Canadian Food Inspection Agency | Agence canadienne d'inspection des aliments

PLANT HEALTH RISK ASSESSMENT

ARGYROTAENIA FRANCISCANA BORDEN

ORANGE TORTRIX

Figure 1: Adult orange tortrix (*Argyrotaenia franciscana*) © Mark Dreiling, Bugwood.org

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EXECUTIVE SUMMARY

Native to the United States, the orange tortrix moth (*Argyrotaenia franciscana* Borden) is believed to have spread along the Pacific coast to Canada and Mexico. *Argyrotaenia franciscana* is one of the most polyphagous species of North American Lepidoptera with over 160 hosts listed. Nearly all hosts are alien plants or native plants growing in domesticated habitats. Fruit species are most impacted by this pest as larvae feed on developing buds, blossoms, fruits, stems and leaves of hosts, damaging fruit quality and yield as well as being a contaminant during harvesting. Many parasites control the population of this moth in its native range; however, none are believed to be present in the UK.

The current assessment indicates with climate modelling that *Argyrotaenia franciscana* would be able to survive and establish in some parts of the PRA area if accidentally introduced. Known hosts of this moth are present across the PRA area and it is anticipated that new hosts would be recorded in the UK.

INTRODUCTION

The purpose of this pest risk assessment is to evaluate the plant health risk associated with *Argyrotaenia franciscana* (orange tortrix). This pest risk assessment was identified via a Commodity Risk Assessment on blueberry plants from Canada to the UK for the Jens-Georg Unger Plant Health Fellowship project, funded by the European and Mediterranean Plant Protection Organisation (EPPO). This project was led by a visiting scientist from the UK Department for the Environment, Food and Rural Affairs, utilising the tools and templates of the Canadian Food Inspection Agency and coordinating with experienced Canadian risk assessors. The method used by the CFIA to initiate and conduct this risk assessment is consistent with international guidelines for pest risk analysis (PRA) (IPPC 2017).

The risk assessment summarizes the available information on *Argyrotaenia franciscana* and evaluates the probability of entry, establishment, and spread in the PRA area, and the potential economic and environmental consequences. The factors considered in each of these sections, along with the guidelines used to assign risk and uncertainty ratings, are provided in a separate document[1]. Overall risk and uncertainty are summarized in terms of probability and consequences. This risk assessment will help risk managers develop an appropriate action plan regarding *A. franciscana*.

[1] Guidelines that are used to assign risk and uncertainty ratings can be requested from the National Manager, Plant Health Risk Assessment Unit, CFIA.

BACKGROUND

Initiation Point: This risk assessment was initiated by the identification of a pest that may require phytosanitary measures.

Brief History of Request: This pest was identified during a commodity risk assessment on blueberry plants for planting imported to the UK from Canada. Following a pest categorisation, *Argyrotaenia franciscana* was assessed to have the potential to satisfy the definition of a quarantine pest in the United Kingdom ("UK") and a Pest Risk Analysis was recommended.

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

Previous documents: A categorization was conducted for *Argyrotaenia franciscana* in August 2022. The categorization indicated that *A. franciscana* qualifies as a potential quarantine pest[2] and could present a risk to the PRA area. A full risk assessment was recommended. There has been no previous risk assessment prepared by the CFIA for *A. franciscana*.

IDENTITY OF ORGANISM

Name: *Argyrotaenia franciscana* Borden (Lepidoptera: Tortricidae)

Synonyms: *Argyrotaenia citrana* (Fernald), *Argyrotaenia purata* Freeman, *Cacoecia franciscana* Penny, *Eulia citrana* Essig, *Eulia franciscana* Frost, *Tortrix citrana* Fernald, *Lozotaenia franciscana* Walsingham

English common names: Orange tortrix, apple skinworm (Gilligan & Epstein 2014)

French common names: Tordeuse des citrus (EPPO 2022)

Description of the organism: *Argyrotaenia franciscana* adults are distinguished from other species in the *Argyrotaenia* genus by possessing a triangular second joint on the appendage in the mouth region used for touching or tasting (known as a palpal appendage) (Freeman 1944). *Argyrotaenia franciscana* is a

[2] A quarantine pest is a "pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled" (IPPC 2018).

member of the Archipini tribe. Its larvae are difficult to distinguish from many species of this tribe, possessing the common features of a brown, unmarked head and prothoracic shield (a plate on the upper surface of the first thorax segment) (Gilligan & Epstein 2014). Eggs of *A. franciscana* are flat, oval, and pale green to cream when laid though darken over time. They are laid in a mass overlapping each other (Basinger 1938).

In the past, *Argyrotaenia franciscana* and *Argyrotaenia citrana* were thought to be separate species, however, with the use of molecular data, it was established that they form a single species (Landry *et al.* 1999).

Lifecycle: There may be between two to five generations of *Argyrotaenia franciscana* per year (Gilligan & Epstein 2014). The lifecycle of this moth is as follows: adults are sexually active during their first scotophase (period of darkness) (Knight 1996). One to three days after mating, multiple egg masses are laid by each female moth, varying in size though typically over 200 eggs in total (Knight 1996, van der Geest & Evenhuis 1991). Egg masses are laid preferably on smooth surfaces, such as foliage, twigs or fruit (Basinger 1938). Once hatched, larvae seek shelter and food, dispersing by spinning down threads of silk which are often carried further by wind (PNW 2022). Larvae then roll leaves together to other leaves, buds, blossoms, stems or fruits to form a shelter upon which they feed (Basinger 1938). When disturbed, larvae wiggle away or drop to the ground (Basinger 1938). *Argyrotaenia franciscana* larvae and pupae overwinter in these shelters on the ground or plastered to canes (Oregon Blueberry No date, PNW 2022). They also overwinter in mummified fruits, in cane galls, under buds or on nearby herbaceous plants (Gilligan & Epstein 2014, Rosenstiel 1949).

Larval instars vary from five to seven, with pupation occurring in the final larval shelter on the ground or on plants (Basinger 1938). Once the adults have emerged, adults disperse by flight though the adult females do not appear to fly distances of 400m or more. They can fly at least 100m to nearby fields (Knight 1986). The adult moths prefer dark areas and remain close to the leaves of trees and plants. Mating and oviposition occur within a few days after emergence (Basinger 1938).

Hosts: This pest is one of the most polyphagous species of North American Lepidoptera and is found on hosts in both urban and agricultural areas, spanning horticulture, forestry and weed species (Powell 1964). Citrus and other fruit species are the main hosts of *Argyrotaenia franciscana*. For example, larvae may feed and overwinter on a wide range of hosts surrounding commercial caneberry fields, but the vast majority of larvae overwinter in the commercial fields (LaLone *et al.* 1988). The reasons for this host preference are unknown. It could be due to the uncontrolled numbers of natural enemies in the wild. Nearly all hosts of *A. franciscana* are alien plants or native plants growing in domesticated habitats (Powell 1964).

The host plants of this insect have been reported as follows (Basinger 1938, Gilligan & Epstein 2014):

Table 1: Reported host range of *Argyrotaenia franciscana*

Family	Genus/species	Common name
Anacardiaceae	*Schinus molle* L.	Peruvian peppertree
Apocynaceae	*Nerium oleander* L.	nerium
Aquifoliaceae	*Ilex opaca* Aiton	American holly
Araliaceae	*Aralia* L.	spikenard
Araliaceae	*Hedera helix* L.	English ivy
Asteraceae	*Achillea millefolium* L.	common yarrow
Asteraceae	*Artemisia californica* Less.	coastal sagebrush
Asteraceae	*Artemisia douglasiana* Besser	Douglas' sagewort
Asteraceae	*Baccharis pilularis* DC.	coyotebrush
Asteraceae	*Baccharis* L.	baccharis
Asteraceae	*Cineraria* L.	
Asteraceae	*Cirsium occidentale* (Nutt.) Jeps.	cobwebby thistle
Asteraceae	*Coreopsis gigantea* (Kellogg) H. M. Hall	giant coreopsis
Asteraceae	*Coreopsis* L.	tickseed
Asteraceae	*Corethrogyne* DC.	sandaster
Asteraceae	*Encelia californica* Nutt.	California brittlebush
Asteraceae	*Erigeron glaucus* Ker Gawl.	seaside fleabane
Asteraceae	*Eriophyllum staechadifolium* Lag.	
Asteraceae	*Gnaphalium* L.	cudweed
Asteraceae	*Grindelia camporum* Greene	Great Valley gumweed
Asteraceae	*Grindelia hirsutula* Hook. & Arn.	hairy gumweed
Asteraceae	*Grindelia* Willd.	gumweed
Asteraceae	*Isocoma veneta* (Kunth) Greene	goldenbush
Asteraceae	*Lactuca sativa* L.	lettuce
Asteraceae	*Lessingia* Cham.	lessingia
Asteraceae	*Leucanthemum maximum*	Max chrysanthemum
Asteraceae	*Pericallis hybrida* B. Nord.	common ragwort
Asteraceae	*Pseudognaphalium biolettii* Anderb.	two-color rabbit-tobacco
Asteraceae	*Pseudognaphalium californicum* (DC.) Anderb.	ladies' tobacco
Asteraceae	*Senecio jacobaea* L.	stinking willie
Asteraceae	*Solidago simplex* Kunth	Mt. Albert goldenrod
Asteraceae	*Solidago* L.	goldenrod
Begoniaceae	*Begonia* L.	begonia
Berberidaceae	*Mahonia pinnata* (Lag.) Fedde	wavyleaf barberry
Berberidaceae	*Mahonia* Nutt.	barberry
Buddlejaceae	*Buddleja* L.	butterflybush
Brassicaceae	*Brassica* L.	Cruciferous vegetables
Caprifoliaceae	*Lonicera involucrata* (Richardson) Banks ex Spreng.	twinberry honeysuckle
Caprifoliaceae	*Sambucus nigra* L. ssp. *cerulea* (Raf.) R. Bolli	blue elderberry
Caprifoliaceae	*Symphoricarpos albus* (L.) S. F. Blake	common snowberry
Caryophyllaceae	*Dianthus caryophyllus* L.	carnation
Caryopyllaceae	*Spergularia macrotheca* (Hornem.) Heynh.	sticky sandspurry
Celastraceae	*Euonymus* L.	spindle tree

