Mini Risk Assessment
Summer Fruit Tortrix Moth, *Adoxophyes orana* (Fischer von Röslerstamm, 1834)
[Lepidoptera: Tortricidae]

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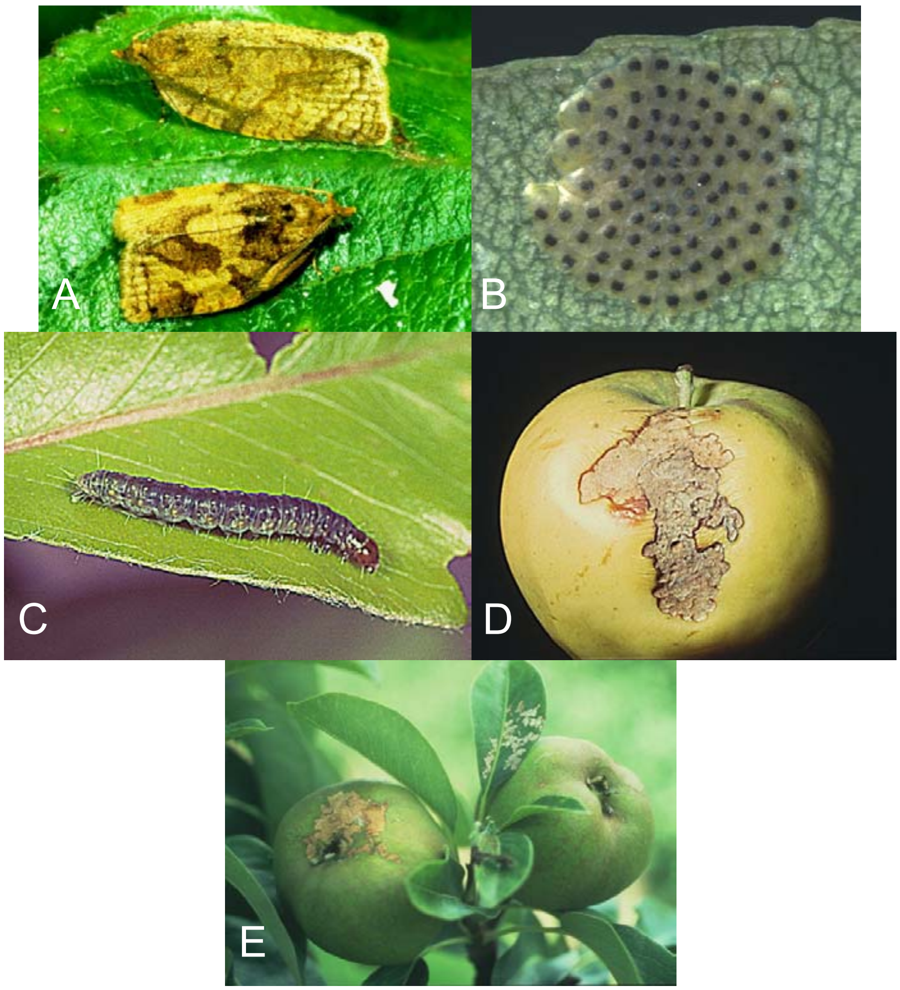

Figure 1. *Adoxophyes orana*: (A) adult female [above] and male [below]; (B) egg "raft" showing black head capsules of larvae prior to hatch on *Malus* leaf; (C) larva on *Pyrus* sp.; (D) damage to apple epidermis showing "gnawed" appearance; (E) damage to pear foliage and fruit.
[Images by R. Coutin/OPIE (INRA 2005)].

Table of Contents

Introduction

The summer fruit tortrix moth, *Adoxophyes orana* (Fischer von Röslerstamm) is a major pest of fruit crops, particularly apple and pear, in temperate regions (Whittle 1985, Hill 1987, INRA 2005). Hosts of this polyphagous pest also include some forest tree species (CAB 2004). *A. orana* occurs throughout much of Europe and Asia but is not known to occur in the United States (CIE 1982).

Risks associated with *A. orana* have been evaluated previously. For example, when evaluating the potential importation of Asian pear, Australia judged the overall risk potential to be high (BA-AQIS 2003). Cave and Lightfield (1997) recognized that *A. orana* might attack fragrant and ya pear in China but did not considered it likely that the pest would remain associated with the fruit if it were allowed to be shipped to the US. The purpose of this "mini-" pest risk assessment document is to further evaluate several factors that contribute to risks posed by *Adoxophyes orana* and apply this information to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: Medium.** *Adoxophyes orana* is present in Asia and Europe (CIE 1982), though much of its range may be adventive. The insect has been introduced and successfully invaded England (Cross 1996) and Greece (Savopoulou-Soultani et al. 1985). Appendix A provides a detailed list of countries reporting this tortricid. *Adoxophyes orana* typically occurs in warm, humid climates. The currently reported distribution of *A. orana* suggests that the pest may be most closely associated with biomes characterized as: tropical and subtropical moist, broadleaf forests, and temperate, broadleaf and mixed forests. Consequently, we estimate that approximately 29% of the continental US would

have a climate suitable for establishment by *A. orana* (Fig. 2). See Appendix A for a more complete description of this analysis.

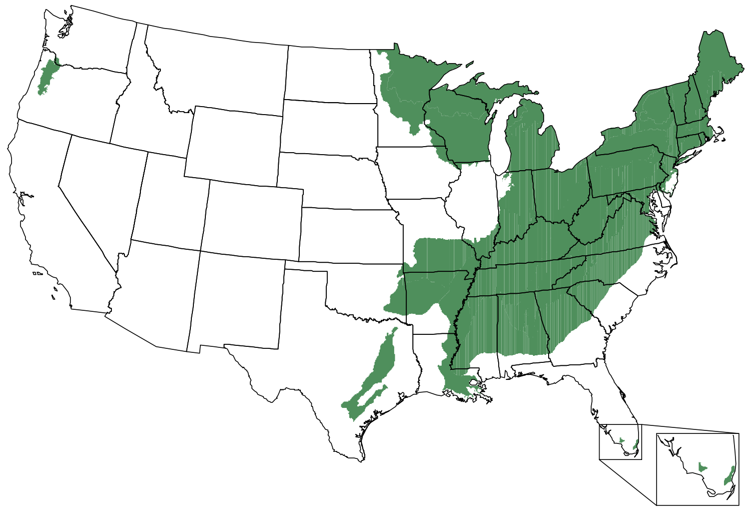

Figure 2. Predicted distribution (shaded green) of *Adoxophyes orana* in the contiguous US.

Figure 2 illustrates where *A. orana* is most likely to encounter a suitable climate for establishment within the continental US. This prediction is based only on the known geographic distribution of the species. Because this forecast is based on coarse information, areas that are not highlighted on the map may have some chance of supporting populations of this exotic species. However, establishment in these areas is less likely than in those areas that are highlighted. Initial survey efforts should be concentrated in the higher risk areas and gradually expanded as needed.

2. **Host Specificity/Availability. Rating: Low/High.** *Adoxophyes orana* is not host specific as it reportedly feeds and develops on more than 50 plant species in multiple families (Table 1). Potential host plants, both cultivated and wild, are common in the US and often occur at high densities. Although the host range includes several forest species, *A. orana* may feed preferentially on apples, pears and other Rosaceous hosts (INRA 2005).

Table 1. Host plants of *Adoxophyes orana*.

Hosts	**References**
alder (*Alnus* sp.)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973a, b, Whittle 1985, CAB 2003)
alfafla (*Medicago* sp.)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
almond tree, flowering (*Prunus triloba*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
apple (*Malus domestica* 'Idared')	(Balazs 1997)

Hosts	**References**
apple (*Malus domestica* 'Boskoop')	(Vanwetswinkel and Soenen 1983)
apple (*Malus domestica* 'Golden Delicious')	(Van Der Kraan and van Deventer 1982, Vanwetswinkel and Soenen 1983, Helsen and Blommers 1989, Balazs 1997)
apple (*Malus domestica* 'Golden')	(Injac and Dulic 1982)
apple (*Malus domestica* 'James Grieve'	(Berlinger and Ankersmit 1976b, Vanwetswinkel and Soenen 1983)
apple (*Malus domestica* 'Jonagold')	(Vanwetswinkel and Soenen 1983, Balazs 1997)
apple (*Malus domestica* 'Jonathan')	(Injac and Dulic 1982, Balazs 1997)
apple (*Malus domestica* 'Lombarts Calville')	(Helsen and Blommers 1989)
apple (*Malus domestica* 'Mollis Delicious')	(Balazs 1997)
apple (*Malus domestica* 'Red Delicious')	(Injac and Dulic 1982)
apple (*Malus domestica* 'Starking')	(Balazs 1997)
apple (*Malus domestica* 'Winston')	(Vanwetswinkel and Soenen 1983)
apple (*Malus* sp.)	(Honma 1970, de Jong et al. 1971, Minks and Noordink 1971, Minks et al. 1971, Honma 1972, Barel 1973a, Minks and Voerman 1973, Minks and de Jong 1975, Alford 1979, Alford et al. 1979, Ankersmit 1980, de Jong 1980, de Jong and Minks 1981, Van Der Pers 1981, CIE 1982, Fluckiger 1982, Fluckiger and Benz 1982, Van Der Kraan and van Deventer 1982, Baumgaertner and Charmillot 1983, Injac 1983, Charmillot et al. 1984, Goh et al. 1984, Stamenkovic and Stamenkovic 1984, Verheyden 1984, Ankersmit 1985, Savopoulou-Soultani et al. 1985, Stamenkovic and Stamenkovic 1985, Ghizdavu 1986, Blommers et al. 1987, Baumgaertner et al. 1988, Charmillot and Brunner 1989, 1990, Zhang et al. 1990, Balazs 1991, Milli and de Kramer 1991, Morgan 1991, Balazs 1992, Morgan and Solomon 1993, Neumann et al. 1993, Minks et al. 1995, Cross 1996, Balazs 1997, Balazs et al. 1997, Kienzle et al. 1997a, Kienzle et al. 1997b, Rama et al. 1997, Zhou et al. 1997, Jay and Cross 1998, Cross et al. 1999a, Cross et al. 1999b, Milonas and Savopoulou-Soultani 1999, Potting et al. 1999, Stamenkovic et al. 1999, Milonas and Savopoulou-Soultani 2000, Jo and Kim 2001, Hrudova 2003)

Hosts	References
apple leaves[1] (*Malus domestica* 'Golden Delicious')	(Fluckiger and Benz 1982)
apple leaves[1] 'Jonathan'	(Fluckiger and Benz 1982)
apple, paradise (*Malus pumila*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, CAB 2003)
apricot (*Prunus armeniaca*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, Stamenkovic et al. 1999, CAB 2003)
ash (*Fraxinus* sp.)	(de Jong et al. 1971, Whittle 1985)
basswood (*Tilia* sp.)	(Janssen 1958, de Jong et al. 1971, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
birch (*Betula* sp.)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973b, de Jong and Minks 1981, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
blackberry	(de Jong et al. 1971)
blackberry (*Rubus fruticosa*)	(CAB 2003)
blackberry, shrubby (*Rubus fruticosus*)	(Janssen 1958, Barel 1973b, Whittle 1985)
blueberry (*Vaccinium* sp.)	(Janssen 1958, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
buckbean (*Menyanthes trifoliata*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985)
Catawba rosebay[1] (*Rhododendron catawbiense*)	(Fluckiger and Benz 1982)
cherry	(de Jong et al. 1971, Savopoulou-Soultani et al. 1985, Charmillot and Brunner 1989, Milonas and Savopoulou-Soultani 1999, Stamenkovic et al. 1999) (CIE 1982, Milonas and Savopoulou-Soultani 2000, 2004)
cherry, bird (*Prunus padus*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
cherry, sour (*Prunus cerasus*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, Stamenkovic et al. 1999)
cherry, sweet (*Prunus avium*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
cinquefoil (*Potentilla* sp.)	(Barel 1973b)
common beech (*Fagus sylvatica*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
common snowberry (*Symphoricarpos albus*)	(Whittle 1985, CAB 2003)
common snowberry (*Symphoricarpos albus* var. *albus* (= *S. racemosus*))	(Janssen 1958, Barel 1973b)
cotoneaster (*Cotoneaster dielsiana*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985)

