Mini Risk Assessment
Japanese Wax Scale: *Ceroplastes japonicus* Green
[Hemiptera: Coccidae]

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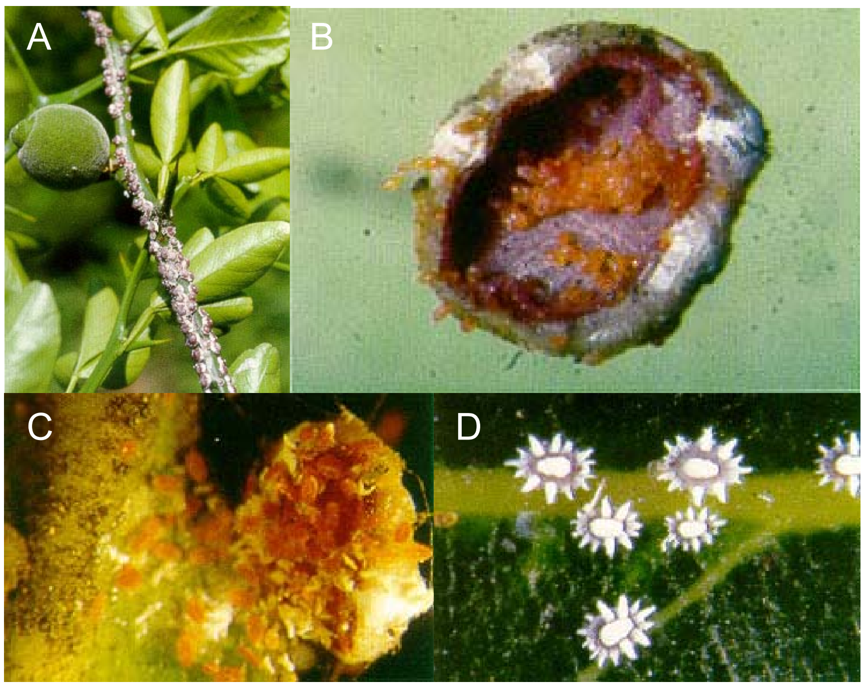

Figure 1. *Ceroplastes japonicus*: (A) infestation on stem; (B) adult female with eggs; (C) crawlers; and (D) juvenile stage of scale clustered at midrib of bay leaf. [Images courtesy of Regione del Veneto (Anon. 2005).]

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Introduction

Ceroplastes japonicus is a significant, economic pest of citrus and other fruit crops in Asia and Europe (Ben-Dov 1993, Ben-Dov and Hodgson 1997, CAB 2004). This insect will also feed on ornamental and natural plantings of trees and shrubs (Ben-Dov 1993), but the degree of damage caused by this feeding is unknown. *Ceroplastes japonicus* is also known as the Japanese or tortoise wax scale and is not known to occur in the US.

The risks posed by *C. japonicus* to US agriculture and ecosystems have been evaluated in previous risk assessments. In evaluations of the potential importation of Chinese penjing into the US, Cave and Redlin (1996a, 1996b) concluded that this insect had a high impact potential and high probability of becoming established. The purpose of this "mini-" pest risk assessment is to further evaluate several factors that contribute to risks posed by *C. japonicus* and apply this information to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: High.** *Ceroplastes japonicus* is present in much of Asia and to a more limited extent in Europe. Appendix A provides a detailed list of countries reporting the presence of the insect. In general, *C. japonicus* occurs in climates ranging from seasonally cool and moist to warm and dry (CAB 2004). The currently reported distribution of *C. japonicus* suggests that the pest may be most closely associated with biomes characterized as: desert and xeric shrublands; mediterranean scrub; temperate broadleaf and mixed forests; and temperate coniferous forests. Consequently, we estimate that approximately 68% of the continental US would have a suitable climate for *C. japonicus* (Fig. 2). See Appendix A for a more complete description of this analysis.

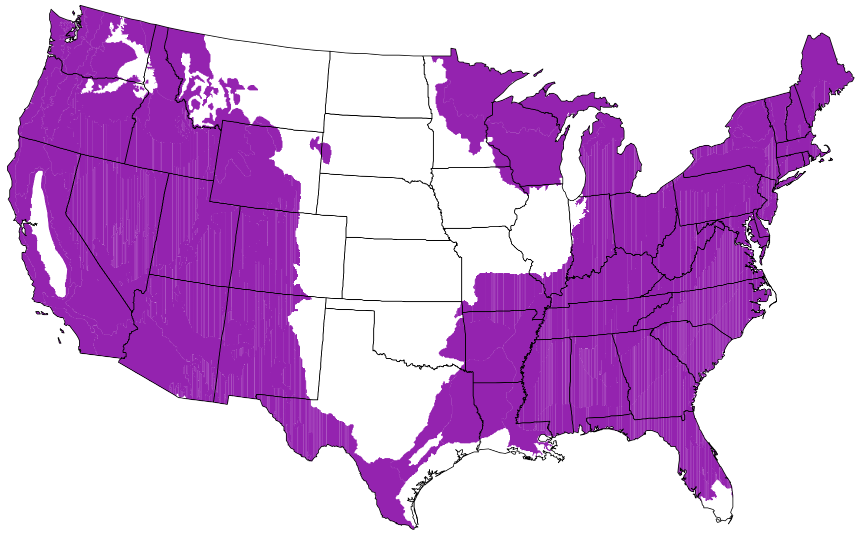

Figure 2. Predicted distribution (purple) of *Ceroplastes japonicus* in the contiguous US.

Figure 2 illustrates where *C. japonicus* 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. For initial surveys, survey efforts should be concentrated in the higher risk areas and gradually expanded as needed.

2. **Host Specificity/Availability. Rating: Low/High.** *Ceroplastes japonicus* is not a selective feeder; it reportedly feeds on over 100 plant hosts in 27 families (Table 1). Many of these species occur broadly within the US, often at high densities. The insect attacks both cultivated and non-cultivated plants.