Chenopodiaceae	*Chenopodium* L.	goosefoot
Commelinaceae	*Tradescantia fluminensis*	river spiderwort
Commelinaceae	*Tradescantia zebrina* hort. ex Bosse	inchplant
Convolvulaceae	*Calystegia macrostegia* (Greene) Brummitt	island false bindweed
Convolvulaceae	*Convolvulus* L.	bindweed
Crassulaceae	*Dudleya farinosa* (Lindl.) Britt. & Rose	powdery liveforever
Crassulaceae	*Sedum spathulifolium* Hook.	broadleaf stonecrop
Cupressaceae	*Chamaecyparis lawsoniana* (A. Murray) Parl.	Port Orford cedar
Cupressaceae	*Cupressus macrocarpa* Hartw. ex Gord.	Monterey cypress
Cupressaceae	*Sequoia sempervirens* (Lamb. ex D. Don) Endl.	redwood
Cupressaceae	*Thuja plicata* Donn ex D. Don	western redcedar
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	western brackenfern
Dryopteridaceae	*Dryopteris arguta* (Kaulf.) Watt	coastal woodfern
Ericaceae	*Arbutus menziesii* Pursh	Pacific madrone
Ericaceae	*Arbutus* L.	madrone
Ericaceae	*Arctostaphylos imbricata* Eastw.	San Bruno Mountain manzanita
Ericaceae	*Vaccinium* L.	blueberry
Ericaceae	*Vaccinium ovatum* Pursh	California huckleberry
Fabaceae	*Acacia* Mill.	acacia
Fabaceae	*Astragalus miguelensis* Greene	San Miguel milkvetch
Fabaceae	*Cytisus scoparius* (L.) Link	Scotch broom
Fabaceae	*Lotus scoparius* (Nutt.) Ottley	common deerweed
Fabaceae	*Lotus* L.	trefoil
Fabaceae	*Lupinus arboreus* Sims	yellow bush lupine
Fabaceae	*Lupinus chamissonis* Eschsch.	Chamisso bush lupine
Fabaceae	*Lupinus* L.	lupine
Fagaceae	*Quercus agrifolia* Nee	California live oak
Fagaceae	*Quercus douglasii* Hook. & Arn.	blue oak
Fagaceae	*Quercus dumosa* Nutt.	coastal sage scrub oak
Fagaceae	*Quercus* L.	oak
Geraniaceae	*Erodium* L'Her. ex Aiton	stork's bill
Geraniaceae	*Geranium* L.	cranebills
Geraniaceae	*Pelargonium* L'Her. ex Aiton	geranium
Grossulariaceae	*Ribes amarum* McClatchie	bitter gooseberry
Grossulariaceae	*Ribes malvaceum* Sm.	chaparral currant
Grossulariaceae	*Ribes menziesii* Pursh	canyon gooseberry
Grossulariaceae	*Ribes sanguineum* Pursh	redflower currant
Grossulariaceae	*Ribes* L.	currant
Hippocastanaceae	*Aesculus californica* (Spach) Nutt.	California buckeye
Hydrophyllaceae	*Eriodictyon californicum* (Hook. & Arn.) Torr.	California yerba santa
Hydrophyllaceae	*Phacelia malvifolia* Cham.	stinging phacelia
Juglandaceae	*Juglans regia* L.	English walnut
Juglandaceae	*Juglans* L.	walnut
Lamiaceae	*Lavandula angustifolia* Mill.	English lavender
Lamiaceae	*Monardella villosa* Benth.	coyote mint
Lamiaceae	*Monardella* Benth.	monardella
Lamiaceae	*Stachys bullata* Benth.	California hedgenettle
Lamiaceae	*Stachys* L.	hedgenettle
Lauraceae	*Persea americana* Mill.	avocado

Lauraceae	*Umbellularia californica* (Hook. & Arn.) Nutt.	California laurel
Liliaceae	*Asparagus* L.	asparagus
Liliaceae	*Calochortus catalinae* S. Watson	Santa Catalina mariposa lily
Liliaceae	*Calochortus* Pursh	mariposa lily
Malvaceae	*Malva* L.	mallow
Malvaceae	*Sphaeralcea ambigua* A. Gray	desert globemallow
Myricaceae	*Morella californica* (Cham.) Wilbur	California wax myrtle
Myrtaceae	*Eucalyptus* L'Her.	gum
Onagraceae	*Epilobium canum* (Greene) P.H. Raven ssp. Canum	hummingbird trumpet
Onagraceae	*Epilobium* L.	willowherb
Onagraceae	*Oenothera* L.	evening primrose
Pinaceae	*Abies* Mill.	fir
Pinaceae	*Cedrus deodara* (Roxb.) G. Don f.	Deodar cedar
Pinaceae	*Picea* A. Dietr.	spruce
Pinaceae	*Picea pungens* Engelm.	blue spruce
Pinaceae	*Pinus radiata* D. Don	Monterey pine
Pinaceae	*Pinus* L.	pine
Pinaceae	*Pseudotsuga menziesii* (Mirb.) Franco	Douglas-fir
Pinaceae	*Pseudostuga* Carriere	Douglas-fir
Pinaceae	*Tsuga canadensis* (L.) Carriere	eastern hemlock
Pinaceae	*Tsuga Carriere*	hemlock
Pittosporaceae	*Pittosporum eugenioides*	lemonwood
Poaceae	*Coix lacryma-jobi* L.	Job's tears
Polygonaceae	*Eriogonum latifolium* Sm.	seaside buckwheat
Polygonaceae	*Eriogonum parvifolium* Sm.	seacliff buckwheat
Proteaceae	*Macadamia* F. Muell.	macadamia
Ranunculaceae	*Aquilegia* L.	columbine
Rhamnaceae	*Ceanothus arboreus* Greene	feltleaf ceanothus
Rhamnaceae	*Ceanothus oliganthus* Nutt.	hairy ceanothus
Rhamnaceae	*Ceanothus sorediatus* Hook. & Arn.	jimbrush
Rhamnaceae	*Ceanothus thyrsiflorus* Eschsch.	blueblossom
Rhamnaceae	*Ceanothus* L.	ceanothus
Rhamnaceae	*Frangula californica* (Eschsch.) A. Gray	California buckthorn
Rosaceae	*Adenostoma* Hook. & Arn.	chamise
Rosaceae	*Crataegus* L.	hawthorn
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl.	loquat
Rosaceae	*Fragaria* L.	strawberry
Rosaceae	*Heteromeles arbutifolia* (Lindl.) M. Roem.	toyon
Rosaceae	*Horkelia californica* Cham. & Schltdl.	California horkelia
Rosaceae	*Lyonothamnus floribundus* A. Gray ssp. *aspleniifolius* (Greene) P. H. Raven	fern-leaf Catalina ironwood
Rosaceae	*Malus pumila* Mill.	paradise apple
Rosaceae	*Malus sylvestris* (L.) Mill.	European crab apple
Rosaceae	*Malus* Mill.	apple
Rosaceae	*Potentilla* L.	cinquefoil
Rosaceae	*Prunus armeniaca* L.	apricot
Rosaceae	*Prunus avium* (L.) L.	sweet cherry
Rosaceae	*Prunus domestica* L.	European plum