Hosts	References
cotton (*Gossypium* sp.)	(de Jong et al. 1971, Savopoulou-Soultani et al. 1985, Shu et al. 2002)
cotton, Arabian (*Gossypium herbaceum*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
cotton, upland (*Gossypium hirsutum*)	(Whittle 1985)
crabapple, European (*Malus sylvestris*)	(Whittle 1985)
crabapple, Siberian (*Malus baccata, M. baccata jackii*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
currant, red (*Ribes rubrum*)	(Janssen 1958, de Jong et al. 1971, Whittle 1985, CAB 2003)
currant, black (*Ribes nigrum*)	(Janssen 1958, de Jong et al. 1971, Barel 1973b, Whittle 1985, CAB 2003)
currant, white	(de Jong et al. 1971, Whittle 1985)
damson	(de Jong et al. 1971)
dock (*Rumex* sp.)	(Barel 1973b)
dock, bitter[1] (*Rumex obtusifolius*)	(Fluckiger and Benz 1982)
dog rose (*Rosa canina*)	(Janssen 1958, Barel 1973b, Whittle 1985, CAB 2003)
elm (*Ulmus* sp.)	(de Jong et al. 1971, Savopoulou-Soultani et al. 1985, Whittle 1985)
elm, English or Wych (*Ulmus campestris*)	(Janssen 1958, Barel 1973b)
elm, European field (*Ulmus minor*)	(CAB 2003)
field bindweed (*Convolvulus arvensis*)	(Barel 1973b)
filbert (*Corylus* sp.)	(Whittle 1985)
forsythia, weeping (*Forsythia suspensa*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
golden chain tree (*Laburnum anagyroides*)	(Janssen 1958, CAB 2003)
gooseberry	(de Jong et al. 1971)
gooseberry, European (*Ribes uva-crispa,* *R. grossularia*)	(Whittle 1985, CAB 2003)
gooseberry, European (*Ribes uva-crispa* var. *sativum* (= *R. grossularia*))	(Janssen 1958, Barel 1973b)
grapevine (*Vitis vinifera*)	(Savopoulou-Soultani et al. 1985)
hawthorn (*Crataegus* sp.)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973a, b, Van Der Pers 1981, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
honeysuckle (*Lonicera* sp.)	(de Jong et al. 1971, Savopoulou-Soultani et al. 1985)
honeysuckle, fly (*Lonicera xylosteum*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
hop (*Humulus* sp.)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
hornbeam (*Carpinus* sp.)	(de Jong et al. 1971)

Hosts	References
hornbeam, European (*Carpinus betulus*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
horsebean (*Vicia faba*)	(Barel 1973b)
ironwood (*Parrotia* sp.)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985)
Italian woodbine (*Lonicera caprifolium*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985)
laburnum (*Laburnum* sp.)	(Balachowsky 1966, de Jong et al. 1971, Barel 1973b, Whittle 1985)
lambsquarters (*Chenopodium album*)	(Barel 1973b)
lilac (*Syringa* sp.)	(de Jong et al. 1971, CIE 1982, Savopoulou-Soultani et al. 1985)
lilac, common (*Syringa vulgaris*)	(Janssen 1958, Barel 1973b, Whittle 1985, CAB 2003)
maple (*Acer* sp.)	(de Jong et al. 1971)
maple, common (*Acer campestre*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
mastic tree (*Pistacia lentiscus*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
mulberry (*Morus* sp.)	(Im and Paik 1982)
nettle (*Urtica* sp.)	(Janssen 1958, Barel 1973b, Whittle 1985)
nettle, stinging (*Urtica dioica*)	(de Jong et al. 1971)
nightshade (*Solanum* sp.)	(Savopoulou-Soultani et al. 1985)
nightshade, climbing (*Solanum dulcamara*)	(Janssen 1958, Barel 1973b, Whittle 1985)
oak (*Quercus* sp.)	(Janssen 1958, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985)
oak, English[1] (*Quercus robur*)	(Fluckiger and Benz 1982)
peach (*Prunus persica*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Meng et al. 1978, Goh et al. 1984, Savopoulou-Soultani et al. 1985, Whittle 1985, Charmillot and Brunner 1989, Zhou et al. 1997, Milonas and Savopoulou-Soultani 1999, Stamenkovic et al. 1999, Milonas and Savopoulou-Soultani 2000, CAB 2003, Ding et al. 2003, Hrudova 2003, Milonas and Savopoulou-Soultani 2004)
peach leaves [1] (*Prunus persica*)	(Milonas and Savopoulou-Soultani 2000)

Hosts	References
pear (*Pyrus communis*)	(Balachowsky 1966, Honma 1970, de Jong et al. 1971, Minks and Noordink 1971, Honma 1972, Alford 1979, de Jong 1980, de Jong and Minks 1981, CIE 1982, Fluckiger and Benz 1982, Van Der Kraan and van Deventer 1982, Goh et al. 1984, Stamenkovic and Stamenkovic 1984, Savopoulou-Soultani et al. 1985, Stamenkovic and Stamenkovic 1985, Ghizdavu 1986, Gendrier 1988, Sechser and Engelhardt 1988, Charmillot and Brunner 1989, 1990, Balazs 1992, Neumann et al. 1993, Cross et al. 1999b, Stamenkovic et al. 1999, Milonas and Savopoulou-Soultani 2000)
pear, European (*Pyrus communis*)	(Janssen 1958, Barel 1973b, Whittle 1985, CAB 2003)
pear leaves[1] (*Pyrus communis*)	(Fluckiger and Benz 1982)
pear, Asian 'Shandong' (*Pyrus pyrifolia*) and pear, Asian 'Ya' (*P. ussuriensis* var. *viridis*) fruit, leaves and shoot	(BA-AQIS 2003)
Peruvian groundcherry (*Physalis peruviana*)	(Whittle 1985)
pillar tree (scientific name unknown)	(Hassan and Rost 1993)
pistachio (*Pistacia* sp.)	(Savopoulou-Soultani et al. 1985)
plum (*Prunus* sp.)	(de Jong et al. 1971, de Jong and Minks 1981, Stamenkovic et al. 1999, Hrudova 2003)
plum, European (*Prunus domestica*)	(Janssen 1958, Balachowsky 1966, Barel 1973b, Whittle 1985, CAB 2003)
poplar (*Populus* sp.)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
privet (*Ligustrum* sp.)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, CAB 2003)
Prunus insistitia	(Balachowsky 1966, Whittle 1985)
Prunus domestica subsp. *insititia*, *Prunus domestica* subsp. *syriaca*; [=*Prunus insistitia syriaca*]	(Janssen 1958, Balachowsky 1966, Barel 1973b)
Prunus sp.	(Van Der Pers 1981, Savopoulou-Soultani et al. 1985)
Pyrus sp.	(Savopoulou-Soultani et al. 1985)

Hosts	References
quince (*Cydonia oblonga*)	(Janssen 1958, Balachowsky 1966, de Jong et al. 1971, Barel 1973b, Savopoulou-Soultani et al. 1985, Whittle 1985, Stamenkovic et al. 1999, CAB 2003)
raspberry (*Rubus idaeus*)	(Janssen 1958, de Jong et al. 1971, Barel 1973b, Whittle 1985, CAB 2003)
Ribes sp.	(Savopoulou-Soultani et al. 1985)
roses (*Rosa* sp.)	(Janssen 1958, de Jong et al. 1971, Barel 1973b, de Jong and Minks 1981, Savopoulou-Soultani et al. 1985, CAB 2003)
Rubus sp.	(Savopoulou-Soultani et al. 1985)
stone fruit	(Sziraki 1984)
strawberry (*Fragaria* sp.)	(de Jong et al. 1971, Whittle 1985)
tea[2] (*Camellia sinensis*)	(Whittle 1985)
tea[2] (*Camellia* sp.)	(de Jong et al. 1971, CIE 1982) (Barel 1973b)
willow (*Salix* sp.)	(de Jong et al. 1971, Van Der Pers 1981, Savopoulou-Soultani et al. 1985)
willow, basket (*Salix viminalis*)	(Janssen 1958, Barel 1973b, Whittle 1985, CAB 2003)
willow, goat (*Salix caprea*)	(Janssen 1958, Barel 1973b, Whittle 1985, CAB 2003)

1. Laboratory experiments;
2. Tea may or may not be a host of *A. orana*, possibly a misidentification due to taxonomic confusion. Tea was reported as a host associated with *A. orana* "tea form" which was later named *A. honmai,* (Yasuda 1998). However according to Barel (1973b), the “tea strain” was likely a synonym of *A. orana*.

See Appendix B for maps showing where various hosts are grown commercially in the continental US.

3. **Survey Methodology. Rating: High.** Several monitoring techniques have been developed and applied to *A. orana*. The most effective approach involves sex-pheromone-baited traps. El-Sayed (2004) and Witzgal et al. (2004) summarize semiochemicals that have been identified for *A. orana*. The sex pheromone is a blend of (*Z*)-9-tetradecenyl acetate and (*Z*)-11-tetradecenyl acetate (Tamaki et al. 1971, Meijer et al. 1972). These two compounds are most attractive to males in a 9:1 blend of (Z)-9:(Z)-11 isomers; *E*-isomers of either compound had a strong inhibitory effect (Minks and Voerman 1973). [CAB (2004)suggests that an 80:20 mixture of (Z)-9:(Z)-11 tetradecenyl acetate is most attractive, but this statement is incorrect.] The 9:1 pheromone blend is available commercially as Adoxomone (Murphy Pherocon™ Summer Fruit Tortrix Moth Attractant) for use with Pherocon 1C traps [Zoecon Corp] (Barel 1973a, Alford et al. 1979). Polythylene caps treated with 100 μg of the pheromone blend remain attractive for >7 weeks (Minks and Voerman 1973), but baits should be changed about every 6 weeks (Alford et al. 1979).

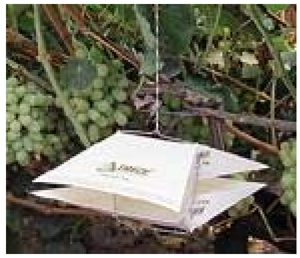

Figure 3. Pherocon 1C trap [Image from Trécé Corp.].
Mention of a product name does not constitute endorsement.

The attractiveness of a trap extends more than 10 m [ca 33 ft] (Shirasaki 1989). For intensive monitoring within orchards, traps should be placed 15-20 m [ca. 50-65 ft]apart (Alford et al. 1979, Hrudova 2003). For general monitoring and surveys, van der Kraan and van Deventer (1982) recommend 45 m [ca. 150 ft] between traps. Traps should be placed approximately 1.5 m [5 ft] above the ground (Barel 1973a, Minks and de Jong 1975, Hrudova 2003); traps at other heights capture substantially fewer moths (Shirasaki 1989). When traps are deployed, night temperatures should be >14°C [57°F], the temperature threshold for adult flight (Barel 1973a).