Table 1. Host plants of *Ceroplastes japonicus*:

Hosts	References
annona (*Annona* sp.)	(Ben-Dov and Hodgson 1997)
apple (*Malus* sp.)	(Konstantinova and Gura 1986, Ben-Dov 1993, CAB 2004)
apple, paradise (*Malus domestica*)	(Jancar et al. 1999)
apricot (*Prunus armeniaca*)	(Camporese and Pellizzari 1998, Jancar et al. 1999)
apricot, Japanese (*Prunus mume*)	(Ben-Dov 1993, CAB 2004)
barberry (*Berberis* sp.)	(Ben-Dov 1993)
barberry, hollyleaved (*Mahonia aquifolium*)	(Jancar et al. 1999)
blueberry tree (*Elaeocarpus decipiens*)	(Ben-Dov 1993, CAB 2004)
boxelder (*Acer negundo*)	(Camporese and Pellizzari 1998)

Hosts	**References**
boxwood (*Buxus* sp.)	(Ben-Dov 1993)
boxwood, African (*Myrsine africana*)	(Camporese and Pellizzari 1998)
broadleaf podocarpus (*Podocarpus nagi*)	(Ben-Dov 1993, CAB 2004)
cherry, sour (*Prunus cerasus* (=*Cerasus vulgaris*))	(Ben-Dov 1993, Camporese and Pellizzari 1998)
cherry, sweet (*Prunus avium (*=Cerasus avium))	(Ben-Dov 1993, Jancar et al. 1999, CAB 2004)
cherry, Yoshino (*Prunus yedoensis*)	(Ben-Dov 1993, Ben-Dov and Hodgson 1997, CAB 2004)
citrus (*Citrus* sp.)	(Longo 1985, Kravchenko 1991, Ben-Dov 1993, Pellizzari and Camporese 1994, Ben-Dov and Hodgson 1997, Camporese and Pellizzari 1998, Yasnosh and Japoshvili 1998, CAB 2004)
common box (*Buxus sempervirens*)	(Jancar et al. 1999)
cornelian cherry (*Cornus mas*)	(Ben-Dov 1993, CAB 2004)
crenate pride-of-Rochester (*Deutzia crenata*)	(Camporese and Pellizzari 1998)
elm, European field (*Ulmus minor*)	(Camporese and Pellizzari 1998, CAB 2004)
elm, wych (*Ulmus campestris*)	(Pellizzari and Camporese 1994)
eurya (*Eurya japonica*)	(Ben-Dov 1993)
feijoa fruit or pineapple guava (*Feijoa sellowiana*)	(Ben-Dov 1993, Ben-Dov and Hodgson 1997, CAB 2004)
fig, edible (*Ficus carica*)	(Jancar et al. 1999)
guava (*Psidium guajava*)	(Ben-Dov and Hodgson 1997)
hawthorn (*Crataegus* sp.)	(Ben-Dov 1993)
holly (*Ilex* sp.)	(Longo 1985, Pellizzari and Camporese 1994)
holly, Black Sea (*Ilex colchica*)	(Yasnosh and Japoshvili 1998)
holly, Chinese (*Ilex cornuta*)	(Camporese and Pellizzari 1998)
holly, English (*Ilex aquifolium*)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Jancar et al. 1999, CAB 2004)
holly, lusterleaf (*Ilex latifolia*)	(Camporese and Pellizzari 1998)
holly, Nepal (*Ilex integra*)	(Ben-Dov 1993, CAB 2004)
hydrangea, common (*Hydrangea hortensia*)	(Jancar et al. 1999)
ivy (*Hedera* sp.)	(Pellizzari and Camporese 1994)
ivy, colchis (*Hedera colchica*)	(Yasnosh and Japoshvili 1998)

Hosts	References
ivy, English (*Hedera helix*)	(Longo 1985, Ben-Dov 1993, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, CAB 2004)
Japanese aralia (*Fatsia japonica*)	(Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, CAB 2004)
jasmine (*Jasminum* sp.)	(Yang et al. 1996, CAB 2004)
jasmine, yellow star (*Trachelospermum asiaticum*)	(Ben-Dov 1993, CAB 2004)
jujube (*Ziziphus* sp.)	(Tang 1984, Tang et al. 1990, Ben-Dov 1993)
jujube, common or Chinese date tree (*Ziziphus jujuba*)	(Luo et al. 1991, CAB 2004)
kiwi (*Actinidia chinensis*)	(Ben-Dov and Hodgson 1997)
kodo wood (*Ehretia acuminata*)	(Ben-Dov 1993, CAB 2004)
laurel (*Laurus* sp.)	(Kravchenko 1991)
laurel, bay (*Laurus nobilis*)	(Longo 1985, Ben-Dov 1993, Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Yasnosh and Japoshvili 1998, Jancar et al. 1999, Japoshvili 2001, CAB 2004)
laurel, cherry (*Prunus laurocerasus*)	(Kravchenko 1991, Ben-Dov 1993, 1997, CAB 2004)
laurel, spotted (*Aucuba japonica*)	(Camporese and Pellizzari 1998)
lemon (*Citrus limon*)	(Jancar et al. 1999)
loquat (*Eriobotrya japonica*)	(Longo 1985, Ben-Dov 1993, 1997, Camporese and Pellizzari 1998, Yasnosh and Japoshvili 1998, Jancar et al. 1999, CAB 2004)
Machilus thunbergii	(Ben-Dov 1993)
magnolia (*Magnolia* sp.)	(Longo 1985)
magnolia, southern (*Magnolia grandiflora*)	(Ben-Dov 1993, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, CAB 2004)
mandarine or tangerine (*Citrus reticulata*)	(Avidzba and Nadaraia 1974, Jancar et al. 1999, CAB 2004)
mandarine, Mediterranean (*Citrus deliciosa*)	(CAB 2004)
mango (*Mangifera indica*)	(CAB 2004)

Hosts	**References**
maple (*Acer* sp.)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, CAB 2004)
maple, downy Japanese (*Acer japonicum*)	(Ben-Dov 1993, CAB 2004)
maple, Japanese (*Acer palmatum*)	(Green 1921)
maple, silver (*Acer saccharinum*)	(Camporese and Pellizzari 1998)
maple, sycamore (*Acer pseudoplatanus*)	(Kozar et al. 1984, Camporese and Pellizzari 1998, CAB 2004)
Maule's quince (*Chaenomeles japonica*)	(Jancar et al. 1999)
mulberry (*Morus* sp.)	(Kravchenko 1991, Ben-Dov 1993, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Yasnosh and Japoshvili 1998, Jancar et al. 1999, CAB 2004)
myrtle (*Myrtus communis*)	(Ben-Dov 1993, CAB 2004)
oleander (*Nerium oleander*)	(Ben-Dov 1993, CAB 2004)
orange, trifoliate (*Poncirus trifoliata* (=*Citrus trifoliata* (=*Aegle sepiaria*)))	(Kozar et al. 1984, Ben-Dov 1993, Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Jancar et al. 1999, CAB 2004)
peach (*Prunus persica*)	(Jancar et al. 1999, CAB 2004) (Ben-Dov 1993, Ben-Dov and Hodgson 1997)
pear (*Pyrus* sp.)	(Kravchenko 1991, Ben-Dov and Hodgson 1997)
pear, Chinese (*Pyrus sinensis*)	(Ben-Dov 1993, Ben-Dov and Hodgson 1997)
pear, European (*Pyrus communis*)	(Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Jancar et al. 1999, CAB 2004)
pear, Japanese (*Pyrus pyrifolia*)	(CAB 2004)
Persea thunbergii	(CAB 2004)
persimmon (*Diospyros* sp.)	(Tang 1984, Tang et al. 1990, Kravchenko 1991, Pellizzari and Camporese 1994, Ben-Dov and Hodgson 1997)
persimmon, oriental (*Diospyros kaki*)	(Ben-Dov 1993, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Yasnosh and Japoshvili 1998, Jancar et al. 1999, CAB 2004)
pittosporum, Japanese (*Pittosporum tobira*)	(Ben-Dov 1993, CAB 2004)