Rosaceae	*Prunus dulcis* (Mill.) D. A. Webb	sweet almond
Rosaceae	*Prunus persica* (L.) Batsch	peach
Rosaceae	*Prunus* L.	
Rosaceae	*Pyracantha* M. Roem.	firethorn
Rosaceae	*Pyrus* L.	pear
Rosaceae	*Rosa* L.	rose
Rosaceae	*Rubus idaeus* L.	raspberry
Rosaceae	*Rubus parviflorus* Nutt.	thimbleberry
Rosaceae	*Rubus ursinus* Cham. & Schltdl.	California blackberry
Rosaceae	*Rubus vitifolius* Cham. & Schltdl.	Pacific dewberry
Rosaceae	*Rubus* L.	caneberry
Rubiaceae	*Pentas* Benth.	
Rutaceae	*Citrus* L.	citrus
Salicaceae	*Salix lasiolepis* Benth.	arroyo willow
Salicaceae	*Salix* L.	willow
Sapindaceae	*Filicium decipiens* Thwaites	
Scrophulariaceae	*Castilleja affinis* Hook. & Arn.	coast Indian paintbrush
Scrophulariaceae	*Castilleja exserta* (A. Heller) T.I. Chuang & Heckard ssp. *exserta*	exserted Indian paintbrush
Scrophulariaceae	*Castilleja* Mutis ex L. f.	Indian paintbrush
Scrophulariaceae	*Diplacus aurantiacus* (W. Curtis) Jeps. ssp. *aurantiacus*	orange bush monkeyflower
Scrophulariaceae	*Scrophularia californica* Cham. & Schltdl.	California figwort
Scrophulariaceae	*Scrophularia* L.	figwort
Scrophulariaceae	*Veronica* L.	speedwell
Solanaceae	*Solanum douglasii* Dunal	greenspot nightshade
Solanaceae	*Solanum pseudocapsicum* L.	Jerusalem cherry
Thymelaeaceae	*Dirca occidentalis* A. Gray	western leatherwood
Urticaceae	*Urtica* L.	nettle
Verbenaceae	*Lantana* L.	lantana
Vitaceae	*Vitis vinifera* L.	wine grape

Current distribution:

North America: Canada, Mexico, United States (see Figure 2).

This moth is present in the Pacific Northwest of the United States ("U.S.") and British Columbia in Canada, as shown in Figure 2. It has also been found in Baja California, Mexico (Belton 1988, Brown 2004, Coquillett 1894, Gilligan *et al.* 2020). This pest has been reported in other states of the U.S., in Arizona, Idaho, Kansas, Montana, Michigan and Nevada, however these reports are either very old or rare.

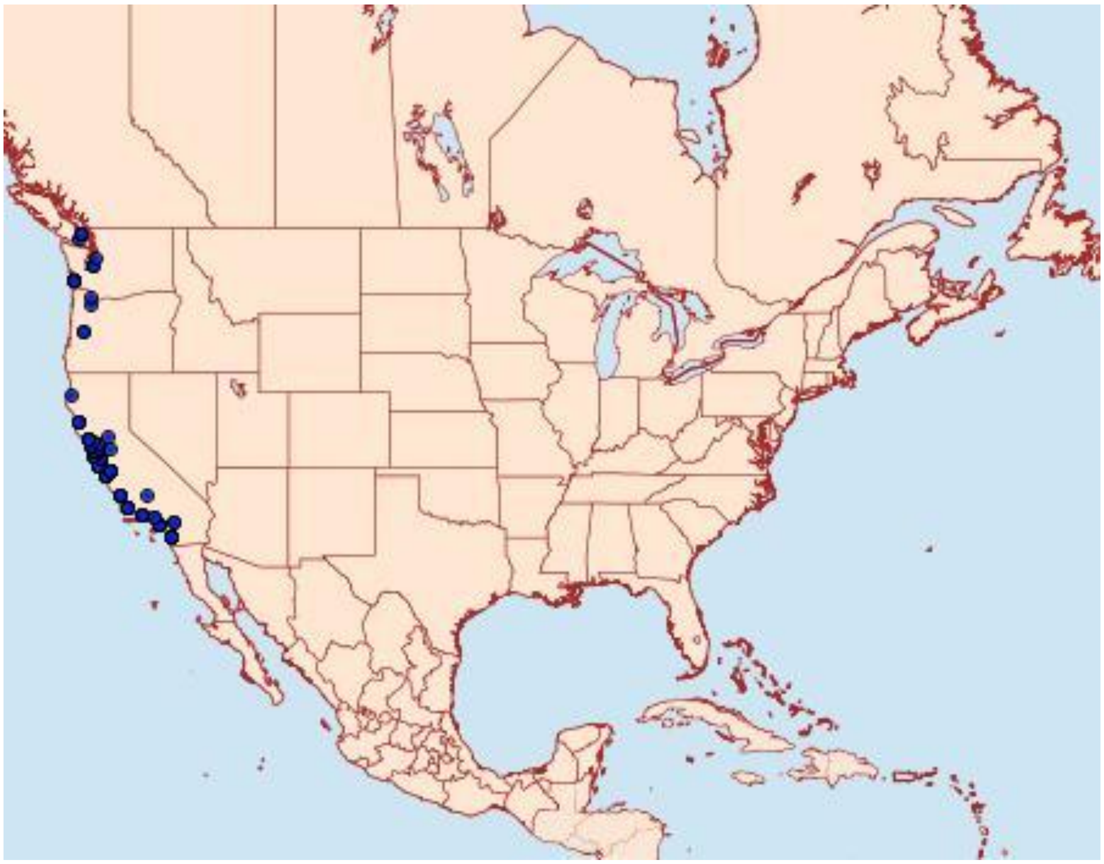

Figure 2: Distribution of *Argyrotaenia franciscana* in Canada and the United States (Moth Photographers Group 2023)

PRESENCE / ABSENCE IN THE PRA AREA

Argyrotaenia franciscana is not known to be present in the PRA area.

CURRENT REGULATORY STATUS

Argyrotaenia franciscana is not currently regulated as a pest in the UK. However, it is regulated as a quarantine pest in Argentina, Cambodia, Chile, Japan, Mexico, Morocco, New Zealand, The Republic of Korea and Western Australia (AGRIC 2022, EPPO 2022, MPI 2022). This pest is not currently listed on the EPPO lists recommended for regulation (EPPO 2023).

PROBABILITY OF ENTRY

Based on the pest biology and host preferences, several pathways for entry into the UK can be identified:

1. Produce (fresh fruits and vegetables for consumption)
2. Plants for planting
3. Cut flowers

Pathway 1: Produce

This pathway focuses on fruit of *Citrus* spp. (such as orange and lemon), *Fragaria* spp. (strawberry), *Malus* spp. (apple), *Persea americana* (avocado), *Prunus* spp. (such as peach, apricot, cherry), *Pyrus* spp. (pear), *Ribes* spp. (currant), *Rubus* spp. (such as raspberry and blackberry), *Vaccinium* spp. (such as blueberry) and *Vitis vinifera* (grape). Vegetables, such as *Asparagus* spp., *Brassica* spp. (such as broccoli) and *Lactuca sativa* (lettuce) and nuts like *Juglans* spp. (walnut) and *Macadamia* (macadamia) are also included though the impact of this pest on these commodities was much less reported.

Probability of association with the pathway at origin **Rating: Low**

This pest is found primarily in cooler coastal areas and river valleys of the Pacific Northwest (Gilligan & Epstein 2014). This is a highly productive agricultural region, with crops like apples, blackberries, blueberries, cherries, pears and raspberries grown that can all act as hosts for *Argyrotaenia franciscana* (Gillespie & Beirne 1982, USDA No date).

All developmental stages of *Argyrotaenia franciscana* are present throughout the year (Gilligan & Epstein 2014, van der Geest & Evenhuis 1991), therefore every stage could be found on the fruit. Eggs are often laid on fruit and larvae feed upon it, as well as often including fruit in their protective shelters (Basinger 1938). Although eggs and larvae are more likely, pupation occurs in the last larval shelter which could be on a host plant or on the ground (Basinger 1938, Gilligan & Epstein 2014). Larvae typically only feed on the surface of developing fruits (Basinger 1938, Oregon Blueberry No date), minimising the risk of association, however they can be dislodged from their shelters and fall in the picking flats during harvest (Oregon Blueberry No date, Rosenstiel 1949). Pickers can also unintentionally transfer the larvae to the picking flats after contacting the larvae-produced silk (Rosenstiel 1953). Larvae have also been reported to bore holes in the fruit (Georgala *et al.* 1975, LaLone *et al.* 1988, Rosenstiel 1949). As a result, they sometimes remain inside the fruit when picked and are taken to processing facilities (Rosenstiel 1953, Vaughan & Rosenstiel 1944), though this appears to be a rare occurrence when populations are large and has only been reported on certain fruits (blackberry, boysenberry, raspberry) (Bolda 2009, LaLone *et al.* 1988). Previous science advice drafted by CFIA on *A. franciscana* has noted that this pest is not expected to enter the fruit (CFIA 2019).

Interceptions of *Argyrotaenia franciscana* on imported fruit have been detected in the past, on apricots and peaches in Canada (CFIA 2000) and table grapes in New Zealand (Biosecurity New Zealand 2009). *Argyrotaenia* spp. have been intercepted on apples (CFIA 2000), strawberries, blueberries, and blackberries as well as Pandanus grass (leaves of *Pandanus* sp. used for cooking) (Camille Grenier, Canadian Food Inspection Agency, *pers. comm*., Sept. 15, 2022).