Dickler (1982) effectively used pheromone baited traps for a regional survey for *A. orana* in East Germany, as did Goh et al. (1984) in Suweon, North Korean. With a high diffusion rate of 15.2 mg/(ha·h), Charmillot (1981) used the 9:1 blend to effectively disrupt mating; a diffusion rate of 7.3 mg/(ha·h) was ineffective. Similar results were obtained by Neumann et al. (1993). There is not a strong relationship between trap capture and plant damage (Alford 1979).

Occasionally, pheromone traps will attract non-target species. Adoxomone also attracted *Ceramica pisi* (Noctuidae) (Alford et al. 1979). However, Hrudova (2003) failed to collect any non-target moths in traps baited for *A. orana*. Hrduova (2003) did note that *A. orana* was attracted very infrequently to traps with semiochemicals for *Cydia molesta*.

As an alternative to pheromone traps, Robinson light traps (Alford et al. 1979) with 125W mercury vapor bulbs, 125W black light bulb, or 100W flood light can be used (Barel 1973a). While sex pheromone traps attract males of a targeted species, light traps non-selectively draw in many flying insects. Minks (1969) captured more specimens of *A. orana* during the first generation in a trap baited with virgin females than in a light trap but obtained the exact opposite result during the second generation. Alford et al. (1979) also reported ca. 30% more moths in light traps than in pheromone traps; however if counts were corrected for the sex bias, pheromone traps captured more specimens than light traps (Alford et al. 1979).

Visual sampling and beat sampling may also be used to inspect trees for eggs and larvae. Both methods are time consuming; 100 shoots should be processed using the beat method (de Jong 1980). For visual surveys, Pralja et al. (1992)

recommend the trunk and "all first order skeleton branches" at 1m from the trunk to sample for eggs and "1.5 m long peripheral parts of four skeleton branches (one branch at each tree side) of the second order (for caterpillars)." Larvae tend to be aggregated among trees (Qiu et al. 1999). Visual sampling or beat sampling are not commonly recommended.

4. **Taxonomic Recognition. Rating: Medium.** *Adoxophyes orana* may occur in mixed populations with closely related or morphologically similar species. By their very secretive nature, leafrollers are difficult to detect. Distinguishing between males and females of adult *Adoxophyes* in general is difficult (Balachowsky 1966). According to Yasuda (1998), "The extensive color and pattern variation of the forewing and morphological resemblance among *Adoxophyes* species have created difficulties in the identification of the species."

   For a description of the morphology and taxonomy of *A. orana*, see Appendix C.

5. **Entry Potential. Rating: Medium.** Officers with USDA-APHIS and the Department of Homeland Security reported only one interception of *A. orana* and two interceptions of "*Adoxophyes* sp." at US ports of entry from 1985-2004 (USDA 2005). The interception of *A. orana* was on a shipment of crabapples (*Malus sylvestris*) from France. The specimen was intercepted in France as part of a pre-clearance program (USDA 2005). The specimens of "*Adoxophyes* sp." were intercepted from *Bupleurum* sp and *Syringa* sp. coming into Anchorage, AK and Los Angeles, CA as permit cargo (USDA 2005). Both of these shipments reportedly originated in the Netherlands. These records may not reflect the true potential for entry of *A. orana*.

   Tortricids can be extremely difficult to identify, particularly as eggs and larvae. Interceptions of "Tortricidae; species of" or "Tortricinae; species of" were reported much more frequently than *Adoxophyes* spp. Unidentified tortricids were intercepted at least 10,523 times between 1985-2004 (USDA 2005). Incomplete records complicate the accuracy of this count. On average, 463 (±31 standard error of the mean) interceptions were reported annually. Most interceptions were associated with international airline baggage (44%), permit cargo (41%), and general cargo (9%). Interceptions were most commonly reported within the continental US from Miami, FL (22%), JFK International airport, NY (19%), Los Angeles, CA (17%), Houston, TX (5%), and Dallas, TX (5%). These ports are the first points of entry for infested material coming into the US and do not necessarily represent the final destination of infested material. Movement of potentially infested material is more fully characterized in the next section.

   Interceptions of unidentified tortricids were not strongly associated with any particular plant product. Tortricids were intercepted on more than 100 plant taxa (USDA 2005). The most frequently reported host was pepper fruit (*Capsicum* sp.), but this taxon only accounted for ~3% of all interceptions (USDA 2005)

If all unidentified specimens of Tortricidae had been *A. orana*, this insect would have a very high rate of arrival relative to other exotic insects. This is not particularly likely given the global degree of taxonomic diversity within this insect family. However, to warrant a medium rating for this risk element, only 2.5% of the intercepted tortricids would have to be *A. orana*. This result is possible though perhaps not probable.. Approximately 20% of the interceptions of Tortricidae originated in France or the Netherlands, countries known to have *A. orana*. Consequently, we assign a medium rating to the potential for entry and emphasize the high degree of uncertainty associated with this rating.

Movement of *A. orana* larvae in commerce has been noted previously (reviewed in Barel 1973a), and introductions of larvae on trees and shrubs have been particularly problematic. Arrivals into the United States were noted as early as 1952 on lilacs from the Netherlands.

6. **Destination of Infested Material. Rating: High.** When an actionable pest is intercepted, officers ask for the intended final destination of the conveyance. The single shipment infested with *A. orana* was destined for Pennsylvania, and the shipments infested with "*Adoxophyes* sp." were destined for Alaska and California (USDA 2005). This small number of interceptions is not particularly informative. Material infested with "Tortricidae; species of" or "Tortricinae; species of" were destined for 47 states, including the District of Columbia, within the contiguous US (USDA 2005). The most commonly reported destinations were California (27%), Florida (23%), New York (17%), and Texas (10%). We note that portions of Florida, New York, and Texas have climates and hosts that would be suitable for establishment by *Adoxophyes orana*. However, because the specimens were only identified to the (sub-) family, we have little confidence in our assessment of the final destination of materials infested with *A. orana*, specifically.

7. **Potential Economic Impact. Rating: High.** The economic impact of *A. orana* is difficult to measure because it frequently occurs in mixed populations with other closely related species, and damage can result from the activity of secondary pests (Whittle 1985). *Adoxophyes orana* is a leafroller, and immature forms will use foliage for shelter while feeding on fruit (Whittle 1985, CAB 2004). Larvae will feed externally on fruit marked creating a "gnawed" or misshapen appearance (Fig 1). Feeding directly on fruit can cause tremendous reductions in the quantity and quality of fruit. Crop losses from 10-50% have been attributed to this insect in fruit growing regions. In the Netherlands, damage in 33,000 ha of apples amounted to $1.2 million in the late 1980s (de Jong et al. 1971, Whittle 1985). External feeding may also enable the attack of secondary organisms which further damage the crop, and reduce shelf and storage life (de Jong and Van Dieren 1974, Whittle 1985, INRA 2005).

Although this insect feeds on foliage and young shoots in addition to fruit (CAB 2004), this feeding may not significantly affect plant growth (INRA 2005). The impact of *A. orana* on forest productivity has not been well studied.

Establishment of *A. orana* in the US could also adversely impact domestic and international trade. Australia considers this insect a high risk pest (CAB 2004). Consequently, establishment of the insect would likely result in domestic or international quarantines and/or additional quarantine treatments to prevent the spread of the pest.

8. **Potential Environmental Impact. Rating: High.** In general, newly established species may adversely affect the environment by reducing biodiversity, disrupting ecosystem function, jeopardizing endangered or threatened plants, degrading critical habitat, or stimulating use of chemical or biological controls. *Adoxophyes orana* is likely to affect the environment in many of these ways.

   Adoxyphese orana has the potential to directly affect forest composition and ecosystem function because it feeds and develops on a number of forest understory and overstory species (see 'Host Specificty'). *Adoxophyes orana* may indirectly harm the environment by stimulating management actions that inadvertently impact non-target species. Historically, the introduction of invasive agricultural pests has initiated control measures to avoid lost production (National Plant Board 1999). Consumer preferences for unblemished, high quality produce encourage the use of pesticides, while at the same time, negative public opinion regarding the use of pesticides on fruits and vegetables is a market concern (Bunn et al. 1990). Parasitoids have been identified for *A. orana*, so biological control seems like a viable management option (Cross et al. 1999b). The establishment of *A. orana* or any new pests of fruits and vegetables destined for fresh markets is likely to stimulate greater use of either chemical or biological controls to ensure market access.

   Adoxophyes orana has a large, wide host range, feeding preferentially on apples, pears and other members within the family Rosaceae [see 'Host Specificity']. Appendix D summarizes federally listed threatened or endangered plant species (USDA NRCS 2004) found within plant genera known to be hosts (or potential hosts) for *A. orana*. Plants listed in Appendix D might be suitable hosts for *A. orana*, and thus, could be adversely affected by this Tortricid.

9. **Establishment Potential**. **Rating: High.** Our initial predictions suggest that approximately one third of the US has a climate that could support populations of *A. orana* (Fig. 2). Known hosts, especially cultivated Rosaceae (e.g., apple, pear, apricot, and peach) and non-cultivated hardwoods (e.g., ash, alder, birch, cottonwood, and elm), are common in these climatically suitable areas. Thus, upon arrival into the United States, the chances for establishment are relatively high. Although direct evidence indicates the arrival rate of *A. orana* is low, indirect evidence (i.e., the number of intercepted, unidentified Tortricidae)

suggests that the arrival rate might be at least moderate, relative to other exotic insects.

See Appendix E for a more detailed description of the biology of *A. orana*.

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Appendix A. Geographic distribution and comparison of climate zones. To determine the potential distribution of a quarantine pest in the US, we first collected information about the worldwide geographic distribution of the species (Table A1). Using a geographic information system (e.g., ArcView 3.2), we then identified which biomes (i.e., habitat types), as defined by the World Wildlife Fund (Olson et al. 2001), occurred within each country or municipality reported An Excel spreadsheet summarizing the occurrence of biomes in each nation or municipality was prepared. The list was sorted based on the total number of biomes that occurred in each country/municipality. The list was then analyzed to determine the minimum number of biomes that could account for the reported worldwide distribution of the species. Countries/municipalities with only one biome were first selected. We then examined each country/municipality with multiple biomes to determine if at least one of its biomes had been selected. If not, an additional biome was selected that occurred in the greatest number of countries or municipalities that had not yet been accounted for. In the event of a tie, the biome that was reported more frequently from the entire species' distribution was selected. The process of selecting additional biomes continued until at least one biome was selected for each country. Finally, the set of selected biomes was compared to those that occur in the US.