Hosts	References
plane, London (*Platanus hybrida* (=*Platanus acerifolia*))	(Huang et al. 1992, Camporese and Pellizzari 1998)
plane, oriental (*Platanus orientalis*)	(Pellizzari and Camporese 1994, CAB 2004)
plum, European (*Prunus domestica*)	(Camporese and Pellizzari 1998, Japoshvili 2001)
pomegranate (*Punica granatum*)	(Jancar et al. 1999)
quince (*Cydonia oblonga* (=*Cydonia vulgaris*))	(Ben-Dov 1993, 1997, Camporese and Pellizzari 1998, CAB 2004)
sago palm (*Cycas revoluta*)	(Ben-Dov 1993, CAB 2004)
sakaki (*Cleyera japonica*)	(CAB 2004)
scarlet firethorn (*Pyracantha coccinea*)	(Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, CAB 2004)
small eleven flower (*Epimedium colchicum*)	(Ben-Dov 1993)
spindletree (*Euonymus* sp.)	(Ben-Dov 1993)
spindletree, Japanese (*Euonymus japonicus*)	(Miyanoshita and Kawai 1992, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998, Jancar et al. 1999, CAB 2004)
stone fruit (*Prunus* sp.)	(Pellizzari and Camporese 1994, Japoshvili 2001, CAB 2004)
Svida sp.	(Ben-Dov 1993)
sweetgum (*Liquidambar styraciflua*)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998)
tea (*Camellia japonica*)	(Ben-Dov 1993, CAB 2004)
tea, green (*Camellia oleifera*)	(Sun 1989)
tea (*Camellia sinensis* (=*Thea sinensis*))	(Ben-Dov 1993, Yang et al. 1996, 1997, CAB 2004)
thorny olive (*Elaeagnus pungens*)	(Ben-Dov 1993, CAB 2004)
willow (*Salix* sp.)	(CAB 2004)
willow, king (*Salix glandulosa*)	(Ben-Dov 1993)
willow, weeping (*Salix babylonica*)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998)
willow (*Salix saidaeana*)	(Ben-Dov 1993)

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

3. **Survey Methodology. Rating: Low.** Surveys for *C. japonicus* will have to rely on visual inspection of potentially infested plant material. No alternative tools

(e.g., chemical or visual attractants) are available to assist with survey efforts. As a result, surveys for this insect will likely involve considerable time and labor. If only a limited effort can be expended, chances of finding low densities are poor.

In China, first instars and overwintering adult females were spatially aggregated (Wu et al. 1991) as were densities of all life stages combined (Liu et al. 2003). Aggregation is a serious concern when the purpose of an inspection is to accurately estimate the mean density of wax scales. For example, 1,149 sample units must be collected to obtain a relative net precision of 10% when the average density is 0.1 scales/plant (Liu et al. 2003). Substantially, less effort is needed when the goal of an inspection is simply to detect *C. japonicus*. Because of the aggregated distribution of scales, when the average density is, for example, 0.1 scales per plant, only 9.3% (=9.3×10^{-2}) of the plants are expected to have scales; 90.7% have no scales. To detect at least one scale with 95% confidence, 31 sample units would have to be collected. If 50% confidence is acceptable, only 7 samples are needed to detect at least one scale. In general, as the proportion of plants with wax scales increases, the inspection effort needed to find at least one of these insects decreases. As the desired statistical confidence in the inspection increases, the number of sample units that must be inspected also increases.

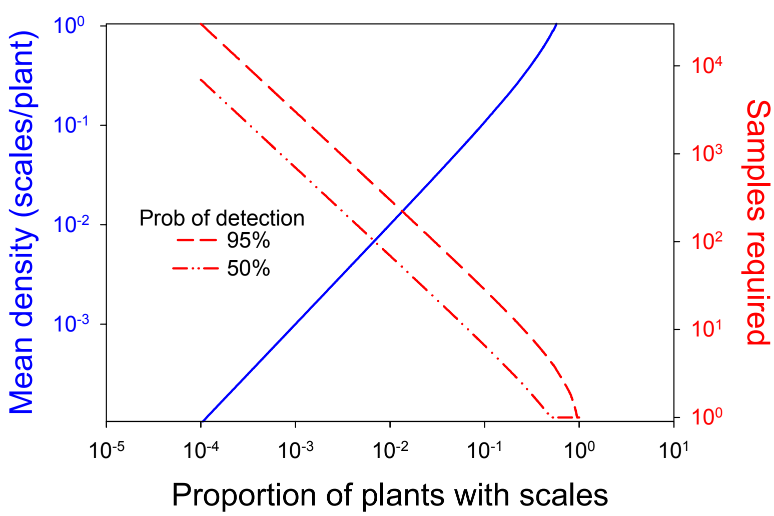

Figure 3. Relationship between the proportion of plants with at least one *C. japonicus* and the mean density of scales (blue) and the number of sample units required to detect at least one scale with a desired degree of statistical confidence.

The available literature makes no recommendations for a sample unit. All life stages of *C. japonicus* can feed on leaves, stems, and fruits (CAB 2004). The scales produce honeydew which contributes to the development of sooty molds (CAB 2004). These black fungi growing on the surface of the plant are potential indicators of the presence of *C. japonicus*. However, other piercing-sucking insects may also encourage the growth of sooty molds, and sooty mold may not always develop when *C. japonicus* is present, particularly if rains wash honeydew away.