However, in Canada, this moth is not found frequently. It is likely that *Argyrotaenia franciscana* is controlled by sprays against any leafroller, fruitworm or fruit fly pest (Tracy Hueppelsheuser, Canadian Food Inspection Agency, *pers. comm*. to M. Damus, Sept. 28, 2022). In Mexico, *A. franciscana* is seen as a serious threat to its horticultural industry and therefore of economic importance. As such, it is a regulated quarantine pest and under regular surveillance (SENASICA 2019).

In the U.S. (California), *Argyrotaenia franciscana* is generally not considered to be a significant pest (David Haviland, University of California, *pers. comm*., Oct. 12, 2022; Elizabeth Grafton-Cardwell, University of California, Sept. 29, 2022; Lucia Graciela Varela, University of California, *pers. comm*., Oct. 01, 2022). Existing biological control typically suppresses this moth (David Haviland, University of California, *pers. comm*., Oct. 12, 2022; Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022) although it is an occasional problem in coastal areas on citrus and grapes (Lucia Graciela Varela, University of California, *pers. comm*., Oct. 01, 2022; Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022). Applications of broad-spectrum pesticides, following the spread of *Diaphorina citri* (Asian citrus psyllid), likely impacted natural enemies of *A. franciscana* on citrus crops. In recent years, an increase of *A. franciscana* populations and subsequent damage has been observed with 40% to 70% of lemon fruit calyces infested and with feeding scars on the immature fruit (Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022). In certain coastal regions,

Table 1: Average annual exports of fresh produce in net mass (kg) from Canada, Mexico and United States to the United Kingdom from 2017 to 2021, rounded to the nearest 10,000 (HMRC 2022)[3]. Any starred figure (*) indicates export activity from areas with the pest in the United States and Canada (Statistics Canada 2022, USATrade 2022).

[3] Averages were taken for commodities where trading activity has occurred for three consecutive years or more in this time range.

grapes are monitored for this pest, but outbreaks can be easily controlled by the application of pesticides (Lucia Graciela Varela, University of California, *pers. comm*., Oct. 01, 2022).

Commodity	**Canada**	**Mexico**	**United States**
Brassica vegetables (fresh or chilled)	-	-	40,000
Lettuce (fresh or chilled)	20,000	-	-
Asparagus (fresh or chilled)	-	470,000	3,210,000*
Avocados (fresh or chilled)	-	5,200,000	2,260,000
Apples (fresh)	230,000	-	2,340,000*
Citrus fruit (fresh or dried)	-	8,880,000	1,030,000*
Cherries (fresh, excluding sour cherries)	260,000*	-	620,000*
Grapes (fresh)	-	110,000	2,140,000*
Strawberries (fresh)	-	80,000	350,000*

Raspberries, blackberries, mulberries and loganberries (fresh)	-	1,050,000	510,000*
Walnuts (fresh or dried, in shell and shelled)	-	-	5,230,000*
Cranberries, blueberries and other berries from the *Vaccinium* genus	190,000*	60,000	610,000*

Probability of survival during transport or storage **Rating: Low**

It is unlikely that this pest will continue to be associated with the fruit after transport or storage. Larvae of *Argyrotaenia franciscana* have been reported to leave the fruit containers during transport to remain in the storage and processing facilities. In addition, the remaining larvae are likely to be detected and removed from the fruit at the processing facility (Oregon Blueberry No date). The shelters that the pest produces and resides in as larvae and pupae increase the chance of detection (CFIA 2019) as would the signs of feeding on the fruit (Australian Government 2010). However, detection is less likely if larvae are feeding inside the fruit or if the larvae are small and immature. Many larvae locate under the sepals of fruit to feed (Basinger 1938; Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022), making detection more difficult or for the larvae to be removed at the processing facility (Australian Government 2010).

The optimal conditions for handling, storage and transportation of fresh strawberries, blueberries, grapes, raspberries and blackberries are 0°C and 90-95% relative humidity (BMT No date, OMAFRA 2016). Apples, asparagus, brassica vegetables, cherries, lettuce, pears, and peaches are all stored in similar conditions with temperatures very close to 0°C and high humidity (BMT No date, OMAFRA 2012a, b). If the pest persisted on the fruit, this temperature should prevent the development of this pest. *Argyrotaenia franciscana* requires temperatures of above 5°C for eggs to hatch and 6-32°C to complete larval development (Basinger 1938, Coop 1982, Kido *et al.* 1981). Nevertheless, low temperatures do not cause immediate mortality – many newly hatched larvae lived longer than 3 weeks in temperatures of 1.7°C (Basinger 1938). Therefore, the probability of pest survival is low as it will be impacted but possibly not completely destroyed by the duration of time in storage.

Storage can be as short as 2-5 days for blackberries, or 2-6 months for grapes (BMT No date, OMAFRA 2016). Storage and transportation of other host fruit, such as avocados and citrus fruits, occur at higher temperatures (BMT No date) and is less likely to have an impact on pest development, potentially enabling pupation and egg hatching to occur. Some fruit is also imported frozen, such as blueberries.

Freezing should eliminate the pest, given that *Argyrotaenia franciscana* larvae and eggs experience high mortality in subfreezing temperatures (Coop 1982, Knight & Croft 1986).

Probability of surviving existing pest management procedures Rating: Medium

To import fruits from Canada, the U.S. and Mexico into the UK, one option is that these fruits must be subject to an effective systems approach or post-harvest treatment to ensure freedom from certain insect pests. These requirements apply for fruits of *Malus* and *Pyrus* concerning the pest *Anthonomus quadrigibbus*, they also apply to fruits of *Malus* concerning the pests *Grapholita prunivora*, *G. inopinata*, *Rhagoletis pomonella* and *Botryosphaeria kuwatsukai*. To import fruits of *Malus, Prunus, Pyrus* and *Vaccinium*, options include that these fruits must be grown in a site that has been subject to preventive treatments against *Grapholita packardi*, or the fruits themselves are subject to an effective systems approach to ensure freedom from the pest (which could involve preventive treatments). Considering that the aforementioned pests are insects, and several in the same family as *Argyrotaenia franciscana*, it is likely that these treatment options would also be effective against *A. franciscana*. However, other import requirements can be chosen by the exporter (Defra 2020, EU 2019). In addition, these requirements only apply to a limited number of types of host produce.

Probability of transfer to a suitable habitat Rating: Low

The imported produce would typically go out to numerous wholesale outlets, then to retail and finally to the consumer (Holt *et al.* 2017). Some produce may go to a growing site for re-packing that could enable the transfer of the pest to host plants, cultivated or wild. However, there are usually biosecurity measures in place to prevent transmission, like keeping the areas separate (AHDB, *pers. comm.,* 2022). A pest transfer could also occur from discarded produce waste to a suitable host though there would be a limited time window for the insect to complete its development as the produce degrades (Australian Government 2020).

Pathway 2: Plants for planting (excluding seeds, bulbs, tubers, crowns and rhizomes)

This pathway encompasses the relevant plants for planting, spanning horticulture, ornamental and forestry species, in Table 1. Weed species, like *Convolvulus arvensis* or *Urtica dioica*, were not included in this assessment as they are not purposefully imported. Seeds, bulbs, tubers, crowns and rhizomes are excluded as the association of this pest with these commodities, grown underground or within produce, appears extremely unlikely.

Probability of association with the pathway at origin Rating: Low

As mentioned previously, the Pacific Northwest is a highly productive agricultural region growing many horticultural hosts (Gillespie & Beirne 1982, USDA No date). All life stages of *Argyrotaenia franciscana* are likely to be associated with host plants for planting, given that eggs are often laid on foliage or twigs and the larvae roll leaves together or to buds or blossoms on the host plant to form a shelter (Basinger 1938, Ebeling & Pence 1957, Gilligan & Epstein 2014, PNW 2022). Larvae also feed and overwinter on these shelters and on the stem (Gilligan & Epstein 2014, Rosenstiel 1949). Finally, the adults prefer dark, shaded areas and remain close to the leaves of trees and plants, flying out if disturbed before returning (Basinger 1938).

This pest has been intercepted in the past on cuttings of *Pelargonium* sp. (geranium) (CFIA 2000), as well as *Pelargonium* and *Citrus* plants for propagation or ornamental use in Canada. An *Argyrotaenia* sp. has also been intercepted on a *Taxus* sp. plant (Camille Grenier, Canadian Food Inspection Agency, *pers. comm.,* Sept. 15, 2022).

The following host species may not be introduced into Great Britain from Canada, the U.S. or Mexico, pending a risk assessment:

- *Acacia* Mill.
- *Crataegus* L.
- *Juglans* L.
- *Lonicera involucrata* (Richardson) Banks ex Spreng.
- *Malus* Mill.
- *Nerium oleander*
- *Persea americana*
- *Prunus* L.
- *Quercus* L.
- *Salix* L.
- *Taxus* L.