Table A1. Reported geographic distribution of *Adoxophyes orana*:

Location	References
Albania	(Kapidani and Duraj 1991)
Armenia	(CAB 2003, 2004)
Asia	(Whittle 1985, Milonas and Savopoulou-Soultani 1999, Jo and Kim 2001)
Asia (north)	(Charmillot and Brunner 1989)
Austria	(Barel 1973b, Whittle 1985, CAB 2003, 2004)
Austria (Tyrol, Vienna, lower Austria)	(CIE 1982)
Azerbaijan	(CAB 2003, 2004)
Belgium	(de Jong et al. 1971, Barel 1973b, CIE 1982, Vanwetswinkel and Soenen 1983, Verheyden 1984, Whittle 1985, Charmillot and Brunner 1989, CAB 2003, 2004)
Bosnia and Herzegovina (Belgrade)	(Stamenkovic et al. 1999)
Bosnia and Herzegovina (near Sarajevo)	(Stamenkovic and Stamenkovic 1984)
Bosnia and Herzegovina (southern)	(Savopoulou-Soultani et al. 1985)
Bulgaria	(CIE 1982, Whittle 1985, CAB 2003, 2004)
China	(de Jong and Minks 1981, Ankersmit 1985, Whittle 1985, Cave and Lightfield 1997)
China (Hebei, Hong Kong, Sichuan)	(CAB 2003, 2004)
China (Jinxian County in Liaoning Province)	(Zhang et al. 1990)
China (Lienping, Szechwan)	(CIE 1982)
China (Nanjing, Yancheng)	(Shu et al. 2002)
China (north)	(Zhou et al. 1997)
China (Peking, Beijing)	(Meng et al. 1978, CIE 1982, Ding et al. 2003)
China (Shandong Province)	(BA-AQIS 2003)
Czech Republic (Brno-Turany, Praksice)	(Hrudova 2003)
Czechloslovakia	(Barel 1973b)
Denmark	(Barel 1973b, CIE 1982, Whittle 1985, CAB 2003, 2004)

Location	References
East Germany	(Whittle 1985)
East Germany (near the mouth of the river Odin)	(Barel 1973b)
England	(Barel 1973b, Fluckiger and Benz 1982, Whittle 1985, Morgan 1992, Stamenkovic et al. 1999)
England (Cambridge, Norfolk, Suffolk)	(CIE 1982)
England (Essex)	(de Jong et al. 1971, CIE 1982, Cross 1996, Jay and Cross 1998)
England (Faversham, Sittingbourne)	(Baker 1991)
England (Hampshire)	(Langmaid 1984)
England (Kent)	(de Jong et al. 1971, Alford 1979, Alford et al. 1979, CIE 1982, Cross 1996, Jay and Cross 1998, Cross et al. 1999a)
England (Oxon)	(Cross 1996)
England (south)	(Baker 1991, Solomon and Morgan 1996)
England (southeast)	(Alford et al. 1979, CIE 1982, Morgan and Solomon 1993)
England (Yorkshire)	(Spence 1998)
England and Wales	(CAB 2003, 2004)
Europe	(Whittle 1985, Yasuda 1998, Jo and Kim 2001)
Europe (central)	(de Jong et al. 1971, de Jong and Minks 1981, Savopoulou-Soultani et al. 1985, Milonas and Savopoulou-Soultani 2000)
Europe (northern)	(Charmillot and Brunner 1989, Milonas and Savopoulou-Soultani 1999)
Europe (northwest)	(Savopoulou-Soultani et al. 1985)
Europe (southern)	(de Jong et al. 1971, Milonas and Savopoulou-Soultani 1999)
Europe (west)	(de Jong 1980, de Jong and Minks 1981, Ankersmit 1985)
Finland	(CIE 1982, Whittle 1985, CAB 2003, 2004)
Finland (to 65°N Latitude)	(Barel 1973b)
France	(Barel 1973b, Whittle 1985, CAB 2003, 2004)
France (northeast)	(Charmillot and Brunner 1989)
France (Paris basin, Pas-de- Calais, Lyonnais)	(CIE 1982)
France (Rhone Valley)	(CIE 1982, Gendrier 1988)
Georgia, Republic	(CAB 2004)
Germany	(de Jong and Minks 1981, Dickler 1984, Whittle 1985, Charmillot and Brunner 1989, Cross et al. 1999b, CAB 2003, 2004)
Germany (Berlin, Ottersleben, Prussendorf, Thuringia, Bonn-Cologne, Frankfurt-am-Main)	(CIE 1982)

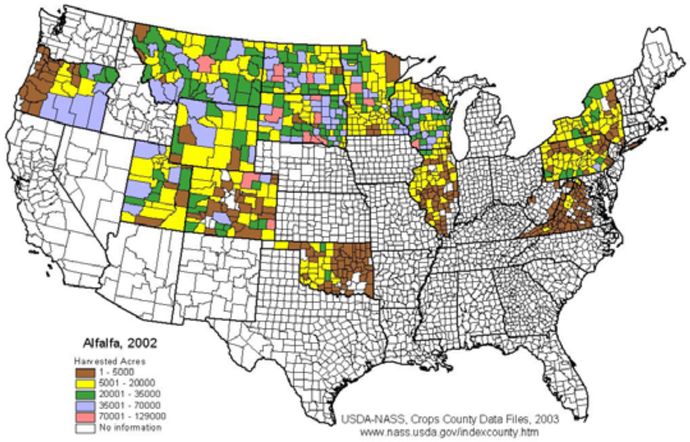
Location	References
Germany (Jork, Nottensdorf, Ebstorf, Berlin-Lichterfelde, Espelkamp, Hannover-Ahlem, Sarstedt-Ruthe, Munster, Herzebrock, Grob Flothe, Gottingen-Weende, Gottengen-Klausberg, Grafschaft, Gieben, Hofheim, Kriftel, Wackernheim, Bernkastle-Wehlen, Maring-Noviand, Darmstadt, Robdorf, Wurzburg, Trier-Zewen, Morlenback, Morlenbach-Weiher, Perl, St. Wedel, Weinheim-Rittenweier, Ladenburg, Dossenheim BBA, Dossenheim, Mannheim-Pfingstberg, Meckenheim, Furth, Puttlengen, Heuchlingen, Ohringen, Schozach-Ilsfeld, Karlsruhe-Grunwettesbach, Murr, Stuttgart-Mohringen, Stuttgart-Hohenheim, Adlkofen-Deutenkofen, Weihenstephan, Vogtsburg, Denzlingen, Meersburg)	(Dickler 1982)
Germany (Monheim)	(Potting et al. 1999)
Germany (Northern Wurttemberg, Lake Constance)	(Kienzle et al. 1997b)
Germany (Rhine region, South Bavaria, Berlin)	(de Jong et al. 1971)
Germany (Schaafheim near Darmstadt)	(Hassan and Rost 1993)
Germany (southern)	(Kienzle et al. 1997a)
Greece (Naoussa area)	(Savopoulou-Soultani et al. 1985, Charmillot and Brunner 1989, Savopoulou-Soultani and Hatzivassiliadis 1991, Milonas and Savopoulou-Soultani 2004)
Greece (northern)	(Milonas and Savopoulou-Soultani 1999, 2000)
Holland	(Barel 1973b, Stamenkovic et al. 1999)
Hungary	(Barel 1973b, Whittle 1985, Balazs 1992, CAB 2003, 2004)
Hungary (Borsod-Abauj-Zemplen County, Zala County, Bacs-Kiskun County)	(Balazs 1997)
Hungary (Budapest)	(CIE 1982)
Hungary (Erd-Elvira, Torokbalint)	(Sziraki 1984)
Hungary (Szabolcs-Szatmar-Bereg County)	(Balazs 1997, Balazs et al. 1997)
Italy	(Whittle 1985, CAB 2003, 2004)
Italy (north)	(de Jong et al. 1971, Barel 1973b, de Jong and Minks 1981, Charmillot and Brunner 1989)
Italy (Trentino)	(Rama et al. 1997)
Italy (Venice)	(CIE 1982)
Italy (Verona)	(CIE 1982, Stamenkovic et al. 1999)
Japan[1]	(Honma 1970, Minks and Noordink 1971, de Jong and Minks 1981, Im and Paik 1982, Ankersmit 1985, Whittle 1985)}(Barel 1973a)
Japan[1] (Hokkaido, Honshu, Kyushu, Shikiko)	(Honma 1972, CIE 1982, CAB 2003, 2004)
Japan[1] (Naruto-shi in the Tokushima Prefecture, Chiba-shi in the Chiba Prefecture)	(Tamaki et al. 1976)
Japan[1] (north)	(de Jong et al. 1971)
Korea (southern)	(Lee et al. 1992)
Korea (Suweon)	(Im and Paik 1982, Goh et al. 1984)
Korea (Youngchon)	(Jo and Kim 2001)
Korea, Republic of	(CAB 2003, 2004)

Location	References
Netherlands	(de Jong et al. 1971, Barel 1973a, b, de Jong and Beeke 1976, de Jong 1980, de Jong and Minks 1981, CIE 1982, Fluckiger and Benz 1982, Vanwetswinkel and Soenen 1983, Ankersmit 1985, Whittle 1985, de Reede and de Wilde 1986, Blommers et al. 1987, Helsen and Blommers 1989, Malais and Ravensberg 1993, Jay and Cross 1998, CAB 2003, 2004, Milonas and Savopoulou-Soultani 2004)
Netherlands (Dronten, Biddinghuizen, Zeewolde, Bunnik, Geldermalsen, Nw Vossemeer, Ovezande, Nisse, Wilhelminadorp, Reuver, Horst)	(Minks et al. 1995)
Netherlands (Echteld)	(Berlinger and Ankersmit 1976b)
Netherlands (Ecken Wiel, Maurik, Kesteren)	(Neumann et al. 1993)
Netherlands (Geldermalsen, Goes)	(Minks and de Jong 1975)
Netherlands (Lieden)	(Minks 1969, Minks and Noordink 1971, Minks et al. 1971, Ankersmit 1980)
Netherlands (Overberg)	(Ankersmit 1980)
Netherlands (region between the Rhine and Waal Rivers)	(Minks and Voerman 1973)
Netherlands (Tiel in the Betuwe region)	(Van Der Kraan and van Deventer 1982)
Netherlands (Wilhelminadorp)	(Minks 1969, Minks and Noordink 1971, Minks et al. 1971, Berlinger and Ankersmit 1976b)
Norway	(CIE 1982, Whittle 1985, CAB 2003, 2004)
Norway (to 65°N Latitude)	(Barel 1973b)
Poland	(Barel 1973b, Whittle 1985, CAB 2003, 2004)
Poland (Poznan)	(CIE 1982)
Romania	(Barel 1973b, CIE 1982, Whittle 1985, CAB 2003, 2004)
Romania (Transylvania, Cluj-Napoca)	(Ghizdavu 1986)
Russia	(Barel 1973b, de Jong and Minks 1981, Ankersmit 1985)
Russia (Amur, Ussuri)	(CIE 1982, Whittle 1985)
Russia (Caucases, Crimea)	(de Jong et al. 1971)
Russia (European Russia)	(CAB 2003, 2004)
Russia (Far East)	(CIE 1982, Whittle 1985, CAB 2003, 2004)
Russia (Krasnodar Territory, Region)	(Mottus et al. 2001)
Russia (Northern Caucases, Transcaucasia)	(CIE 1982, Whittle 1985)
Russia (Siberia)	(CIE 1982, Whittle 1985, CAB 2003, 2004)
Russia (south-east)	(de Jong et al. 1971)
Russia (Volgo-Urals)	(CIE 1982)
Scandinavia (except northern regions)	(de Jong et al. 1971)
Serbia	(CIE 1982, Stamenkovic 1988, Stamenkovic et al. 1999)
Serbia (Cacak, Ljubic, Zdravljak, and Srcanik in Cacak region)	(Stamenkovic and Stamenkovic 1984, Stamenkovic et al. 1999) (Stamenkovic and Stamenkovic 1985)
Serbia (Subotica)	(Injac and Dulic 1982)
Serbia (Subotica, Zemun, Sremska Mitrovica)	(Krnjajic et al. 1993)
Serbia (Valjevo)	(Stamenkovic and Stamenkovic 1984, 1985)
Serbia and Montenegro	(CAB 2004)
Serbia, Western	(Stamenkovic and Stamenkovic 1984)
Spain	(Whittle 1985, CAB 2003, 2004)