4. **Taxonomic Recognition. Rating: Medium.** Both immature and adult stages of *C. japonicus* may be difficult to distinguish from *C. floridensis* (Longo 1985, Camporese and Pellizzari 1994). Identification of *C. japonicus* in the field might be difficult. Precise identification requires proper preparation of specimen and examination by a trained taxonomist. Immature stages may only be distinguished with slide-mounted specimens. Adult females may be positively identified by close examination of morphological characters. Pellizzari and Camporese (1994) provide a key to *Ceroplastes* species of the Mediterranean basin, and morphological descriptions of *C. japonicus*, *C. floridensis*, and *C. sinensis*.

   Several members of the genus *Ceroplastes* occur in the US (Ben-Dov 1993, Ben-Dov and Hodgson 1997, USDA 2005b), and early stages of these congeneric scales may be difficult to distinguish: *C. cirripediformis* (in AL, AZ, AR, CA, D.C., FL, GA, LA, MD, MS, MO, NC, OH, PA, SC, and TX), *C. sinensis* (in CA, NC, PA, and VA), *C dugesii* (in FL) and *C. floridensis* (in FL).

   For a more detailed description of the morphology and taxonomy of *C. japonicus*, see Appendix C.

5. **Entry Potential. Rating: Low.** *Ceroplastes japonicus* has been intercepted by officers with the US Department of Agriculture-Animal and Plant Health Inspection Service or the Department of Homeland Security at least 20 times between 1985 and 2004 (USDA 2005a). Incomplete records complicate the accuracy of this count. Interceptions of insects designated as "*Ceroplastes* sp." are more common. Interceptions of *C. japonicus* or "*Ceroplastes* sp." have been reported at least 190 times between 1985 and 2004. Annually, only about 9.5 (±1.1 standard error of the mean) interceptions have been reported nationally (USDA 2005a). The majority of interceptions have been associated with international airline baggage (64%), permit cargo (21%), and general cargo (6%). The majority of interceptions were reported from JFK International airport, NY (21%), Los Angeles, CA (12%), Miami, FL (11%), Elizabeth, NJ (6%), and Boston, MA (6%). 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 *C. japonicus* or "*Ceroplastes* sp." have been reported from 90 plant taxa (USDA 2005a). Interceptions were most common on various *Citrus* spp. (13%), *Ficus carica* (10%), "*Diospyros* sp." (5%), and *Laurus nobilis* (5%).

   The low rating for this risk element is associated with substantial uncertainty. It is conceivable that *C. japonicus* arrived more frequently than the PIN records suggest. *C. japonicus* could have been intercepted but simply identified as "Coccidae; species of." Between 1985 and 2004, "Coccidae; species of" have been intercepted 158 (±21) times per year on average (USDA 2005a). Although unlikely, if all of these individuals were *C. japonicus*, a high rating would be warranted.

6. **Destination of Infested Material. Rating: High.** When an actionable pest is intercepted, officers ask for the intended final destination of the conveyance. Materials infested with *C. japonicus* or "*Ceroplastes* sp." were destined for 21 states, including the District of Columbia (USDA 2005a). The most commonly reported destinations were California (22%), New York (20%), Florida (16%), New Jersey (9%), Massachusetts (7%), Texas (6%), and Illinois (6%). Portions of each of these states have climates and hosts that would be suitable for establishment by *Ceroplastes japonicus*.

7. **Potential Economic Impact. Rating: High.** *Ceroplastes japonicus* is an important pest of persimmon, green tea, and jujube in China; ornamental trees and shrubs, nursery stock and persimmon in northern and central Italy; ornamental plants in urban Japan; and citrus, persimmon, mulberry; fruit trees in Georgia (former USSR); and citrus in Southern Russia (Tang 1984, Longo 1985, Sun 1989, Tang et al. 1990, Pellizzari and Camporese 1994, Ben-Dov and Hodgson 1997, CAB 2003).

   The economic impact of *C. japonicus* is difficult to measure because the pest tends to aggregate and co-occur with other pests (Konstantinova and Gura 1986, Japoshvili 2001, Liu et al. 2003). Furthermore, damage may result directly or indirectly from scale feeding. Scales cause direct plant injury by feeding on plants and depleting nutrients necessary for growth. This competition for nutrients between the scale and its host may ultimately impact yield and overall plant health. Scales may settle to feed on leaf surfaces (typically along the midrib), leaf petioles, young stems, flowers, or fruits. Feeding damage may result in visible chlorosis of leaves, discoloration of fruit, wilting, dieback of foliage and stems, and premature foliage, flower and fruit drop. In extreme cases, feeding may cause tree mortality. Indirect damage is caused by the introduction of scale-vectored pathogens and excreted honeydew that covers plant surfaces which serves as a food source for attendant ants and other insects, and provides a medium for sooty mold growth. Presence of sooty mold may reduce photosynthesis, fruit quality, yield, and ultimately the marketability of a commodity (Ben-Dov and Hodgson 1997, Jancar et al. 1999, CAB 2003).

   Control measures for *C. japonicus* are only feasible in the crawler stage, prior to settling on a plant host. A thorough understanding of the biology of *C. japonicus* as well as conditions that favor attack by this pest will be essential for successful detection and control efforts.

   Establishment of *C. japonicus* might impact domestic or international trade. The pest is of quarantine significance in Australia (BA-AQIS 2003). Domestic quarantines, international quarantines, or additional commodity treatments might be required to prevent the spread of the insect.

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

   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). Therefore, the establishment of 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.

   Ceroplastes japonicus has a wide host range, feeding on leaves, stems, and fruits of numerous fruit crops, trees and shrubs [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 *C. japonicus*. Plants listed in Appendix D might be suitable hosts for *C. japonicus*, and thus, could be adversely affected by this insect.

9. **Establishment Potential. Rating: High.** Our initial predictions suggest that nearly 70% of the US has a climate that could support populations of *C. japonicus* (Fig. 2). Suitable host plants are common within these climatically suitable areas. Thus, upon arrival into the United States, the chances for establishment are relatively high, compared with other exotic insects that are not known to occur in the US. We note that the likelihood of introduction seems highly uncertain. Interception records of *Ceroplastes* sp. or *C. japonicus* indicate a low potential for arrival, but interception records for unidentified coccids suggest a high arrival rate is possible.

   See Appendix E for a more detailed description of the biology of *C. japonicus*.

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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 *Ceroplastes japonicus*.