In addition, the importation of plants of *Abies, Cedrus, Chamaecyparis, Citrus, Pinus, Picea, Pseudotsuga, Tsuga, Vitis* and *Rosa* is prohibited from Canada, the U.S. or Mexico into the UK, though *Rosa* spp. may be imported if dormant and free from leaves, flowers and fruits. The importation of *Pyrus* and *Fragaria* plants for planting is also prohibited from Mexico (Defra 2020) but *Pyrus* may be imported from Canada and the U.S. if dormant and free from leaves, flowers and fruit. Notably, due to the import requirements concerning the pathogen *Xylella fastidiosa*, the importation of *Brassica, Pelargonium*, *Rubus* and *Vaccinium* plants for planting from Canada or Mexico cannot occur due to the lack of declaration for a pest-free area or place of production (Defra 2022a). However, this could change in future if a declaration was made by the relevant NPPOs.

90,000 kg of edible fruit or nut trees, shrubs and bushes and 170,000 kg of live plants (excluding the relevant commodities such as fruit and nut trees, roses, unrooted cuttings and slips) are annually exported from Mexico to the UK (HMRC 2022). However, the majority of relevant host species that are likely to be grown and exported commercially will not be included in these volumes, given the aforementioned prohibitions. In addition, zero exports of *Ribes* plants for planting (including shrubs, trees, woody plants, and cuttings) from Mexico were reported in 2021 (Rachael Longhorn, Animal and Plant Health Agency, *pers. comm*., Sept. 20, 2022).

Consistent trade of plants for planting from Canada and the U.S. were either negligible (in the case of edible fruit or nut plants) or very low (below 750 kg in the case of live plants and unrooted cuttings) (HMRC 2022). The total exports of *Fragaria, Rubus* and *Vaccinium* plants for planting (including shrubs, trees, woody plants, and cuttings) from the U.S. were similarly very low (less than 5) in 2021. Zero exports of *Pyrus, Fragaria* and *Ribes* plants for planting were reported from Canada (Rachael Longhorn, Animal and Plant Health Agency, *pers. comm*., Sept. 20, 2022).

To summarise, due to the stringent import requirements and limited trade for the remaining hosts, the risk of this pest associating with plants for planting appears low.

Probability of survival during transport or storage **Rating: High**

Laboratory studies have shown that *Argyrotaenia franciscana* requires temperatures of above 5°C for eggs to hatch and 6-32°C to complete larval development (Basinger 1938, Coop 1982, Kido *et al.* 1981). The transport conditions for shipping foliage plants generally occur at temperatures between 10°C and 18°C (BMT No date), therefore the pest should be able to survive transport and storage on these imports. Egg hatching and pupation should be able to occur on the plant during transport.

Probability of surviving existing pest management procedures **Rating: Medium**

All plants for planting, other than seeds, being imported into the UK from Canada, the U.S. and Mexico must be free from plant debris, fruits and flowers. They also must be accompanied by an official statement from the exporting NPPO that these plants have been inspected prior to their export and found to be free from signs of harmful insects or subject to appropriate treatment to eliminate such organisms (Defra 2020, EU 2019). These import requirements should prevent *Argyrotaenia franciscana* from entering the UK if associated with buds or flowers of the host plant.

Deciduous trees and shrubs must be dormant and free from leaves (Defra 2020, EU 2019). This import requirement significantly reduces the risk of this pest arriving if associated with the foliage. Nevertheless, there is an unmitigated risk that the pest enters on the foliage of evergreen hosts, such as certain blueberry varieties.

Probability of transfer to a suitable habitat **Rating: High**

Pupation may occur during transport (see text above), increasing the ability of this pest to disperse and locate a host plant.

A successful transfer may follow if an infested plant was moved within the vicinity of another suitable host plant. Imported plants for planting are moved to nurseries for propagation, sale to final users or for further distribution across the country to other nurseries. Nurseries are likely to be cultivating large volumes of host plants. In addition, the hosts of *Argyrotaenia franciscana* are widespread in the UK as woodland or weed species. Therefore, if introduced in the PRA area, there is a high probability that this pest could transfer to a suitable habitat.

Pathway 3: Cut flowers

The cut flowers considered for this pathway focus on ornamental host species, such as *Geranium* spp. (cranesbill), *Rosa* spp. (rose), *Solidago* spp. (goldenrod), *Begonia* spp. (begonia) and *Pelargonium* spp. (geranium).

Probability of association with the pathway at origin **Rating: Low**

Argyrotaenia franciscana could be associated with cut flowers given that eggs are laid on foliage and twigs and that larvae form a shelter with leaves, buds or blossoms, of the host plant. A single petal lying on a leaf may hide a small larva (Basinger 1938). The presence of leaves as part of this commodity also increases the risk of this leafroller pest. However no interceptions of *A. franciscana* have been reported on cut flowers, though other *Argyrotaenia* species have been found on this commodity imported into the UK (Defra 2022d). However, cut flowers need to be excellent quality to be marketable (Loyola *et al.* 2019) and it is highly likely that any damage incurred from *A. franciscana* larvae would have prevented the commodity continuing through the market chain, ruling out the possible association with the larvae. Eggs of this pest could still be associated with cut flowers.

Zero exports of the relevant cut flowers were identified from Canada or Mexico. Nevertheless, significant trade was found from the USA to the UK, with around 56,000 kg of fresh-cut roses and buds exported annually. More generally, 43,000 kg of fresh cut flowers and buds (excluding roses, carnations, orchids, chrysanthemums and lilies, but should include any exports of the remaining ornamental host species) are exported annually (HMRC 2022).

Probability of survival during transport or storage **Rating: Low**

Most cut flowers are held at 0-1°C during distribution (BMT No date) which should prevent egg hatching. Some tropical cut flowers do need to be stored in conditions of 10°C or above (BMT No date), which would allow eggs of *Argyrotaenia franciscana* to hatch. Given the climate of the known pest range (Canada, the U.S. and Mexico), the risk of *A. franciscana* on tropical flowers would only be of concern for imports from Mexico. Tropical flowers are unlikely to be grown outdoors in the Baja California region of Mexico, given that this region is cooler, being by the coast, and also contains a significant portion of deserts (Baja Flora 2023). In addition, although greenhouse horticulture is significant in Baja California (Victoria *et al.* 2011), only around 70 hectares are utilised to grow flowers (0.5% of the total floriculture area in Mexico) (Rijk 2008). Over 80% of Mexican commercial cut flowers are produced in central Mexico instead (OPF 2020).

Probability of surviving existing pest management procedures **Rating: Medium**

Importation of cut flowers is allowed with the general condition to be free of soil. Despite the foliage and flowers of the commodity providing additional cover for the pest, the shelters that the larvae reside in would make them easier to spot during inspections. In addition, the presence of larvae should only be a risk on the tropical cut flowers (see above).

Probability of transfer to a suitable habitat **Rating: Negligible**

Imported cut flowers are likely to be moved to auction or a wholesaler before transferring to retail, such as florists or supermarkets. Cold storage and transportation facilities are recommended to maintain the quality of this commodity (Sirisaranlak 2017). The possibility of this pest remaining on the cut flowers during transport was already minimum, as mentioned above, therefore the probability of transfer to a live host outdoors was deemed negligible.

Overall risk rating for probability of entry: The risk rating for probability of entry of *Argyrotaenia franciscana* into the PRA area is **Low**. Produce (rated **Low**) and plants for planting (rated **Low**) are both potential pathways for entry of this pest into the PRA area. The risk of entry via the cut flower pathway was rated as **Negligible**.

Uncertainty and information gaps: The impact of this pest in its current range in Mexico is uncertain. The scale of exports from the Baja California region in Mexico to the United Kingdom is also unknown, although it has been recorded that a significant number of host plants are cultivated in that region (SENASICA 2019). The risk of pest entry may increase with increased trade volumes of commodities associated with the potential pathways of entry, depending on the risk mitigation measures that may be put in place.

PROBABILITY OF ESTABLISHMENT

Suitability of environment and potential range in the PRA area

This moth was originally identified in California but in later years found in Canada (British Columbia), Mexico (Baja California) and other areas of the U.S. (Oregon, Washington) (Belton 1988, Brown 2004, Coquillett 1894, Gilligan *et al.* 2020).

Rare reports of this species have been made in the U.S. states of Arizona, Idaho, Kansas, Montana, Michigan and Nevada (GBIF 2022, Heppner 2004, Lotts & Naberhaus 2021, Montana Government 2022), indicating potential introduction events occurring outside of its recognised distribution. However, the reports from Idaho, Kansas and Michigan were all recorded in the 1940s or earlier, suggesting that these populations did not successfully establish. Sightings of adults in Montana and Nevada have been reported in the last ten years but these were solitary findings (Lotts & Naberhaus 2021, Montana Government 2022). However, as female adults lay fertilised eggs 1-3 days after mating, laying on average over 200 eggs, there is a risk that a single introduced female could enable a population to establish in a new area.