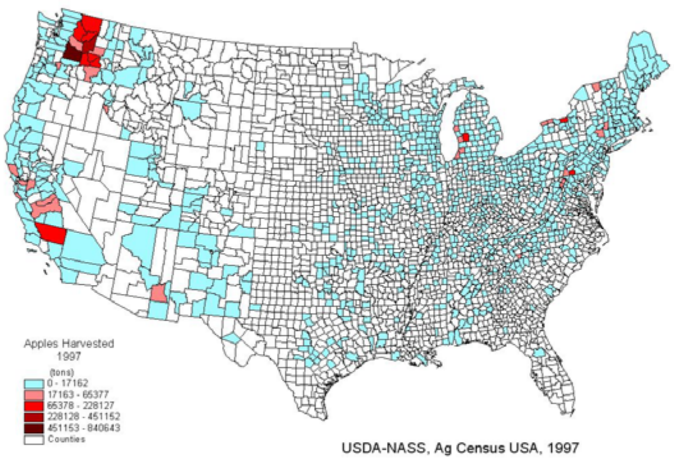
Location	References
Spain (Ebro Valley, Lerida)	(CIE 1982)
Spain (north)	(Barel 1973b)
Sweden	(CIE 1982, Whittle 1985, CAB 2003, 2004)
Sweden (to 65°N Latitude)	(Barel 1973b)
Switzerland	(Barel 1973b, de Jong and Minks 1981, Whittle 1985, Charmillot and Brunner 1989, Minks et al. 1995, CAB 2003, 2004)
Switzerland (Chateauneuf, Pratteln, Zurich, Changins)	(Fluckiger and Benz 1982)
Switzerland (Lake Leman)	(Baumgaertner and Charmillot 1983)
Switzerland (Rhone valley)	(Sechser and Engelhardt 1988)
Switzerland (Sion)	(Baumgaertner et al. 1988)
Switzerland (Valais, Lake Geneva)	(CIE 1982, Fluckiger and Benz 1982)
Switzerland (western)	(Charmillot et al. 1984)
Ukraine	(Whittle 1985, CAB 2003, 2004)
West Germany	(Whittle 1985)
West Germany (Wurtemberg)	(Barel 1973b)
Yugoslavia	(de Jong and Minks 1981, Whittle 1985, Charmillot and Brunner 1989, CAB 2003)

1. In Japan, *A. orana* "tea form" was later named as one of two new species, *A. honmai* or *A. dubia*, all of which occur in Japan and are not easily distinguishable. Possible misidentification.

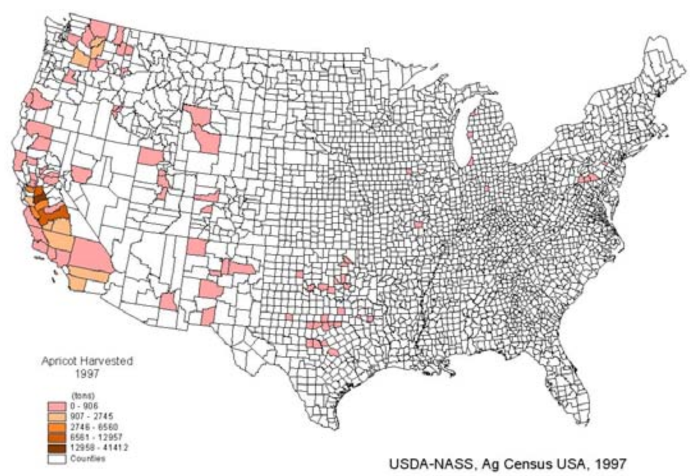
Appendix B. Host distribution for *Adoxophyes orana* in the contiguous US.



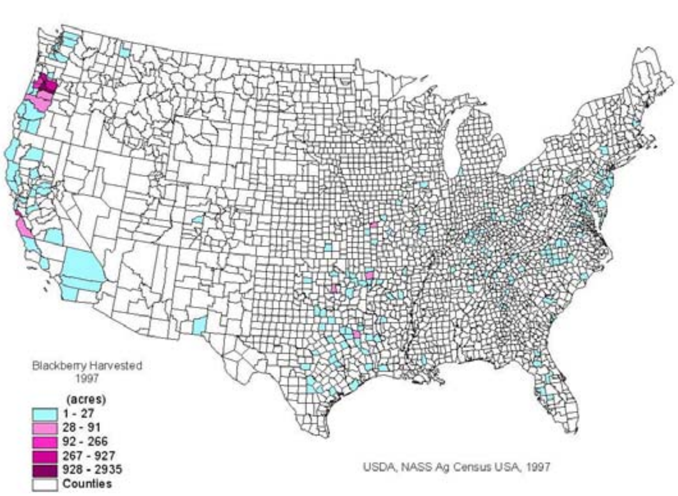
Map 1. Alfalfa (*Medicago sativa*)



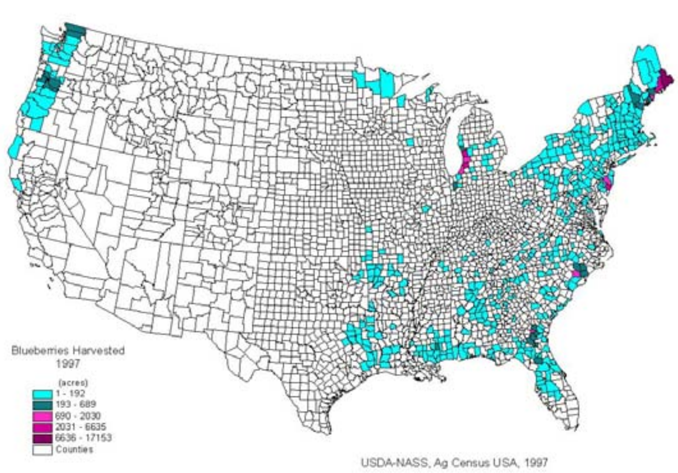
Map 2. Apple (*Malus domestica*)



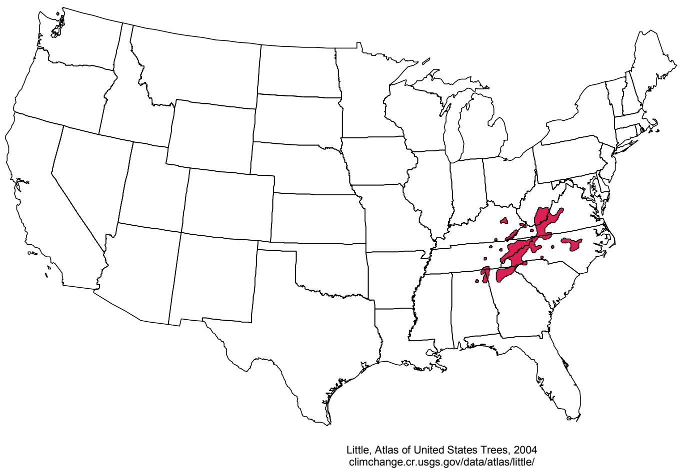
Map 3. Apricot (*Prunus armeniaca*)



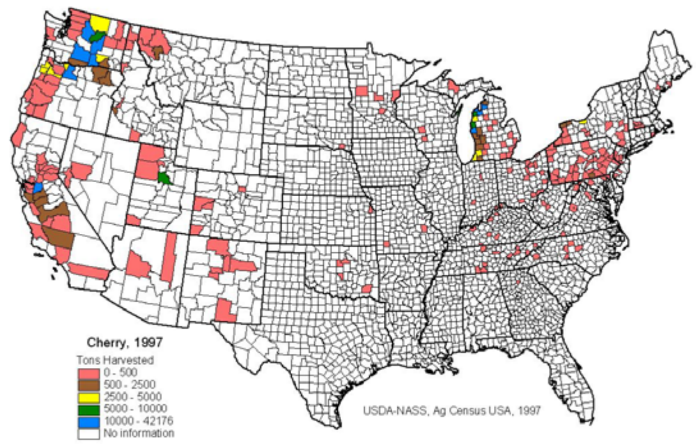
Map 4. Blackberry (*Rubus* spp.)



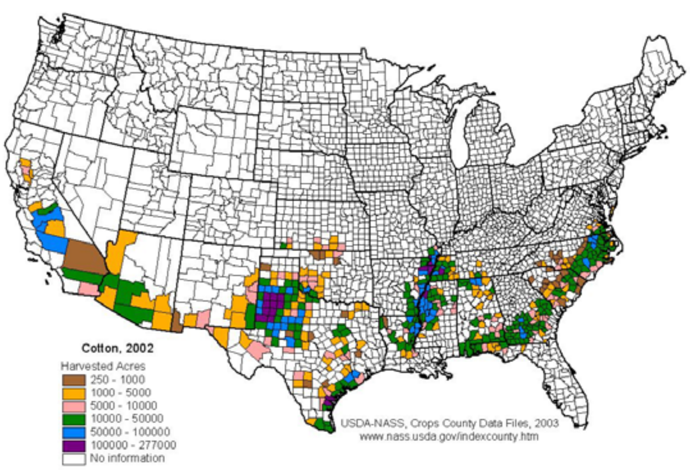
Map 5. Blueberry (*Vaccinium* spp.)



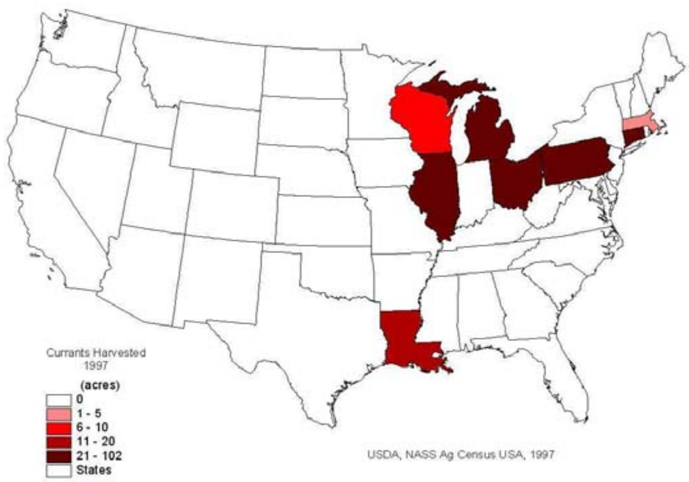
Map 6. Catawba Rosebay (*Rhododendron catawbiense*)



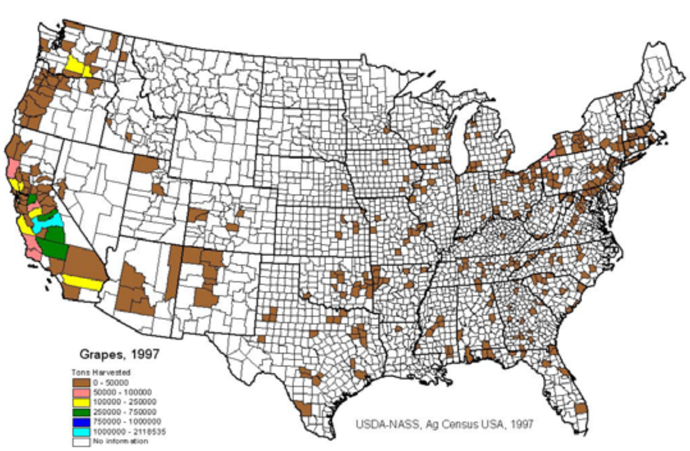
Map 7. Cherry (*Prunus avium*)



