EU European countries if accompanied by a PC. Entry of *C. asterum* on this pathway seems very unlikely with low uncertainty due to this requirement, the lack of interceptions, and the intended use of the material. If it is considered that measures are required, foliage would have to originate in pest-free areas or places of production in the countries from which such imports (if they exist) arise.

Plants for planting of bonsai Pinus *from Japan and Korea – risk of entry very unlikely – low uncertainty*
The current measures for bonsai *Pinus* from Japan and Korea are stringent enough to prevent entry of *C. asterum* on this pathway. For parity with Korea, it would seem

appropriate to add *C. asterum* to the list of pests in the derogation legislation for imports of bonsai *Pinus* from Japan. (Albeit the species of *Pinus* that is allowed entry is not likely to become infected with *C. asterum*).

Eradication

C. asterum could be eradicated if it is detected soon after it had transferred from the pathways of entry to susceptible host plants in the UK, but it would depend upon the extent and location of the outbreak.

If localised, and on a nursery, then eradication could be achieved by:

- Removal of symptomatic material and it's safe destruction
- Holding non-symptomatic host material for a reasonable period (probably 3 weeks during a period of active growth) to determine whether the plants were infected and taking action against any plants that display symptoms
- Effective control of weeds that may be alternate hosts using a systemic herbicide (e.g. glyphosate)

Eradication would not be easily achievable if outbreaks were detected in private or public gardens, woodlands or forest plantations, or in the wider environment either on *Pinus* spp. or on alternate hosts, since the extent of the outbreak would be difficult to determine, depending upon whether conditions were favourable for symptom development. If sporulating pustules are present when detected, then spread may already have occurred.

Containment

The principles of containment are similar to those outlined above for eradication. The extent of an outbreak would have to be determined by surveillance and possibly by testing known host material for infection (or by surveillance of hosts for several weeks during a period of active growth to determine how much plant material is infected). A buffer zone would need to be delineated at the perimeter of the outbreak. All host plants in the zone, including susceptible trees, would have to be removed and disposed of safely. The size of the zone is difficult to define and depends very much on the extent of the original outbreak including the inoculum density. Eradication of the outbreak itself would need to be undertaken as outlined above.

Buffer zone size should be a minimum of 140m width from the perimeter of the outbreak. This is based upon a single study which showed that infection of *P. banksiana* occurred up to 140m from infected *A. macrophyllus* in Ontario (Milhail *et al*., 2002). However, it may need to be wider (up to *ca*. 800m) based upon advice and information supplied by the CFIA - see non-statutory controls below.

Non-statutory controls

Under protection

Crops grown under protection that are susceptible to infection by *C. asterum* can be managed by ensuring the premises and the immediate vicinity are free of weed hosts that are susceptible to infection, by good hygiene and ventilation, as well as by avoiding overhead irrigation. Effective approved fungicides can be used as protectants in areas where *C. asterum* is present in the vicinity of the place of production. However, a programme would need to be devised to avoid the development of resistance to any chemicals that are used in this way. If *C. asterum*

is detected on the premises or in the immediate vicinity, infected material should be removed and disposed of safely (not by composting). Selection of species that are not susceptible to infection by *C. asterum* could be considered if a grower decides to produce other plants. However, even those species of Compositae and Pinaceae that are not currently recorded as natural hosts could succumb to infection. If a grower wishes to keep growing plants in these families then they would need to be vigilant and take eradication action if symptoms of rust infection appear.

Outdoors: Pinus *spp.*
Information on disease control for *Pinus* spp., in Canada was provided as a *personal communication* by S. Gulden (CFIA, April 2014) and is summarised below:

Timber plantations
No control measures are required or used in '*industrial forests*' (timber plantations).