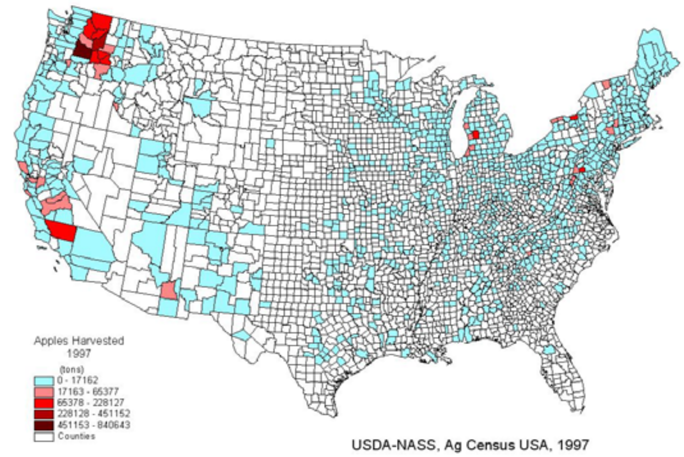
Location	References
Abkhazia	(Avidzba and Nadaraia 1974, Pellizzari and Camporese 1994, Ben-Dov and Hodgson 1997, Camporese and Pellizzari 1998)
Armenia	(CAB 2004)
Azerbaijan	(CAB 2004)
Azerbaijan (Lenkhoran)	(Yasnosh and Japoshvili 1998)
Black Sea coast of the Caucasus	(Yasnosh and Japoshvili 1998)
Caucasus	(Kozar et al. 1984)
China	(Ben-Dov 1993, Ben-Dov and Hodgson 1997, Camporese and Pellizzari 1998)
China (Hebei, Henan, Shanxi)	(Tang 1984, Pellizzari and Camporese 1994, CAB 2004)
China (Hubei, Shaanxi, Zhejiang)	(CAB 2004)
China (Hunan, Jiangsu)	(Pellizzari and Camporese 1994)
China (Shanghai)	(Pellizzari and Camporese 1994)
China (Shenxi)	(Tang 1984, Pellizzari and Camporese 1994)
China (Szechwan)	(Ben-Dov and Hodgson 1997)
China (Zhejiang province - Xiaoshan City)	(Wu et al. 1991)
England[1] (St. Albans; Hertfordshire)	(Green 1921, Ben-Dov 1993)
England[1]	(Ben-Dov and Hodgson 1997, CAB 2003, 2004)
France	(CAB 2004)
France (Antibes, Carqueiranne, Valauris)	(Pellizzari and Camporese 1994)
France (southern)	(Pellizzari and Camporese 1994, Camporese and Pellizzari 1998)
Georgia, Republic of	(Kozar et al. 1982, Pellizzari and Camporese 1994) (Ben-Dov 1993, Ben-Dov and Hodgson

Location	References
	1997, Camporese and Pellizzari 1998, CAB 2004)
Georgia, Republic of (Sukhumi)	(Yasnosh and Japoshvili 1998)
Georgia, Republic of (Tbilisi)	(Yasnosh and Japoshvili 1998, Japoshvili 2001)
Italy	(Ben-Dov and Hodgson 1997, CAB 2004)
Italy (Campania-Naples)	(Camporese and Pellizzari 1998)
Italy (Capri)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998)
Italy (central)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994, Canovai and Raspi 1999)
Italy (Emilia- Romagna - Bologna, Forlì, Rimini)	(Camporese and Pellizzari 1998)
Italy (Florence)	(Pellizzari and Camporese 1994)
Italy (Friuli-Venezia Giulia:-Trieste, Gorizia, Udine, Pordenone)	(Camporese and Pellizzari 1998)
Italy (Islands of Burano and San Francesco del Deserto)	(Camporese and Pellizzari 1998)
Italy (Latium - Rome, Frosinone)	(Camporese and Pellizzari 1998)
Italy (Liguria - Imperia)	(Camporese and Pellizzari 1998)
Italy (Lombardy - Milan, Brescia)	(Camporese and Pellizzari 1998)
Italy (Marche - Pesaro, Ascoli Piceno)	(Camporese and Pellizzari 1998)
Italy (northeastern)	(Pellizzari and Camporese 1994, 1997)
Italy (northern)	(Ben-Dov 1993, Camporese and Pellizzari 1994, Canovai and Raspi 1999)
Italy (Padua)	(Kozar et al. 1984, Longo 1985, Camporese and Pellizzari 1994, Pellizzari and Camporese 1994)
Italy (Pisa)	(Longo 1985, Pellizzari and Camporese 1994)
Italy (Riccione)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994)
Italy (Rome)	(Longo 1985, Camporese and Pellizzari 1994, Pellizzari and Camporese 1994)
Italy (southern)	(Camporese and Pellizzari 1994, Pellizzari and Camporese 1994)
Italy (Tuscany - Florence, Pisa, Lucca)	(Camporese and Pellizzari 1998)
Italy (Venetia - Venice, Treviso, Padua, Vicenza, Verona, Rovigo)	(Camporese and Pellizzari 1998)
Italy (Venice)	(Longo 1985, Pellizzari and Camporese 1994)
Japan	(Yasnosh and Japoshvili 1998) (Ben-Dov 1993, Ben-Dov and Hodgson 1997, Camporese and Pellizzari 1998)
Japan (Honshu, Kyushu, Shikoku)	(Pellizzari and Camporese 1994, CAB 2004)
Japan (Kyoto)	(Takabayshi and Takahashi 1985)
Japan (Ryukyu Archipelago)	(CAB 2004)
Korea	(Ben-Dov 1993, Pellizzari and Camporese 1994, Camporese and Pellizzari 1998)

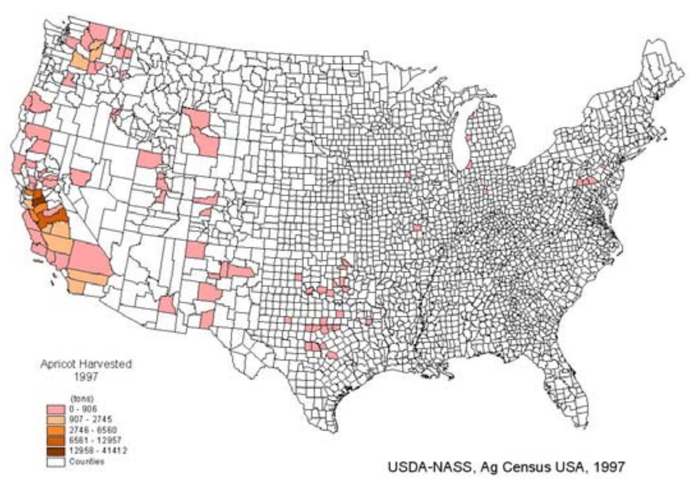
Location	References
Korea (Chonnam Province)	(Park et al. 1992)
Korea, Republic of	(CAB 2004)
Nepal	(CAB 2004)
Russia (eastern)	(Ben-Dov and Hodgson 1997)
Russia (southern)	(Ben-Dov and Hodgson 1997, CAB 2004)
Russia (Transcaucasia)	(Kravchenko 1991, Yasnosh and Japoshvili 1998)
Slovenia	(Camporese and Pellizzari 1998, CAB 2004)
Slovenia (Primorska, Slovenia Istria, Gonška Brda)	(Jancar et al. 1999)