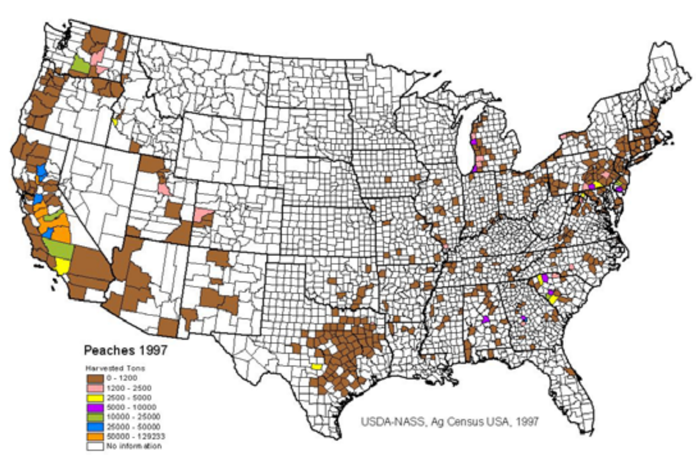
Map 8. Cotton (*Gossypium hirsutum*)



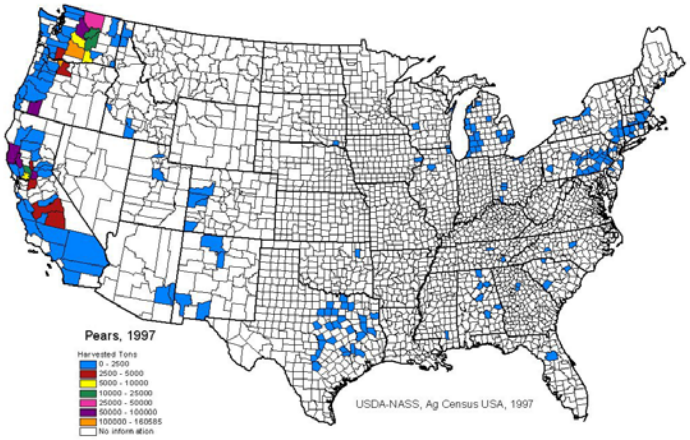
Map 9. Currant (*Ribes* spp.)



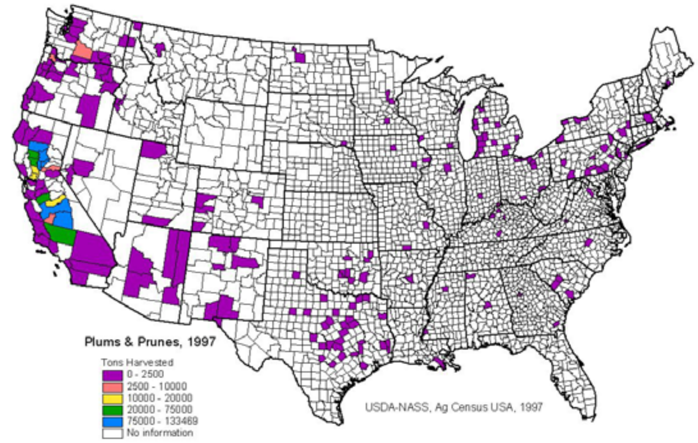
Map 10. Grape (*Vitis* spp.)



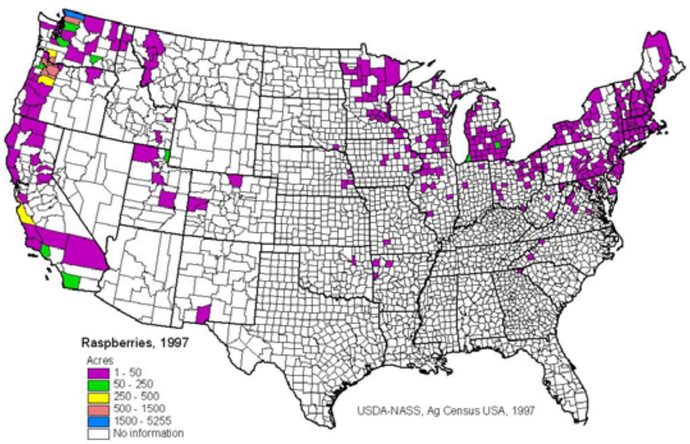
Map 11. Peach (*Prunus persica*)



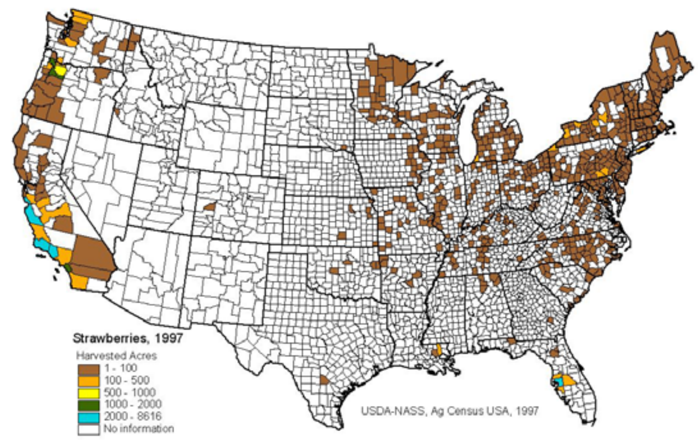
Map 12. Pear (*Pyrus communis*)



Map 13. Plum & Prunes (*Prunus* spp.)



Map 14. Raspberry (*Rubus* spp.)



Map 15. Strawberry (*Fragaria* spp.)

Appendix C. Taxonomy and morphology of *Adoxophyes orana*

The genus *Adoxophyes* was originally described by Meyrick (1882). Yasuda (1998) re-examined the genus and described adults differences among species based on the morphology of genitalia. In the review of the genus, Yasuda (1998) included species that occur in Japan: *A. orana*, *A. orana orana*, *A. orana fasciata*, *A honmai*, and *A. dubia*.

Taxonomy of the immature stages of *Adoxophyes* was originally studied by Honma (1970, 1972)and recently revised by Sakamaki and Hayakawa (2004). Various life stages of *Adoxophyes orana* have been described by Yasuda (1998), Balachowsky (1966), and others (Whittle 1985, CAB 2004). Sakamaki and Hayakawa (2004) describe larval and pupal characters of *A. orana fasciata*, *A. honmai*, and *A. dubia*.

Synonyms (Yasuda 1998, CAB 2004)

Adoxophyes orana Bradley, 1952
Adoxophyes reticulana Chambon & d'Aguilar, 1974
Adoxophyes reticulana Hübner
Capua reticulana Hübner
Cacoecia reticulana
Capua orana
Tortrix orana Fischer von Röeslerstamm
Tortrix reticulana
Capua congruana
Adoxophyes tripsiana
Adoxophyes fasciata Walsh
Acleris reticulana
Adoxophyes congruana Walker
Tortrix orana Fischer von Röeslerstamm,1834
Tortrix reticulana Hübner, 1818

The species, *A. fasciata*, is technically a subspecies of *A. orana*. "The subspecies has so far been generally known from continental Europe" (Yasuda 1998). *Adoxophyes fasciata* is considered a synonym of *A. orana*. *Adoxophyes orana fasciata* Walsingham has the following synonyms:

Adoxophyes fasciasta Walsingham, 1900
Adoxophyes orana fasciata
Adoxophyes orana

Diagnostic features

For complete accuracy the following sections are quoted from Yasuda (1998) and Bradley et al. (1973).

"FL. Male 10.0-11.0 mm, Female 11.0-13.0 mm. The forewing of the female is rather dull greyish brown, while in the male the coloration is brighter and is a yellowish brown. The male has a fold that extends about ½ of the length of the costa, and the fold is lined with whitish small glandular scales" (Yasuda 1998).

"♂ 15-19 mm, ♀ 18-22 mm. Sexual dimorphism pronounced; antenna of male shortly ciliate, forewing with broad costal fold from base to about one-third, markings usually conspicuous, contrasting with paler ground colour ; female usually larger, antenna minutely ciliate, forewing without costal fold, with darker general coloration and less contrasting markings" (Bradley et al. 1973).

Male (Fig. C1).
"Ground colour of forewing light greyish brown; markings dark brown suffused with ochreous; outer margin of basal fasciae poorly defined, oblique to middle; median fascia narrow, margins irregular, usually constricted at middle before emitting strong tornal spur; pre-apical spot broken and reduced, emitting a strong stria extending to the tornal area, and a second much thinner stria parallel with termen. Hindwing grey" (Bradley et al. 1973)

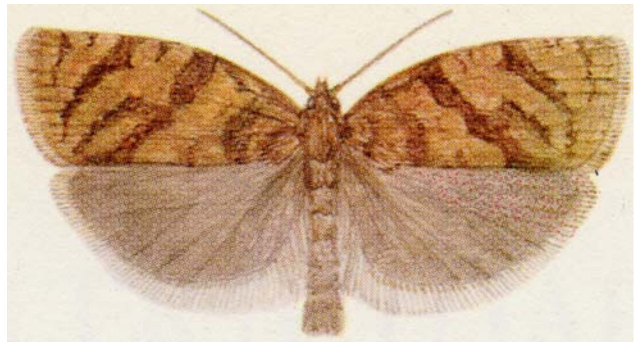


Figure C1. Male *A. orana.* [Color plate reproduced from Bradley (1973).]

Female (Fig. C2 **)**
"Forewing ground colour greyish brown; markings essentially as in male but more subdued and often partially obsolete. Hindwing grey" (Bradley et al. 1973).

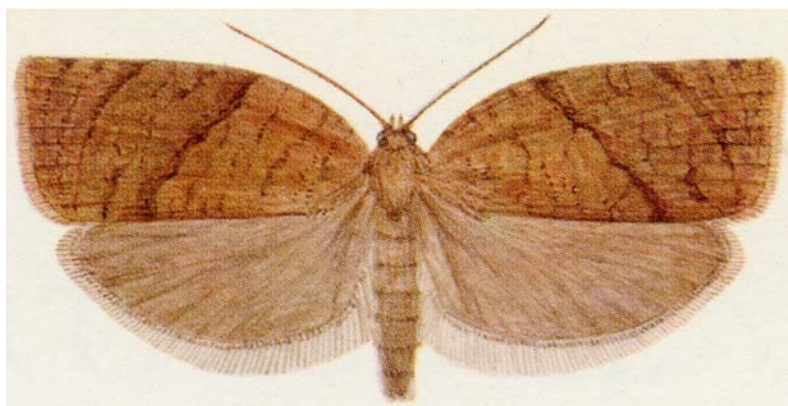


Figure C2. Female *A. orana.* The larger image size reflects the larger relative size of females. [Color plate reproduced from Bradley (1973).]

Variation
"This species shows little variation. In the male the forewing ground colour is sometimes dull and the markings show less contrast. The female is seldom strongly marked, but occasionally has a rather conspicuous reticulate pattern in the forewing, especially in the distal half" (Bradley et al. 1973).

Appendix D. Threatened or endangered plants potentially affected by *Adoxophyes orana*.

Adoxophyes orana has the potential to adversely affect threatened and endangered plant species. However, because *A. orana* is not known to be established in the US, and some plant species that are considered threatened and endangered in the US may not occur outside the US, it is not possible to confirm the host status of these rare plants from the scientific literature. Several known hosts that are considered threatened or endangered in the US include: *Chenopodium album*, *Gossypium hirsutum*, *Menyanthes trifoliata*, *Prunus armeniaca*, and *Symphoricarpos albus* (See Table D1). From available host records, *A. orana* appears to feed primarily on species within the families Rosaceae, but may feed or develop on hosts in several other families including Aceraceae, Betulaceae, Caprifoliaceae, Chenopodiaceae, Convolvulaceae, Ericaceae, Fabaceae, Fagaceae, Malvaceae, Menycanthaceae, Moraceae, Oleaceae, Polygonaceae, Salicaceae, Solanaceae, Tiliaceae, Ulmaceae, Vitaceae. From these host records, we infer that threatened or endangered plant species which are closely related to known host plants might also be suitable hosts (Table D1). For our purposes closely related plant species belong to the same genus.