Christmas trees and nurseries
Although the disease is a problem from time to time for growers of pines as Christmas trees in North America, many of them no longer plant pine because the demand is for other species. Controls have included:

- Site selection – not planting on wet/humid sites
- Removal of alternate hosts (primarily goldenrod and asters) by mowing
- Control of further emergence of alternate hosts with herbicides
- Pruning of infected twigs in severe outbreaks

More detail is available through Anon. (1998) as cited on the Ontario Ministry of Agriculture website; information from this and other references provided by the CFIA can be summarised thus:

- The needles of 3- to 6-year-old pine trees should be examined in May and June
- Check at least 50 trees scattered throughout the plantation
- If >25% of the trees exhibit symptoms of rust and have suffered significant loss of foliage, goldenrod and aster should be removed in and around the plantation before August by mowing (to avoid herbicide use and to avoid basidiospore production on these alternate hosts)
- As the alternate hosts are perennial, mowing will have to be repeated each year until the trees are mature enough for the disease to have no significant impact on tree quality
- The alternative to mowing is to kill the alternate hosts that are within 1000ft (305m) of newly-planted seedlings before August. Other references suggest this should be undertaken up to ½ mile (805m)
- Ensure that pine trees are free of rust at the time of planting (testing may be required in asymptomatic material) but it would be better to source planting material from a pest-free area or place of production
- Alternatively, plant *Pinus* spp. that are not susceptible to infection by *C. asterum* (i.e. not two- and three-needled pines)

- When planting a new crop of trees, remove as much understory vegetation as possible including non-hosts as these increase humidity which would favour infection and disease development
- Avoid planting on wet and/or humid sites north or west of a stand of tall trees, and avoid steep, northern or western slopes
- Avoid planting in small openings
- Trees should not be crowded and adequate sunlight and air circulation should be maintained
- Trees could be protected by spraying appropriate/approved protectant fungicides in late summer and early autumn when they are most susceptible to infection

Outdoors – ornamental plants for planting and cut flower crops in the family Compositae

Disease prevention and control for cultivated susceptible ornamental plants grown outdoors either as plants for planting or as flowers for cutting is likely to be similar to that used for *Pinus* spp. Fungicides used as protectants or for eradication should be carefully considered and deployed in such a way to avoid the development of resistance. This happened with long-term use of triazole and strobilurin fungicides used to control Chrysanthemum white rust (*Puccinia horiana*) in the UK (Cook, 2001). An appropriate programme, alternating effective active ingredients at an effective dose along with growing species in the family Compositae that are currently not recorded as being susceptible to infection by *C. asterum* would need to be developed. However, these should still be observed in case they succumb to infection. Control of susceptible weeds and other weeds that favour humidity and wetness at places of production would be required.

16. Summary and conclusion of the PRA.

Coleosporium asterum is a rust fungus which affects a wide-range of hosts in the family Compositae (especially *Solidago* and *Aster* spp.) and a number of species of two- and three-needled species of *Pinus*.

C. asterum is not reported as occurring in the UK. However, since 2002 there have been nine UK interceptions on cut flowers originating in Africa and statutory action was only taken on the second of these, in 2005. Although two of the other consignments were ultimately destined for Barbados, *C. asterum* may already have entered the UK. The lack of UK records may be for a number of reasons; either it is absent, or if present it may have been misidentified and reported as another species, or not reported at all, particularly as the host-range of the indigenous rust *C. tussilaginis* overlaps with that of *C. asterum* and identification to species entails some effort.

The geographic distribution of *C. asterum* has increased since the first UK PRA (2005) and there are some tentative reports of *C. asterum* in the EU. Uncertainty on distribution globally arises in part from the difficulty of identifying species of *Coleosporium* as well as the fact that there appear to be no official surveys for *C. asterum* presumably because it is not listed as a pest of quarantine concern, with the exception of the derogation that allows bonsai *Pinus spp.* to be imported into the UK/EU from Korea. Nevertheless, it appears to be widespread in North America and Asia with a few records in South America and the Caribbean. Presence in Africa is

suspected based upon the UK interceptions, but there are no published records of *C. asterum* there; this again may be for similar reasons in addition to resource constraints for diagnosis and reporting. Also, cut flowers may harbour latent infections which are not detected prior to export, especially if crops are treated with fungicides which suppress symptoms to maintain quality.

The diseases caused by *C. asterum* on *Pinus* spp. are not considered to be major in mature trees in forest plantations in North America. The main impact is on young pines which can be severely affected, including loss of needles and stunting. On Compositae there are a few reports of impact but those which are published suggest it can cause significant losses on species grown as ornamentals (as they would be of poor quality either as cut flowers or as plants for planting) or if intended for human consumption (the latter arises from a recent publication from Asia).