1. Recorded but not established in the UK (CAB 2003, 2004).

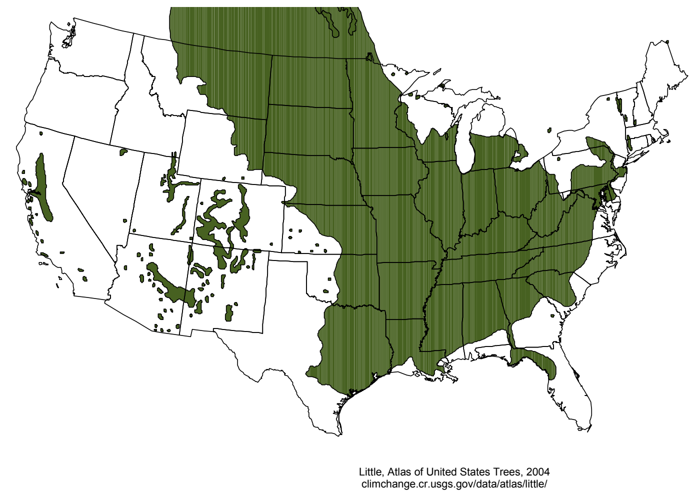
Appendix B. Host distribution (partial) for *Ceroplastes japonicus* in the contiguous US.



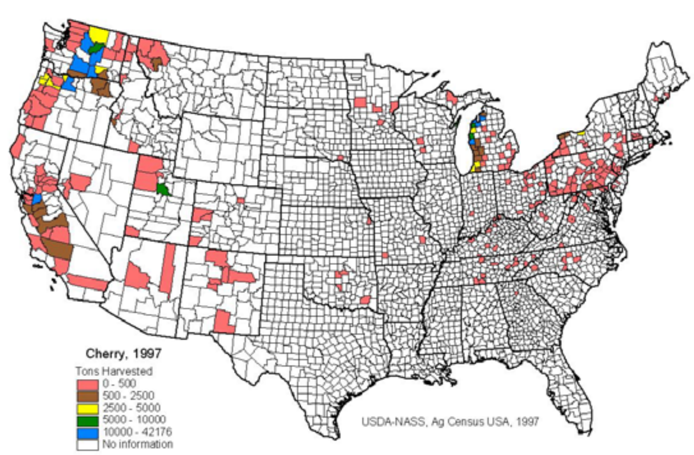
Map 1. Apple (*Malus domestica*)



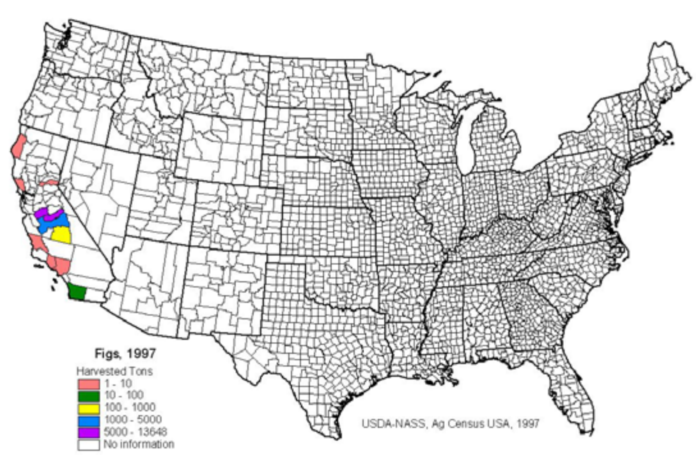
Map 2. Apricot (*Prunus armeniaca*)



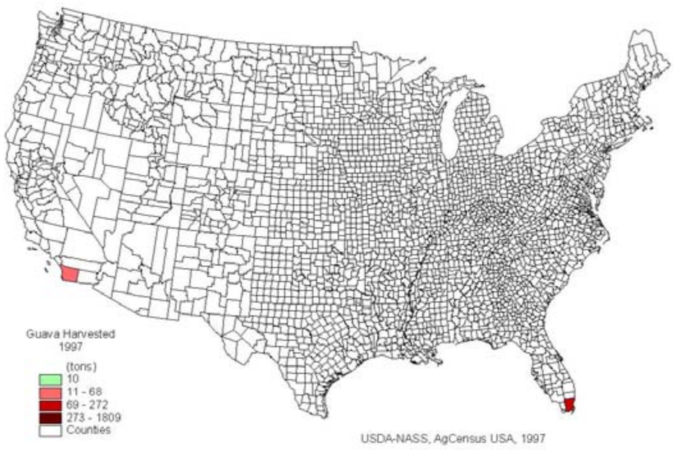
Map 3. Boxelder (*Acer negundo*)



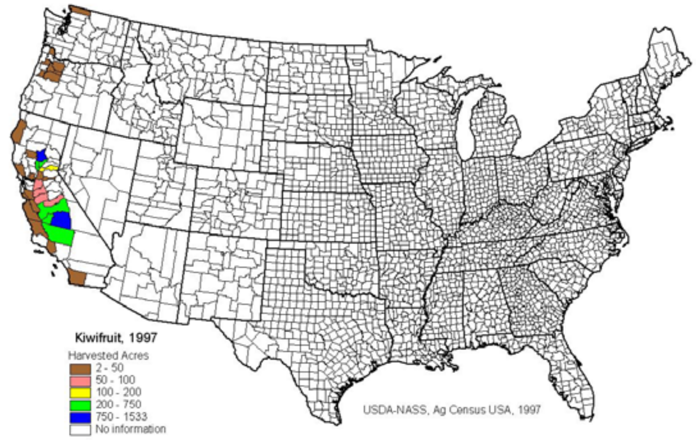
Map 4. Cherry (*Prunus avium*)