As mentioned previously, *Argyrotaenia franciscana* is found primarily in cooler coastal areas and river valleys (see Figure 2) (Gilligan & Epstein 2014). This can be attributed to their preference for mild temperatures and high relative humidity. Laboratory studies have shown that *A. franciscana* requires temperatures of above 5°C for egg hatching and 6-32°C to complete larval development, with an optimum temperature of 25.6°C (Basinger 1938, Coop 1982, Kido *et al.* 1981). In addition, a lower relative humidity was shown to delay development (Basinger 1938). Populations of *A. franciscana* are also strongly influenced by winter conditions although cold tolerance is influenced by the precise larval stage (Knight & Croft 1986). Larvae and eggs have been shown to suffer high mortality in subfreezing temperatures (Coop 1982, Knight & Croft 1986). Climate-matching of the pest location findings in North America to the UK suggests that the PRA area possesses the suitable conditions for the establishment and spread of this species (see Figure 3).

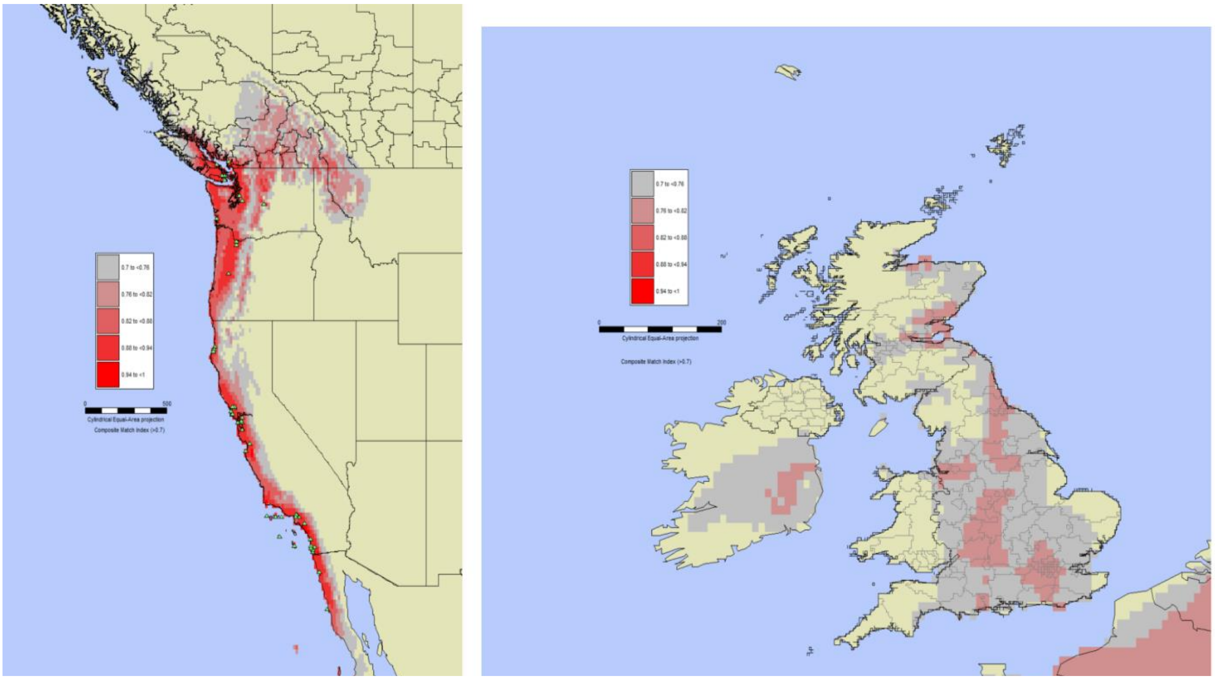

Figure 3: Results of CLIMEX regional climate matching in North America and the United Kingdom. Red or grey shading indicates an area suitable for the establishment of *Argyrotaenia franciscana* (a 70% or higher match). Green triangles indicate the current location of the pest in North America.

Availability of suitable habitats in the PRA area

A considerable number of hosts (*Malus*, *Prunus*, *Fragaria*, *Rubus*, *Vaccinium*, *Ribes*, *Brassica*, *Lactuca*, *Rosa*, *Pelargonium*, *Begonia* species) are grown commercially in the UK (Defra 2022c). In addition, oak, willow, hawthorn, spruce, Douglas fir and pine are all principal trees in the woodlands of Great Britain (Forest Research 2021). Finally, weed species such as bindweed and nettle grow wild in a wide range of habitats across the UK (see Figure 4), including open scrub, rough or short grassland, gardens, roadsides, rubbish tips, railway banks, cultivated and waste ground (PlantAtlas 2022). Therefore, the presence of these hosts could enable the establishment and spread of this pest in the UK. It is also likely that, in the event of *Argyrotaenia franciscana* reaching the UK, new hosts would be recorded, given its highly polyphagous and adaptable nature.

Given the preference exhibited by *Argyrotaenia franciscana* for cooler coastal areas and river valleys, it is likely that these habitats will be similarly preferred in the UK.

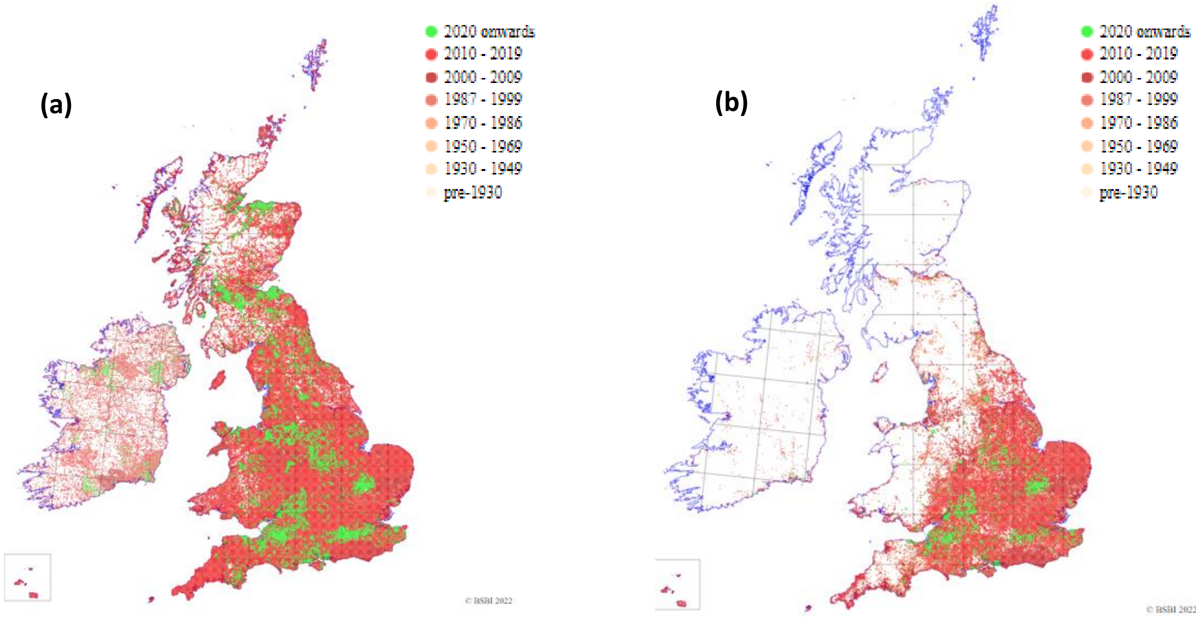

Figure 4: Distribution of weed hosts **(a)** *Urtica dioica* (common nettle) and **(b)** *Convolvulus arvensis* (field bindweed) in the United Kingdom (Online Atlas of the British and Irish Flora, 2022)

Cultural practices and control measures

Several natural enemies control the population of *Argyrotaenia franciscana* in its native range. More than 24 parasites attack *A. franciscana*, including insects such as: *Apanteles aristoteliae*, *Diabrachys cavus, Enytus eureka*, *Exochus nigripalpis subobscurus, Meteorus argyrotaeniae*, *Oncophanes americanus* and *Phytodietus vulgaris* (Basinger 1938, Coop 1982, Kido *et al.* 1981, Krombein *et al.* 1979). The total parasitism of an *A. franciscana* population can vary from 16-66%. Given that the populations with higher parasitism levels were consistently smaller, these parasites appear to play a significant role in suppressing the numbers of this pest (Coop 1982, Kido *et al.* 1981). Notably, in one study, over 80% of the difference in total parasitism between high- and low-density populations was due to only three parasites: *Apanteles aristoteliae*, *M. argyrotaeniae*, and *O. americanus* (Coop 1982).