<u>This PRA shows:</u>

Risk of entry of C. asterum *into the UK*
The risk of entry varies with the pathway:

- *C. asterum* is unlikely (medium uncertainty) to enter the UK on cut flowers of Compositae (especially *Aster*, *Solidago* and *Solidaster*), despite imports from countries where its presence is known, as cut flowers present a relatively low risk of transfer to suitable hosts. The main uncertainties arise from the lack of records in Africa (from which interceptions have been made) and the existence of tentative records in Europe for *C. asterum*, as well as whether the UK imports cut flowers from within the EU (as there are no trade data for this).
- *C. asterum* is moderately likely (high uncertainty) to enter the UK on plants for planting of Compositae originating in areas where the pest is present or suspected to occur. The main uncertainties arise from a lack of trade data for this pathway along with the uncertainty on geographic distribution in the EU and in Africa
- Because of phytosanitary controls related to *Pinus* spp. which effectively only allows entry of foliage of *Pinus* spp. from non-EU European countries (where the pest is not recorded) and EU countries where the only record on pine dates back to 1954 (Portugal), and the lack of interceptions, *C. asterum* is very unlikely (with low uncertainty) to enter the UK from non-EU European countries (due to the requirement for a PC) and with medium uncertainty from within the EU (no PC required).

Plants for planting of *Pinus* spp. are prohibited entry to the UK with some exceptions:

- *Pinus* spp. as plants for planting are permitted entry from within the EU and are imported into the UK. However, because there is only one dated record of *C. asterum* on *Pinus* in the EU this may be another species of *Coleosporium* such as *C. tussilaginis.* Although no official surveillance has been undertaken for this pest and there are two other tentative reports from other EU member states there is a lack of firm evidence that the pathogen is in the EU. Thus it is very unlikely (high uncertainty) that *C. asterum* could enter the UK on this pathway.

- Imports of *Pinus* spp. as plants for planting are permitted entry to the EU including the UK from non-EU European countries if accompanied by a PC. It seems very unlikely with medium uncertainty that *C. asterum* could enter the UK on this pathway.
- Other than this, plants for planting of *Pinus* spp. are only permitted to enter the EU including the UK as bonsai of a species that is not susceptible to infection by *C. asterum* originating in Japan and Korea. Strict phytosanitary controls are enacted on this trade under the terms of a derogation from prohibition for each country. Although the derogation for plants of *Pinus* from Japan does not include *C. asterum* in the list of regulated pests, other species of *Coleosporium* are included. It seems that *C. asterum* is therefore very unlikely (low uncertainty) to enter the UK on this pathway.

Risk of establishment

In the absence of controls, (statutory and non-statutory). *C. asterum is* very likely (low uncertainty) to establish both outdoors and under protection in the UK. Host species of susceptible *Pinus* and members of the Compositae (the alternate hosts) have a wide distribution outdoors. Some host species are likely to be grown under protection before planting-out. Climatic conditions in the UK are not dissimilar to areas of North America where *C. asterum* is widely distributed. *Solidago* and *Aster* spp. are commonly grown as ornamentals and can be invasive in the wider environment. Various members of the Compositae are also common as weeds. In areas where susceptible species of pine co-exist with susceptible alternate hosts then *C. asterum* has the potential to complete its lifecycle. Cut flowers of Compositae are commonly used as fillers in bouquets. As these may be discarded on compost heaps (private and public, including local authority windrows recycling green waste) it is possible that spores of *C. asterum* could disperse from infected discarded material. Where host species are located nearby this could result in transfer from infected green waste to living plants; under favourable conditions; although this is considered unlikely. *C. asterum* may infect these plants, developing sporulating pustules that can disperse more spores to host plants nearby. Given that the size of buffer zones proposed from various references is up to 800m then dispersal from infected plant material (planted or as green waste) is not likely to limit the risk of establishment.