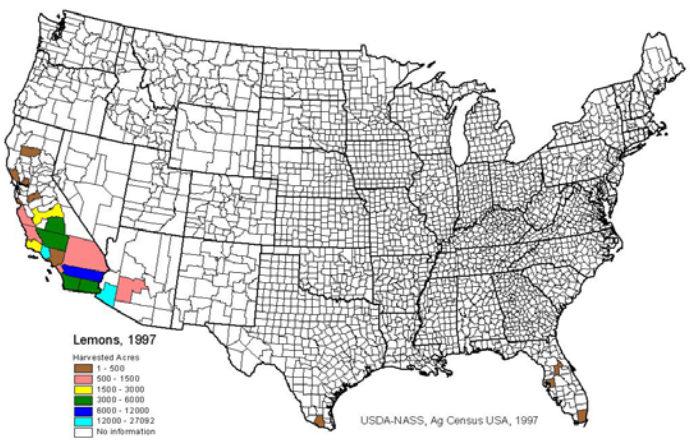
Map 5. Fig (*Ficus carica*)



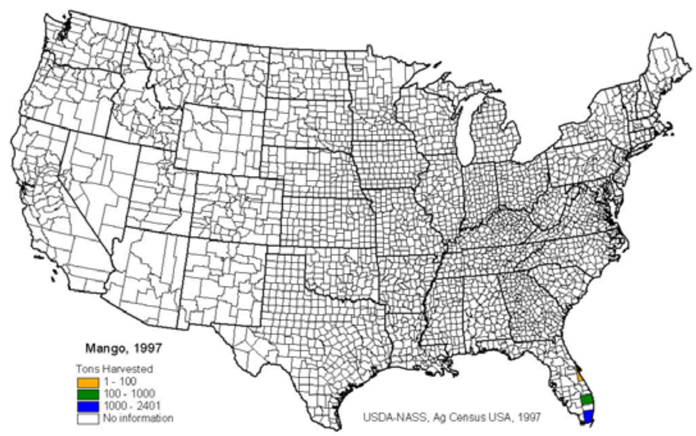
Map 6. Guava (*Psidium guajava*)



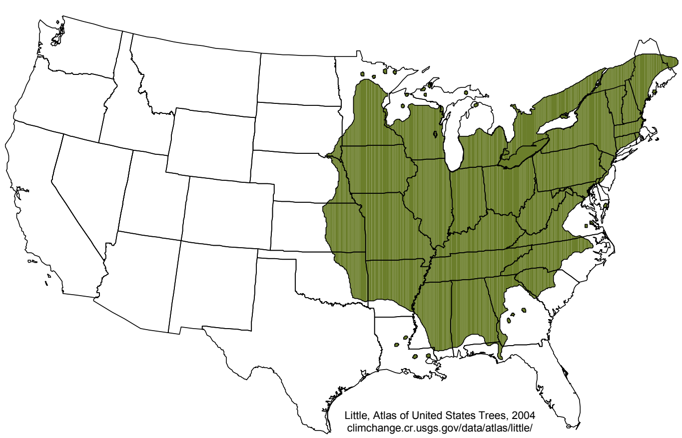
Map 7. Kiwi (*Actinidia chinensis*)



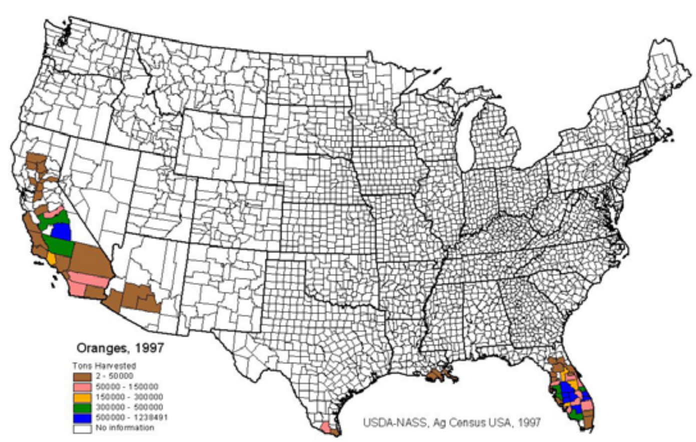
Map 8. Lemon (*Citrus limon*)



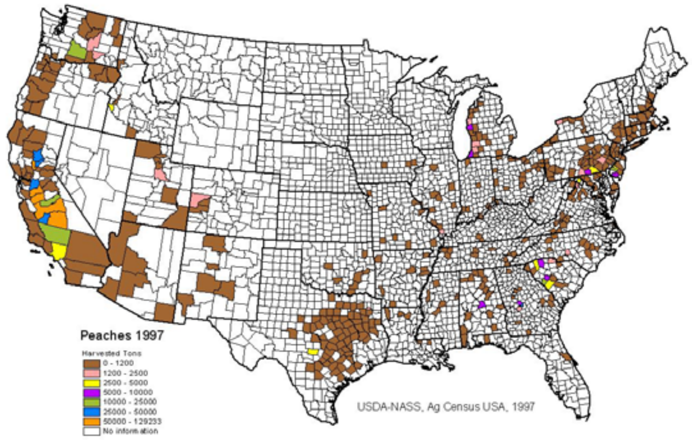
Map 9. Mango (*Mangifera indica*)



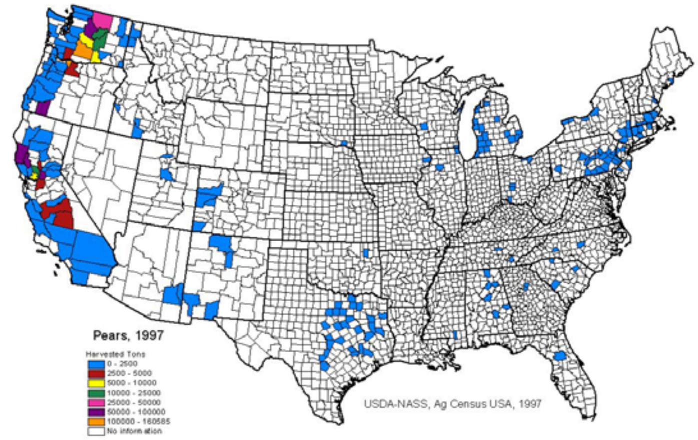
Map 10. Silver maple (*Acer saccharinum*)



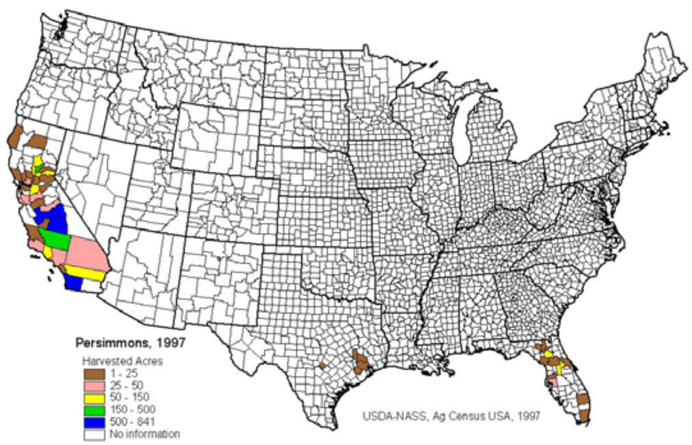
Map 11. Orange (*Citrus* spp.)