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Acer sp., *A. campestre*	*Acer nigrum*	black maple		NH (T)
	A. pensylvanicum	striped maple		OH (E)
	A. spicatum	mountain maple		KY (E)
Alnus sp.	*Alnus incana* ssp. *rugosa*	speckled alder		IL (E)
	A. viridis ssp. *crispa*	mountain alder		PA (E)
Betula sp.	*Betula alleghaniensis*	yellow birch		IL (E)
	B. minor	dwarf white birch		ME (E) NY (E)
	B. nana [=*Betula glandulosa*]	dwarf birch		ME (E) NH (T) NY (E)
	B. nigra	river birch		NH (T)
	Betula papyrifera var. *cordifolia*	mountain paper birch		TN (E)
	B. populifolia	gray birch		IL (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Betula pumila	bog birch		IA (T) MA (T) NH (E) NY (T) OH (T)
	Betula pumila var. *glandulifera*	bog birch		VT (E)
	B. uber	Virginia roundleaf birch	T	VA (E)
Chenopodium album	*Chenopodium album* var. *missouriense*	Missouri lambsquarters		NY (E)
	Chenopodium berlandieri var. *boscianum* [=*C. boscianum*]	pitseed goosefoot		NH (E)
	Chenopodium berlandieri var. *macrocalycium*	pitseed goosefoot		NY (E)
	C. foggii	Fogg's goosefoot		PA (E)
	C. humile	marshland goosefoot		ME (T)
	C. rubrum	red goosefoot		ME (T) NH (T) NJ (E) NY (T)
	C. simplex [= *C. gigantospermum*]	mapleleaf goosefoot		MD (E)
	C. standleyanum	Standley's goosefoot		MD (E)
Convolvulus arvensis	*Convolvulus spithamaeus*			NH (T)
Corylus sp.	*Corylus cornuta* var. *cornuta* [= *C. rostrata*]	beaked hazelnut		IL (E)
Crataegus sp.	*Crataegus arborea*	Montgomery hawthorn		IN (E)
	C. berberifolia	barberry hawthorn		NY (E)
	C. calpodendron	pear hawthorn		NJ (E)
	C. chrysocarpa	fireberry hawthorn		IN (E)
	C. compacta	clustered hawthorn		NY (E)
	C. douglasii	black hawthorn		MN (T)
	C. grandis	grand hawthorn		IN (E)

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Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Crataegus harbisonii	Harbison's hawthorn		TN (E)
	C. intricata [= *C. biltmoreana*]	Copenhagen hawthorn		IN (E)
	C. kelloggii	Kellogg's hawthorn		IN (E)
	C. mollis	Arnold hawthorn		NY (E)
	C. pedicellata	scarlet hawthorn		IN (T)
	C. phaenopyrum	Washington hawthorn		FL (E)
	C. prona	Illinois hawthorn		IN (E)
	C. succulenta [= *C. bicknelli*]	fleshy hawthorn		NJ (E) MA (E)
	C. uniflora	dwarf hawthorn		NY (E) OH (E)
	C. viridis	green hawthorn		IN (T)
Fraxinus sp.	*Fraxinus profunda*	pumpkin ash		MI (T) NJ (E) PA (E)
	F. quadrangulata	blue ash		IA (T) WI (T)
Gossypium sp., *G. herbaceum*, *G. hirsutum*	*Gossypium hirsutum*	upland cotton		FL (E)
Lonicera sp., *L. caprifolium*, *L. xylosteum*	*Lonicera canadensis*	American fly honeysuckle		MD (E) NJ (E)
	L. dioica [= *L. dioica* var. *orientalis* [= *L. dioica* var. *glaucescens*]]	limber honeysuckle		IL (E) KY (E) ME (E)
	L. flava	yellow honeysuckle		IL (E)
	L. hirsuta	hairy honeysuckle		MA (E) PA (E)

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Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Lonicera involucrata	twinberry honeysuckle		MI (T) WI (E)
	L. oblongifolia	swamp fly honeysuckle		PA (E)
	L. reticulata [= *L. prolifera*]	grape honeysuckle		KY (E) TN (E)
	L. sempervirens	trumpet honeysuckle		ME (E)
	L. villosa	mountain fly honeysuckle		PA (E)
Malus sp., *M. domestica* 'Idared', *M. domestica* 'Boskoop', *M. domestica* 'Golden Delicious', *M. domestica* 'Golden', *M. domestica* 'James Grieve', *M. domestica* 'Jonagold', *M. domestica* 'Jonathan', *M. domestica* 'Lombarts Calville', *M. domestica* 'Mollis Delicious', *M. domestica* 'Red Delicious', *M. domestica* 'Starking', *M. domestica* 'Winston', *M. baccata*, *M. baccata jackii*, *M. pumila*, *M. sylvestris*	*Malus angustifolia*	southern crabapple		FL (T) IL (E)
	M. glaucescens	Dunbar crabapple		NY (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Menyanthes trifoliata	*Menyanthes trifoliata*	buckbean		IA (T) MD (E) NC (T) OH (T)
Morus sp.	*Morus rubra*	red mulberry		CT (E) MA (E) MI (T) VT (T)
Physalis peruviana	*Physalis pubescens* var. *integrifolia* [= *P. pruinosa*]	husk tomato		NY (E)
	P. virginiana	Virginia groundcherry		NY (E) OH (E) PA (E)
Populus sp.	*Populus balsamifera*	balsam poplar		IL (E) OH (E) PA (E)
	P. heterophylla	swamp cottonwood		CT (E) MI (E) NY (T)
Potentilla sp.	*Argentina anserina* [=*Potentilla anserina*]	silverweed cinquefoil		IA (T) IN (T) PA (T)
	Argentina egedii spp. *egedii* [= *Potentilla anserina* spp. *egedii*]	Pacific silverweed		NY (T)
	Comarum palustre [= *Potentilla palustris*]	purple marshlocks		NJ (E)
	Dasiphora floribunda comb. nov. ined. [= *Potentilla fruticosa*]	shrubby cinquefoil		IA (T) PA (E)
	Potentilla arguta	tall cinquefoil		AR (T) OH (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Potentilla bipinnatifida [= *P. pensylvanica* var. *bipinnatifida*]	tansy cinquefoil		VT (E)
	P. hickmanii	Hickman's cinquefoil	E	CA (E)
	P. paradoxa	Paradox cinquefoil		MI (T) NY (E) OH (T) PA (E)
	P. pensylvanica	Pennsylvania cinquefoil		IA (T) MI (T)
	P. rivalis var. *millegrana*	brook cinquefoil		IL (E)
	P. robbinsiana	dwarf mountain cinquefoil	E	NH (E)
	P. tridentata	three-toothed cinquefoil		CT (E) IA (E) NJ (E) PA (E)
Prunus sp., *P. armeniaca*, *P. avium*, *P. cerasus*, *P. domestica*, *P. isistitia*, *P. insistitia syriaka*, *P. padus*, *P. persica*, *P. triloba*	*Prunus alleghaniensis*	Allegheny plum		MD (T) NJ (E) PA (T)
	P. americana	American plum		NH (T) VT (T)
	P. angustifolia	Chicasaw plum		NJ (E)
	P. geniculata	scrub plum	E	FL (E)
	P. maritima	beach plum		MD (E) ME (E) PA (E)
	P. maritima var. *gravesii*	Grave's plum		CT (E)
	P. nigra	Canadian plum		IA (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Prunus pumila	sandcherry		AR (T) TN (T)
	P. pumila var. *depressa*	eastern sandcherry		NY (T)
	P. pumila var. *pumila*	Great Lakes sandcherry		NY (E)
	P. pumila var. *susquehanae*	Sesquehana sandcherry		OH (T)
Quercus sp., *Q. robur*	*Quercus acerifolia*	mapleleaf oak		AR (T)
	Q. bicolor	swamp white oak		ME (T)
	Q. coccinea	scarlet oak		ME (E)
	Q. falcata	southern red oak		OH (T) PA (E)
	Q. hinckleyi	Hinckley oak	T	TX (T)
	Q. ilicifolia	bear oak		VT (E)
	Q. imbricaria	shingle oak		NJ (E)
	Q. lyrata	overcup oak		NJ (E)
	Q. macrocarpa	bur oak		CT (E)
	Q. muehlenbergii [= *Q. prinoides*]	chinkapin oak		IN (E)
	Q. nigra	water oak		NJ (E)
	Q. oglethorpensis	Oglethorpe oak		GA (T)
	Q. phellos	willow oak		IL (T) NY (E) PA (E)
	Q. prinus [= *Q. montana*]	chestnut oak		IL (T) ME (T)
	Q. shumardii	Shumard's oak		MD (T) PA (E)
	Q. sinuata var. *sinuata* [= *Q. durandii*]	bastard oak		AR (T)
	Q. texana [= *Q. nuttallii*]	Texas red oak		IL (E)
Rhododendron catawbiense	*Rhododendron alabamense*	Alabama azalea		FL (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Rhododendron atlanticum	dwarf azalea		NJ (E) PA (E)
	R. austrinum	orange azalea		FL (E)
	R. calendulaceum	flame azalea		OH (E)
	R. canadense	rhodora		NJ (E) NY(T)
	R. canescens	mountain azalea		KY (E)
	R. chapmanii	Chapman's rhododendron	E	FL (E)
	R. lapponicum	Lapland rosebay		ME (T) NY (E) WI (E)
	R. maximum	great laurel		MA (T) ME (T) OH (T) VT (T)
	R. periclymenoides [= *R. nudiflorum*]	pink azalea		NH (E) OH (T)
	R. prunifolium	plumleaf azalea		GA (T)
	R. viscosum	swamp azalea		ME (E) NH (T)
Ribes sp., *R. grossularia*, *R. nigrum*, *R. rubrum*, *R. uva-crispa*	*Ribes americanum*	American black currant		MD (E)
	R. aureum var. *villosum* [= *R. odoratum*]	golden currant		TN (T)
	R. echinellum	Miccosukee gooseberry	T	FL (E)
	R. glandulosum	skunk currant		CT (E) NJ (E)
	R. hirtellum	hairystem gooseberry		IL (E)
	R. hudsonianum	northern black currant		IA (T)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	R. lacustre	prickly currant		PA (E)
	R. missouriense	Missouri gooseberry		NJ (E) OH (E) PA (E)
	R. oxyacanthoides	Canadian gooseberry		WI (T)
	R. triste	red currant		CT (E) OH (E) PA (T)
Rosa sp., *R. canina*	*Rosa acicularis*	prickly rose		IA (E) IL (E) MA (E) NH (E) VT (E)
	R. acicularis ssp. *sayi*	prickly rose		NY (E)
	R. blanda	smooth rose		MD (E) OH (T)
	R. minutifolia	Baja rose		CA (E)
	R. nitida	shining rose		NY (E)
Rubus sp., *R. fruticosa*, *R. fruticosus*, *R. idaeus*	*Rubus arcticus* spp. *acaulis* [= *R. acaulis*]	dwarf raspberry		MI (E)
	R. canadensis	smooth blackberry		KY (E) NJ (E)
	R. centralis	Illinois dewberry		IN (E)
	R. chamaemorus	cloudberry		MN (T) NH (E)
	R. cuneifolius	sand blackberry		NH (E) NY (E) PA (E)
	R. flagellaris [= *R. enslenii*]	northern dewberry		IN (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Rubus nigerrimus	dark raspberry		WA (E)
	R. odoratus	purpleflowering raspberry		IL (E) IN (T)
	R. pubescens	dwarf red raspberry		IL (T)
	R. setosus	setose blackberry		IL (E) IN (E)
	R. whartoniae	Wharton's dewberry		KY (T)
Rumex sp., *R. obtusifolius*	*Rumex altissimus*	pale dock		MD (E)
	R. aquaticus var. *fenestratus* [= *R. occidentalis*]	western dock		MI (E)
	R. hastatulus	heartwing sorrel		NY (E)
	R. maritimus [=*Rumex maritimus* var. *fueginus*]	golden dock		NY (E)
	R. pallidus	seaside dock		MA (T), NH (E)
	R. verticillatus [= *R. floridanus*]	swamp dock		MA (T), MD (E)
Salix sp., *S. caprea*, *S. viminalis*	*Salix arctophila*	northern willow		ME (E)
	S. argyrocarpa	Labrador willow		ME (E) NH (T)
	S. bebbiana	Bebb willow		MD (E)
	S. candida	sageleaf willow		ME (T) OH (T) PA (E)
	S. caroliniana	costal plain willow		OH (T) PA (E)
	S. cordata [= *S. syrticola*]	heartleaf willow		IL (E) NY (E) WI (E)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Salix eriocephala [= *S. cordata*]	Missouri River willow		FL (E) IN (T)
	S. exigua	narrowleaf willow		CT (T) MD (E)
	S. floridana	Florida willow		FL (E) GA (E)
	S. herbacea	snowbed willow		ME (T) NH (T) NY (E)
	S. interior	sandbar willow		ME (E)
	S. lucida	shining willow		IA (T) MD (E)
	S. myricoides	bayberry willow		ME (E)
	S. pedicellaris	bog willow		CT (E) IA (T) NJ (E) OH (E) PA (E)
	S. pellita	satiny willow		NH (T) WI (E)
	S. petiolaris	meadow willow		OH (T) PA (E)
	S. planifolia	diamondleaf willow		ME (T) MI (T) NH (T) VT (T) WI (T)
	S. pyrifolia	balsam willow		NY (T)
	S. sericea	silky willow		AR (E)