Predation of larvae by certain spiders, *Chrysopidae* spp. (green lacewing) and *Hemerobius pacificus* (brown lacewing) insects has been reported (Kido *et al.* 1971, PNW 2022, UCANR 2012, 2014). *Chrysopidae* spp. predatory insects are present in the UK (GBIF 2022), however, predators appear less effective than parasites at suppressing tortricid populations (Walker & Welter 2004). Fewer parasites of *Argyrotaenia franciscana* are present in Canada (GBIF 2022) than in the US or Mexico, and therefore pesticides are believed to play a larger role in controlling this pest in agricultural settings. Only a couple of the aforementioned parasites are believed to be present in the UK, such as *Diabrachys cavus* and *Exochus nigripalpis* (GBIF 2022, UKSI 2022), so pesticides may be needed to manage populations should they become established.

Pesticides recommended to suppress *Argyrotaenia franciscana* are already being applied in UK orchards and greenhouses against *Drosophila suzukii* and other pests (Ridley *et al.* 2022a, b, UCANR 2012, 2014, 2015, 2017). These existing applications should suppress or prevent the establishment of this moth in commercially grown areas.

Other characteristics of the pest affecting the probability of establishment

The pest is expected to be able to establish in the PRA area, given the appropriate climate and host presence. Temperatures higher than 25.6°C and a lower relative humidity inhibits the development of this species (Basinger 1938), as shown in its native range, where two generations of *Argyrotaenia franciscana* have been reported in warm inland areas and up to five generations in colder coastal areas (Gilligan & Epstein 2014, Powell 1964, van der Geest & Evenhuis 1991). A similar pattern could be seen in the UK. The pest is also highly adaptable, indicated by its polyphagous nature and successful establishment in both urban and agricultural areas in its native range.

Risk Rating for Probability of Establishment: Probability of establishment is rated **Medium** for *Argyrotaenia franciscana*, given the appropriate climate, host presence and reduction in natural enemies yet bearing in mind the existing use of pesticides effective against this pest.

Uncertainty and Information Gaps: There is limited uncertainty about the presence of this pest outside of its common geographical range of the Pacific Northwest, in parts of the U.S. where it was found very rarely or back in the 1940s-1930s.

PROBABILITY OF SPREAD

Natural spread potential

Argyrotaenia franciscana was first reported in California, U.S., in the late 1800s. In subsequent decades, it was reported in Oregon and Washington, as well as along the Pacific coast of Canada (British Columbia) and Mexico (Baja California) (Belton 1988, Brown 2004, Coquillett 1894, Gilligan *et al.* 2020).

There is considerable uncertainty whether this pest spread to these regions or was present originally. In British Columbia, Oregon and Washington, production of host crops including apples and peaches have been reported from 1900, before this pest was reported (MacKinnon 1941, USDA 1902, 2019). Reports of this pest in British Columbia, Oregon, Washington only began from the 1930s (Belton 1988, Powell 1964). In addition, *Argyrotaenia franciscana* was originally reported as only being present in the greenhouses of British Columbia (Belton 1988, Freeman 1944). This could suggest pest spread, however, these reports could also be attributed to shifts in the host range of this pest or have resulted from taxonomic confusion around *A. franciscana.* However, some expansion in its geographical range has been suggested in recent literature (Gilligan *et al.* 2020).

The pest may have spread naturally, although adult females do not appear to fly distances of 400m or more. They can fly at least 100m to nearby fields (Knight 1986). Larvae can also move between fields by being dispersed on windblown silk threads (Oregon Blueberry No date, PNW 2022).

The presence of this pest in Mexico and Canada appears to be limited to certain regions. For example, in Canada, the distribution of *Argyrotaenia franciscana* is limited to the Lower Mainland of British Columbia (Pohl *et al.* 2018). It is expected that the spread of this moth would be limited to the coastal areas and river valleys of the UK, given its environmental requirements for mild temperatures and higher relative humidity. These areas in the UK should be suitable for the natural spread of this pest, host plants are likely to be present and the presence of natural enemies is thought to be limited (see Cultural practices and control measures).

Human-mediated spread potential

This moth does have the ability to move with traded goods, as demonstrated by the reported interceptions of this pest in Canada, Japan and New Zealand, regardless of the end-use of the commodity (Amano & Higo 2015, Biosecurity New Zealand 2009, CFIA 2000). As mentioned previously, the first reports of *Argyrotaenia franciscana* in Canada were in greenhouses. This could have been an outcome of pest spread by human activity (although see caveats above).

History of introductions / Behaviour outside natural range

Rare reports have been made of *Argyrotaenia franciscana* further east of its known distribution (GBIF 2022, Heppner 2004, Lotts & Naberhaus 2021, Montana Government 2022), such as in Montana (see Figure 2). It has been suggested that these outlying reports are either misidentifications or a result of host plants and plant products moving long distances for trade (Heppner 2004). Human-mediated spread appears likely given the interceptions mentioned above. However, these limited detections in these areas appears to have either failed to establish or not reached significant levels to be identified in recent years.

Other factors affecting the probability of spread

Natural spread of this pest should be slowed by the sea between Great Britain and Northern Ireland, although it is unlikely to be prevented completely, as shown by the pest spread to islands off the coast of California and Mexico. Human-mediated spread could also provide an opportunity for this pest to cross the sea barrier to Northern Ireland and to trading partners of the UK.

Risk Rating for Probability of Spread: Probability of spread is considered **Medium** for *Argyrotaenia franciscana* given the evidence this pest has spread outside of its natural range. The flight ability of this moth is limited so any long-distance movements is presumably due to human activity.

Uncertainty and Information Gaps: The pathway that this pest used to disperse eastward from its natural range to U.S. states such as Michigan and Kansas remains unknown. There is also significant uncertainty regarding the native range of this pest outside of California.

POTENTIAL ECONOMIC AND ENVIRONMENTAL CONSEQUENCES

Direct economic and environmental effects

Larvae feed on developing buds, blossoms, stems and leaves of hosts, as well as fruits. This can cause leaf injury, girdling of the stems, early fruit drop, as well as undesirable branching and loss of fruit quality and yield (Ebeling & Pence 1957, Gilligan & Epstein 2014, Kido *et al.* 1971, PNW 2022). Feeding also enables the entry of bacterial and fungal pathogens, such as *Botrytis cinerea*, that cause fruit rot disease (Bettiga 2013, Lange 1936, PNW 2022). *Argyrotaenia franciscana* larvae can also be a serious contaminant of the fruit during harvesting (Kieffer *et al.* 1983, PNW 2022).

Few reports of damage by this pest to forestry species could be found. *Argyrotaenia franciscana* is an occasional feeder of conifer trees (Powell & De Benedictis 1995), and although reported to cause significant damage to coniferous trees, such as pine, only a few trees are attacked overall (Lange 1936), potentially due to the host preferences as discussed previously. This pest is also reported to be a minor problem in cherries and pears (UCANR 2012, 2015).

Argyrotaenia franciscana has been listed as a species of economically important Lepidoptera (EPPO 2016, Zhang 1994). The economic impact of this pest is primarily important on fruit (van der Geest & Evenhuis 1991), causing damage to citrus (UCANR 2017), apricot and peach (Belton 1988), as well as described as a major pest of grapes (Kreiter 2018, UCANR 2014), raspberry, blackberry, and blueberry (Kido *et al.* 1981, Knight & Croft 1986). Historically, growers have been known to lose their entire raspberry crop to this pest, after being rejected by processors, causing a loss of around $150,000 in one county alone in 1947 (Breakey & Batchelor 1948). This sum is equivalent to just over $2 million in today's prices (Webster 2022). Significant crop losses have also been reported in the past on oranges (of up to 40%), avocados (damage up to 50%), and apples (each larva found on a plant corresponds to roughly 1% of fruit damage) (Basinger 1938, Ebeling & Pence 1957, Gilligan & Epstein 2014, Walker & Welter 2001, Zalom & Pickel 1988), though heavy pest infestations were sporadic (Basinger 1938).

In recent years, this moth has not been considered to be a significant pest in Canada or the U.S. It is likely that *Argyrotaenia franciscana* is controlled in Canada by pesticide applications intended to control any leafroller, fruitworm or fruit fly pest (Tracy Hueppelsheuser, Canadian Food Inspection Agency, *pers. comm*. to M. Damus, Sept. 28, 2022). In the U.S., existing biological control populations typically suppress the population of this moth (David Haviland, University of California, *pers. comm*., Oct. 12, 2022; Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022), although an increase of *A. franciscana* populations and subsequent damage on citrus crops has been observed recently following the use of broad-spectrum pesticides (Tom Roberts, Integrated Consulting Entomology, *pers. comm*., Oct. 13, 2022). In Mexico, *A. franciscana* is seen as a serious threat to its horticultural industry and therefore of economic importance. As such, it is a regulated quarantine pest and regular surveillance is conducted.

Apples, plums, cherries, strawberries, raspberries, blueberries, blackcurrants, brassica vegetables and lettuce are all commercially produced in the UK and are at risk from this pest. Particular hosts have significant economic value in the UK horticultural industry, for example, in 2021, the UK production of dessert and culinary apples was valued at £198 million, strawberries valued at £352 million, and raspberries valued at £148 million. Roses, geraniums and begonias are also significant in the ornamental sector (Defra 2022c).