Economic impact

C. asterum is likely to have a very small impact (low uncertainty) on *Pinus* spp. in timber plantations; this is because it is only young trees that suffer significant damage in the current area(s) of distribution. Nursery pine stock (including forestry, ornamental and Christmas trees) are likely to suffer a small to medium impact (medium uncertainty) depending upon whether effective control of weeds that are susceptible hosts (e.g. groundsel, ragwort etc.) is undertaken at the places of production. Regeneration of young pines in forests are likely to suffer a small to medium impact (high uncertainty) based on the current situation in North American pine forests and comparison with damage caused by a similar species. Cultivated Compositae such as *Aster*, *Solidago* and *Solidaster* grown for the cut flower trade and as plants for planting are likely to suffer a large impact with low uncertainty in the absence of controls. As with *Pinus* spp. impacts can be reduced where alternate hosts that are weeds are removed and (if infected) are disposed of safely (not by composting). Judicious use of fungicides to protect uninfected crops in areas where *C. asterum* occurs may reduce the potential impacts.

Endangered area
The area endangered by *C. asterum* is all areas of the UK where host plants in the Compositae and Pinaceae co-exist. The pest could potentially become established throughout the range of its known hosts.

Risk management

Exclusion
Exclusion of *C. asterum* from the UK (if it hasn't already entered) depends upon detection of the pest on the pathways of entry either prior to export or at the point of entry into the UK.

Management options for exclusion include the application of phytosanitary controls to those pathways of entry which are currently not subject to regulation and for those pathways that are controlled to be amended to account specifically for the pest. These options could be considered depending upon whether the assessed risk is deemed to be unacceptable.

Cut flowers and plants for planting of Compositae from all countries and plants for planting of Pinus *spp. from within the EU and from non-EU European countries*
Options for managing these pathways would be for *C. asterum* to become listed as a quarantine pest (status dependent upon presence or absence in the EU) with requirements for imports of cut flowers and plants for planting of Compositae; mainly *Aster*, *Solidago* and *Solidaster* and plants for planting of *Pinus* spp. from within the EU (the only permitted trade except for bonsai species from Japan and Korea and *Pinus* spp. from non-EU European countries) to originate in a pest-free area or pest-free place of production for *C. asterum.*

Foliage of Pinus *spp.*
Foliage of *Pinus* spp. is permitted entry from within the EU and from non-EU European countries if accompanied by a PC. Due to the uncertainty on the status of *C. asterum* in the EU and the absence of reports of *C. asterum* from non-EU European countries entry on this pathway seems very unlikely but with medium to low uncertainty respectfully. However, if it is considered that measures are required, foliage would have to originate in pest-free areas or pest-free places of production in the countries from which such imports (if they exist) originate.

Plants for planting of bonsai Pinus *from Japan and Korea*
The current measures for bonsai *Pinus* from Japan and Korea are sufficient to prevent entry of C. *asterum* on this pathway; especially as the only permitted imports are of a non-susceptible species of pine (*P. parviflora* or *P. parviflora* grafted onto a rootstock of other *Pinus* spp.). For parity with Korea, it would seem appropriate to add *C. asterum* to the list of pests in the derogation legislation for imports of bonsai *Pinus* from Japan if the risk from *C. asterum* is deemed unacceptable.

Eradication
C. asterum could only be eradicated if it is detected very soon after it had transferred from the pathways of entry to susceptible host plants in the UK, but the success of eradication measures would depend upon the extent and location of the outbreak. Eradication measures would include:

At places of production

- Removal of symptomatic material and it's safe destruction
- Holding non-symptomatic host material for a reasonable period (probably 3 weeks during a period of active growth) to determine whether the plants were infected
- Effective control of weeds that may be alternate hosts using a systemic herbicide (e.g. glyphosate)

Eradication would not be easily achievable in the wider environment since the extent of the outbreak may be difficult to determine (i.e. once observed it may be the case that *C. asterum* has already spread over a wider area).

Containment

The principles of containment are similar to those outlined above for eradication. Containment under protection is possible if alternate hosts are removed and disposed of safely and the existing outbreak subject to eradication measures. Outdoors, the extent of an outbreak would have to be determined by surveillance and possibly by testing known host material for infection (or by surveillance of hosts for several weeks during a period of active growth to determine how much plant material is infected). A buffer zone (up to *ca*. 800m from the edge of the outbreak) would need to be delineated and all host plants including susceptible trees would have to be removed and disposed of safely. Eradication of the outbreak itself would need to be undertaken as outlined above.