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Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Salix serissima	autumn willow		IL (E) IN (T) PA (T)
	S. sessilifolia	northwest sandbar willow		WA (T)
	S. uva-ursi	bearberry willow		ME (T) NY (T) VT (E)
Symphoricarpos albus, *S. racemosus*	*Symphoricarpos albus*	common snowberry		KY (E) MD (T)
	Symphoricarpos albus var. *albus*	common snowberry		IL (E) MA (E)
Tilia sp.	*Tilia americana* var. *heterophylla* [= *T. heterophylla*]	American basswood		IL (E)
Ulmus sp., *U. campestris*, *U. minor*	*Ulmus thomasii*	rock elm		IL (E) NY (T) OH (T)
Urtica sp., *U. dioica*	*Urtica chamaedryoides*	heartleaf nettle		IL (T) OH (E)
Vaccinium sp.	*Vaccinium angustifolium*	lowbush blueberry		IA (T)
	V. boreale	northern blueberry		ME (T) NY (T)
	V. caespitosum	dwarf bilberry		MI (T) NY (E) WI (E)
	V. corymbosum	highbush blueberry		IL (E)
	V. elliottii	Elliott's blueberry		TN (E)
	V. macrocarpon	cranberry		IL (E) TN (T)

Table D1: Threatened and endangered plants in the conterminous U.S. that are potential hosts for *Adoxophyes orana*.

Documented/Reported Host(s)	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Vaccinium myrtilloides	velvetleaf huckleberry		IA (T) IN (E) OH (T)
	V. oxycoccos	small cranberry		IL (E) IN (T) MD (T) OH (T)
	V. stamineum	deerberry		VT (E)
	V. uliginosum	bog blueberry		MI (T) MN (T)
	V. vitis-idaea	lingonberry		MI (E)
	Vaccinium vitis-idaea ssp. *minus*	northern mountain cranberry		MA (E) WI (E)
Vicia faba	*Vicia americana*	American vetch		MD (E)
	V. caroliniana	Carolina vetch		NJ (E)
	V. ocalensis	Ocala vetch		FL (E)
Vitis vinifera	*Vitis aestivalis*	summer grape		ME (E)
	Vitis cinerea var. *baileyana*	graybark grape		PA (E)
	V. rupestris	sand grape		IN (E), KY (T), PA (E)
	V. vulpina	frost grape		MI (T) NY (E)
	Vitis x*novae-angliae* (pro sp.) [*labrusca* x *riparia*]	pilgrim grape		MD (E) PA (E)

1. E= Endangered; T=Threatened

Appendix E. Biology of *Adoxophyes orana*

Population phenology

In the Netherlands and in much of Europe, *Adoxophyes orana* has two generations annually. A partial third generation is possible if warm temperatures persist in fall; however larvae may not enter diapause and are likely to die (de Jong et al. 1971, Barel 1973a, de Jong and Van Dieren 1974, Berlinger and Ankersmit 1976b, Stamenkovic and Stamenkovic 1984, Charmillot and Brunner 1989, 1990, Stamenkovic et al. 1999). Summer or first generation larvae actively feed on leaves, buds, flowers and developing fruit in June and July. The overwintering or second generation feeds in fall and in teh following spring (Fluckiger and Benz 1982). *A. orana* overwinters as a diapausing second or thrid instar. Feeding resumes in the spring, typically April, on young leaves, buds and flowers (Fluckiger and Benz 1982).

The number of generations and the size of the population in each generation is determined by several factors including photoperiod, temperature, humidity, host availability and quality, and presence of natural enemies (Cross et al. 1999b) Development time depends primarily on temperature (see Table E1} (Balachowsky 1966, Minks and Noordink 1971, Barel 1973a, de Jong and Beeke 1976, Fluckiger and Benz 1982, Charmillot and Megevand 1983, Vanwetswinkel and Soenen 1983, Charmillot et al. 1984, Stamenkovic and Stamenkovic 1984, Stamenkovic 1988, Charmillot and Brunner 1989, Minks et al. 1995, Milonas and Savopoulou-Soultani 2000, 2004). Under field conditions, eggs typically hatch in 10-14 days, pupation occurs in about 10 days, and egg-pupa development is completed in about 35 days. There are 5-6 larval instars (Barel 1973a, CAB 2004).

Stage specific biology

Adult

Adults are active in summer and fall, though emergence may vary according to climatic conditions. Flight periods of the first and second generation may overlap (Whittle 1985). Duration of the adult stage depends primarily on temperature and relative humidity. Under natural conditions, the longest recorded life span is 23 days (Barel 1973a). The ratio of males to females is about 1:1, with little difference between the sexes in average life span (Barel 1973a).

Flight lasts approximately 4 weeks and is greatest in the first half of the flight period when conditions are optimal for egg and larval development (Barel 1973a). Moths fly at temperatures above 13°C (Whittle 1985). Males precede females in flight by a few days and may disperse up to 400 meters. Female dispersal is limited (Barel 1973a, CAB 2004). First, second and third generation flight in northwestern Europe occurs from late May to late June, late July to early September, and October, respectively (CAB 2004). Mating occurs at night or in early morning hours, about a day afer emergence (de Jong et al. 1971, Whittle 1985, He et al. 1996). Adults rest on leaves within the tree canopy during the day and become active at dusk (Bradley et al. 1973).

Oviposition is initiated at an accumulated 135 degree days above 10°C after flight begins, and typically occurs during the afternoon and evening (CAB 2004). Egg-laying increases at temeperatures above 15°C, decreases below 13°C, and ceases below 9°C (de Jong et al. 1971) (Charmillot et al. 1984, Whittle 1985, CAB 2004). Females lay eggs in masses of 4-150 or more (CAB 2004), on upper and lower leaf surfaces during spring and summer. A single female can lay a total of 200-400 eggs (Bradley et al. 1973, Whittle 1985, CAB 2004). Eggs will occasionally be deposited on fruit in the fall (Bradley et al. 1973) or on tree trunks if the population density is high (CAB 2004).

Egg
Eggs develop after an accumulated 90 degree days, with a developmental threshold of 10°C (Charmillot and Megevand 1983). Eggs hatch in about 8-20 days, depending on temperature (Bradley et al. 1973, de Jong 1980, CAB 2004). In the United Kingdom, the second generation hatches early in fall (Bradley et al. 1973). Eggs become transparent just before hatching, making the dark head capsules of larvae visible (CAB 2004).

Larva
There are 5-6 instars (CAB 2004). In the Netherlands, larvae feed on young leaves, buds and flowers beginning in April and on developing fruit in May (de Jong and Beeke 1976, Whittle 1985). Larvae may feed sheltered under a leaf bound to fruit with silk (Bradley et al. 1973) Summer-generation larvae feed extensively and causing considerable damage to fruit (de Jong and Beeke 1976). Overwintered larvae begin feeding in the spring after an accumulated 67 degree days above a developmental threshold of 9-10°C (Charmillot and Megevand 1983, Whittle 1985). Summer generation larvae complete development on average in 430 degree days above a threshold of 7-8°C (Charmillot and Megevand 1983, Whittle 1985).

Second generation larvae occur in early fall and overwinter as second or third instars (Bradley et al. 1973). In the fall, second or third-instar larvae feed on fruit, spin a white silken web along the midrib on the lower surface of a leaf, then overwinter in diapause, provided that sufficient development has occurred (Berlinger and Ankersmit 1976b).

Diapause is influenced by several factors including photoperiod and the ability of an insect to withstand freezing temperatures (Jo and Kim 2001, Milonas and Savopoulou-Soultani 2004). Diapause in late-instar larvae is induced by short day length ranging from <12-16 h at 20-25°C (Barel 1973a, Berlinger and Ankersmit 1976a, Bonnemaison 1977, Whittle 1985). Duration of diapause influences when diapause will be terminated (Milonas and Savopoulou-Soultani 2004). Protected feeding resumes in the spring after the larvae bind together leaves, flower buds and other plant parts (CAB 2004). Late instars may be found near new shoot growth in the crown (CAB 2004). Fully developed larvae (measuring approx. 2cm) pupate in leaves bound together with silk, or within a silk cocoon spun between leaves and twigs or shoots, in mumified fruit attached with silk to a fruiting spur, or inside crevises on trunks and branches (Bradley et al. 1973, CAB 2004).

Pupa
Pupal development requires an accumulated 90 degree days above a developmental threshold of 10°C (Charmillot and Megevand 1983).

Table E1. Developmental threshold and degree day requirements for *A. orana*

Stage	**Developmental threshold (°C)**	**Degree Days (°C)**	**Reference**
Egg	10		
	15	263	(deJong 1965 cited in (Berlinger and Ankersmit 1976a))
Larva			
1st generation (summer)	7-8	430	(Charmillot and Megevand 1983)
2nd generation(enter diapause; overwinter as late-instars/spring) generation	9-10	67	(Charmillot and Megevand 1983)
prediapause	15	420	(deJong 1965 cited in (Berlinger and Ankersmit 1976a))
Pupa	10	90	(Charmillot and Megevand 1983)
Oviposition	10	135 (after flight begins)	(de Jong 1980, de Jong and Minks 1981, CAB 2004)