In the U.S., the natural enemies of *Argyrotaenia franciscana* normally keep the population under control (UCANR 2012, 2015), whilst insecticides are believed to suppress this pest in Canada (Tracy Hueppelsheuser, Canadian Food Inspection Agency, *pers. comm*. to M. Damus, Sept. 28, 2022), a country where many of its natural enemies are not present (GBIF 2022). It is likely that similar risk mitigation measures would need to be imposed if this pest arrived in the UK. Few natural enemies of *Argyrotaenia franciscana* are present in the UK (GBIF 2022, UKSI 2022) and the release of any non-native species as biological controls would require a specific licence (Defra No date). Several effective biological and chemical controls can be utilised instead (UCANR 2012, 2014, 2015, 2017). Some of these controls are already being applied in UK orchards and greenhouses against *Drosophila suzukii* and other pests (Ridley *et al.* 2022a, b), therefore cost and application of these controls should not provide a significant additional burden to growers or cause a more significant impact on the environment.

As mentioned previously, nearly all hosts of *Argyrotaenia franciscana* are alien plants or native plants growing in domesticated habitats (Powell 1964). In addition, the impact of this pest on its host plants is mainly on fruit quality and yield and does not appear to cause host mortality (LaLone *et al.* 1988). Therefore, the direct environmental impacts from *A. franciscana* are not considered to be significant.

Indirect economic and environmental effects

Given that this pest is a regulated quarantine pest in Argentina, Cambodia, Chile, Japan, Mexico, Morocco, New Zealand, The Republic of Korea and Western Australia and the *Argyrotaenia* genus is listed as regulated pests by the U.S. (AGRIC 2022, APHIS-USDA 2022, EPPO 2022, MPI 2022), it is likely that the introduction of this pest in the UK could influence export requirements of host commodities to these countries. However, the actual impact of these requirements on trade could be very limited, considering the UK is a net importer of plants and plant products. For example, zero exports of cider apples, perry pears, plums, peaches, nectarines, strawberries and raspberries from the UK were recorded in 2021, although considerable amounts were domestically produced in the UK (Defra 2022c).

The silk that the dispersing larvae produce may have a social impact by being an annoyance in recreational areas and camping grounds, in home gardens, etc. Larvae of *Argyrotaenia franciscana* could also impact the aesthetic appeal of recreational areas by creating webbed shelters in branches of the surrounding trees. Given the limited impact of this pest on forestry species, these predicted social effects are not expected to be significant.

Risk Rating for Potential Economic and Environmental Consequences: Potential economic and environmental consequences are rated **Low** for *Argyrotaenia franciscana*, as it reportedly has limited significance as a pest in the U.S. and Canada, it is thought to be controlled or suppressed by pest control measures already taking place for other pests in agricultural settings, and it is unlikely to interfere with access to existing export markets.

Uncertainty and Information Gaps: Given the polyphagous nature of this pest, it is likely that *Argyrotaenia franciscana* will find new hosts in the UK though it is uncertain what these new hosts will be.

RATING SUMMARY

The following table summarises the risk and uncertainty ratings for *Argyrotaenia franciscana*, assigned in each section of the risk assessment, above. The overall probability of introduction and spread, and associated uncertainty rating, were calculated following the guidance provided in the document titled "Pest Risk Assessment Guidelines".

	Risk Rating	Uncertainty
Probability		
Probability of Entry	*Low*	*Low*
Probability of Establishment	*Medium*	*Low*
Probability of Spread	*Medium*	*Medium*
Overall Probability of Introduction (entry X establishment) and Spread	**Low**	**Medium**
Consequences		
Potential Economic and Environmental Consequences	**Low**	**Medium**

CONCLUSION

To conclude, the overall risk rating for the introduction of the orange tortrix moth, *Argyrotaenia franciscana*, into the PRA area is assessed as **Low** (with **medium** uncertainty). However, if introduced into the PRA area, this pest could become established in most parts of the UK due to the availability of hosts and climate suitability. This potential for establishment and spread, coupled with the **medium** uncertainty in this PRA, indicate that this pest should be added to the UK Plant Health Risk Register. Regulation of this pest does not appear proportionate with its current risk rating; however, this conclusion should be reviewed in future if long distance spread of this pest is detected in countries outside of its existing range. In this event, the below mitigation measures could be adopted as a result.

RECOMMENDATIONS AND MITIGATION MEASURES

In-field controls, post-harvest treatments and/or pre-export inspections of fruit would be beneficial in preventing the entry of this pest. This is a risk mitigation measure applied or proposed for *Argyrotaenia franciscana* by other countries for the importation of certain fruit (for example, grapes, blueberries, stone fruit, apples) (AQIS 2000, Australian Government 2010, 2020, PPIS 2022).

APPENDIX 1: LIST OF LOCATIONS USED FOR CLIMEX REGIONAL CLIMATE MATCH MODELLING

Table 2: Location dataset for *Argyrotaenia franciscana* (GBIF 2022, Lotts & Naberhaus 2021)

Latitude	Longitude	Altitude	Name
30.49	-116.11	96.00	Isla San Martin, Baja California, Mexico
31.88	-116.63	99.00	Empleados, 22820 Ensenada, Baja California, Mexico
32.85	-117.00	115.00	California, U.S.
32.63	-117.08	16.00	San Diego, California, U.S.
32.76	-117.10	111.00	4305 42nd St, San Diego, California, U.S.
32.74	-117.11	90.00	Azalea - Hollywood Park, San Diego, California, U.S.
32.92	-117.23	68.00	Carmel Creek Rd, San Diego, California, U.S.
32.80	-117.25	30.00	1320 Chalcedony St, San Diego, California, U.S.
33.13	-117.31	67.00	San Diego, California, U.S.
33.76	-117.70	257.00	Orange, California, U.S.
34.01	-118.11	64.00	Los Angeles County, California, U.S.
34.08	-118.23	154.00	Los Angeles, California, U.S.
34.12	-118.29	298.00	Los Angeles County, California, U.S.
34.02	-118.34	32.00	Los Angeles County, California, U.S.
32.88	-118.44	448.00	Grove Canyon, California, U.S.
34.02	-119.36	48.00	Channel Islands National Park, California, U.S.
36.62	-121.92	48.00	Pacific Grove, California, U.S.
36.62	-121.92	53.00	Pacific Grove, CA, USA
37.45	-122.14	6.00	Island Dr, Palo Alto, CA, US
47.43	-122.15	165.00	East Hill-Meridian, WA, U.S.
37.74	-122.15	21.00	Broadmoor Blvd, San Leandro, California, U.S.
37.93	-122.16	213.00	16 Bear Creek Rd, Lafayette, California, U.S.
37.81	-122.22	70.00	Alameda County, California, U.S.
37.81	-122.22	68.00	1158 Norwood Ave, Oakland, California, U.S.
47.70	-122.37	105.00	Crown Hill, Seattle, WA, USA
37.75	-122.43	77.00	Noe Valley, San Francisco, California, U.S.
37.75	-122.43	58.00	Noe Valley, San Francisco, California, U.S.
45.42	-122.54	104.00	11891 SE Mountain Sun Dr, Clackamas, Oregon, U.S.
45.54	-122.57	67.00	Eric's Yard, Oregon, U.S.
38.33	-122.68	38.00	Camino Colegio, Rohnert Park, California, U.S.
38.42	-122.70	69.00	303 Brookwood Ave, Santa Rosa, California, U.S.
38.41	-122.86	49.00	Sonoma County, California, U.S.
38.20	-122.96	136.00	Tomales Point Trail, Inverness, California, U.S.
49.33	-123.11	45.00	Greater Vancouver, California, U.S.
48.43	-123.35	37.00	Vancouver Island, Victoria, British Columbia, Canada
48.47	-123.38	24.00	Saanich, Jolly Place, British Columbia, Canada
48.66	-123.41	10.00	Harbour Road, Sidney, British Columbia, Canada

Latitude	Longitude	Altitude	Name
48.65	-123.55	22.00	Mill Bay, British Columbia, Canada
49.21	-123.97	21.00	Nanaimo, British Columbia, Canada
40.90	-124.09	10.00	Arcata, California, U.S.
40.79	-124.13	28.00	Myrtletown, Eureka, California, U.S.
40.69	-124.21	2.00	1038–1050 Ranch Rd, Loleta, California, U.S.
46.62	-123.95	11.00	Bay Center, Edge of Willapa Bay, Washington, U.S.
36.90	-121.60	34.00	San Benito County, Aromas, California, U.S.
33.25	-119.51	244.00	San Nicolas Island, California, U.S.
38.11	-122.87	47.00	West Inverness, Kehoe Way, California, U.S.
47.32	-120.61	1306.00	Washington, U.S.
34.04	-120.38	163.00	San Miguel Island, California, U.S.
34.00	-119.73	68.00	Santa Cruz Island, California, U.S.
44.09	-123.09	122.79	Eugene, Oregon, U.S.

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