Non-statutory controls

Under protection

C. asterum can be managed by ensuring the premises and the immediate vicinity are free of weed hosts that are susceptible to infection, by good hygiene and ventilation, and, by avoiding overhead irrigation. Effective approved fungicides can be used as protectants in areas where *C. asterum* is present in the vicinity of the place of production. However, a treatment programme would need to be devised to avoid the development of resistance to any chemicals that are used in this way. If *C. asterum* is detected on the premises or in the immediate vicinity, infected material should be removed and disposed of safely (not by composting). Selection of species that are not susceptible to infection by *C. asterum* could be considered if a grower decides to produce other plants. However, even those species of Compositae and Pinaceae that are not currently recorded as natural hosts could succumb to infection. If a grower wishes to keep growing plants in these families then they would need to be vigilant and take eradication action if symptoms of rust infection appear.

Outdoors – Pinus *spp.:*

For *Pinus* spp. in timber plantations, controls are unlikely to be necessary as only young plants are likely to suffer if they become infected. For *Pinus* spp. on outdoor nurseries, controls should centre around: using healthy planting material sourced from pest-free areas or places of production, not planting on wet/humid sites, avoidance of over-crowding of planted trees to encourage adequate sunlight and air circulation, removal of alternate hosts (mainly *Solidago* and *Aster*) by roguing or the use of herbicides up to *ca*. 800m from the sites, and, pruning of infected twigs in severe outbreaks. Valuable trees could be protected by spraying

appropriate/approved protectant fungicides in late summer and early autumn when they are most susceptible to infection

Outdoors – ornamental plants for planting and cut flower crops in the family Compositae
Disease prevention and control for cultivated susceptible ornamental plants grown outdoors either as plants for planting or as flowers for cutting is likely to be similar to that used for *Pinus* spp. Fungicide use as protectants or for eradication should be carefully considered and deployed in such a way so as to avoid the development of resistance to the active ingredients as well as the suppression of symptoms (i.e. to avid movement of asymptomatic infected plants). Choosing to grow members of the family Compositae that are currently not susceptible to *C. asterum* may need to be considered but these would need to be observed to see if they succumbed to infection. Control of susceptible weeds and other weeds that favour humidity and wetness at places of production would be required.

17. Is there a need for a detailed PRA?

No	✓

There should be sufficient detail in this PRA to be able to consult stakeholders on whether or not to apply phytosanitary controls or to choose to manage *C. asterum* themselves if it becomes established in the UK (if it isn't already present). The related rust, *C. tussilaginis* is already present and widespread in the UK and appears not to be causing a problem for growers of susceptible species, presumably because existing non-statutory controls (weed control and fungicides) are effective against this indigenous related rust. Provided growers are made aware of the rust *C. asterum* and the benefits from current practices which appear to be limiting the impact of *C. tussilaginis* then it may not be necessary to enact additional phytosanitary controls. Stakeholder consultation would help determine future action.

18. IMAGES OF PEST

Coleosporium asterum on *Pinus sylvestris*

Source: USDA Forest Service - North Central Research Station Archive, USDA Forest Service, Bugwood.org - See more at: http://www.forestryimages.org/browse/detail.cfm?imgnum=1406005#sthash.3T6DcBaP.dpuf

Coleosporium asterum on goldenrod

Source: Christmas Tree IPM Pest web page sponsored by the Department of Plant Pathology at Cornell http://www.plantpath.cornell.edu/Trees/ColeospRust.html

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

Yes Statutory action		No Statutory action	✓

From May 2002 to January 2014, statutory action has only been taken on one of the nine interceptions of *C. asterum* on cut flowers imported into the UK from Africa (albeit two of the consignments on which no action was taken were destined for Barbados). Though entry of the pathogen on cut flowers is considered unlikely due to the lack of opportunities for the pest to transfer to a suitable host, it is possible *C. asterum* may already have entered the UK. If *C. asterum* has been introduced, or is introduced in the future, it may be inadvertently controlled on places of production by non-statutory controls that are limiting damage by the endemic rust, *C. tussilaginis*. This related rust has a similar lifecycle to *C. asterum* and is present and widespread in the UK but appears not to be causing a problem, at least in commercial production. This is most likely because non-statutory practices for weed control for production of young pines and cultivated Compositae as well as fungicide use against other rusts are inadvertently protecting these crops from infection. Provided growers are made aware of this, then they should be able to manage the risk from *C. asterum* by good practice.

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