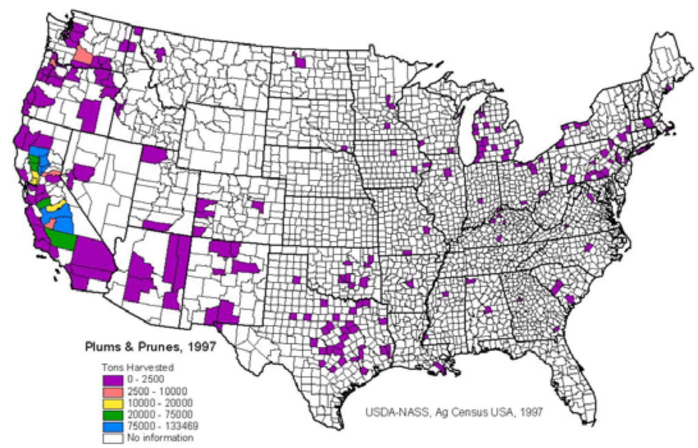
Map 12. Peach (*Prunus persica*)



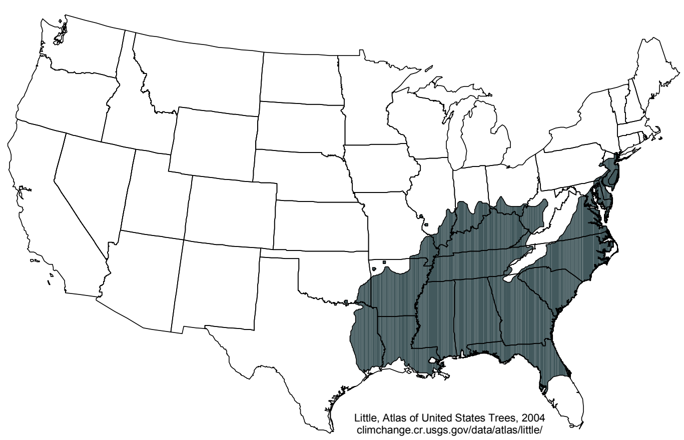
Map 13. Pear (*Pyrus communis*)



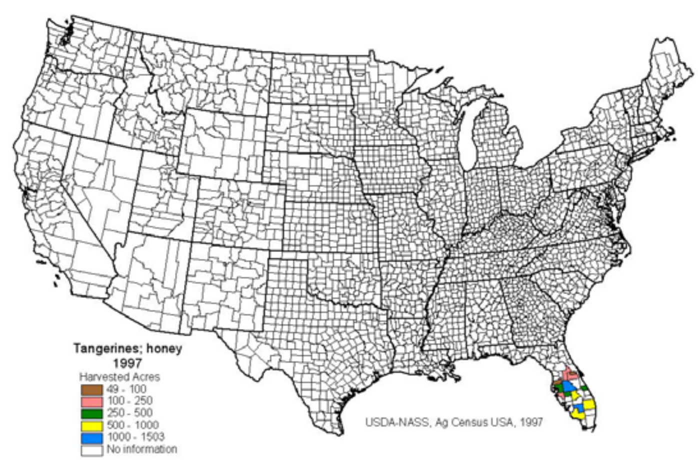
Map 14. Persimmon (*Diospyros* spp.)



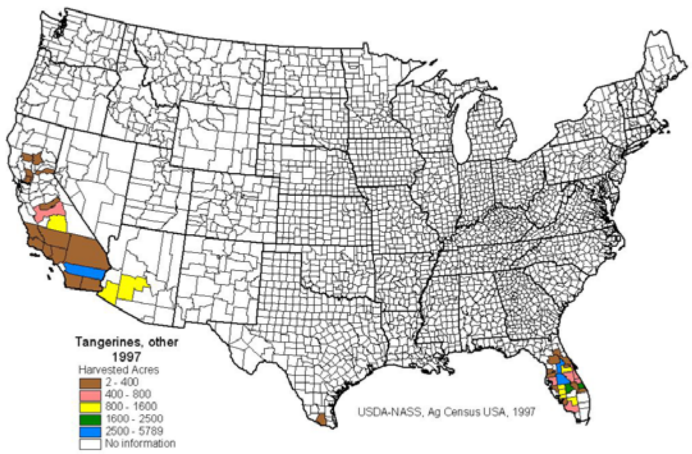
Map 15. Plum & Prunes (*Prunus* spp.)



Map 16. Sweetgum (*Liquidambar styraciflua*)



Map 17. Tangerine, honey (*Citrus reticulata*)



Map 18. Tangerine, other (*Citrus reticulata*)

Appendix C. Taxonomy and morphology of *Ceroplastes japonicus* Green

Ceroplastes japonicus [=*Ceroplastes floridensis japonicus*] was originally described by Green (1921). Recent descriptions of the adult female were provided by Camporese and Pellizzari (1994) and Longo (1985). Immature stages were described by Pellizzari and Camporese (1994), and Camporese and Pellizzari (1994).

Synonyms (Ben-Dov 1993, USDA 2005b)
Ceroplastes floridensis japonicus Green, 1921
Ceroplastes japonicus; Borchsenius, 1949. Change of status.
Cerostegia japonica; De Lotto, 1969. Change of combination.
Ceroplastes rusci; Pellizzari Scaltriti & Antonucci, 1982. Misidentification.
Paracerostegia japonica; Tang, 1991. Change of combination.
Ceroplastes japonicus; Ben-Dov, 1993. Change of combination."

Diagnostic features

For complete accuracy, the following morphological description characterizing the adult female is quoted from Camporese and Pellizzari (1994), and Pellizzari and Camporese (1994):

Adult female (Fig. C1).

"Mounted female oval in shape. 6-segmented antennae. Legs well developed, without tibio-tarsal scleroses. Claw without denticle. Claw digitules of the same shape, broad, with expanded apices.

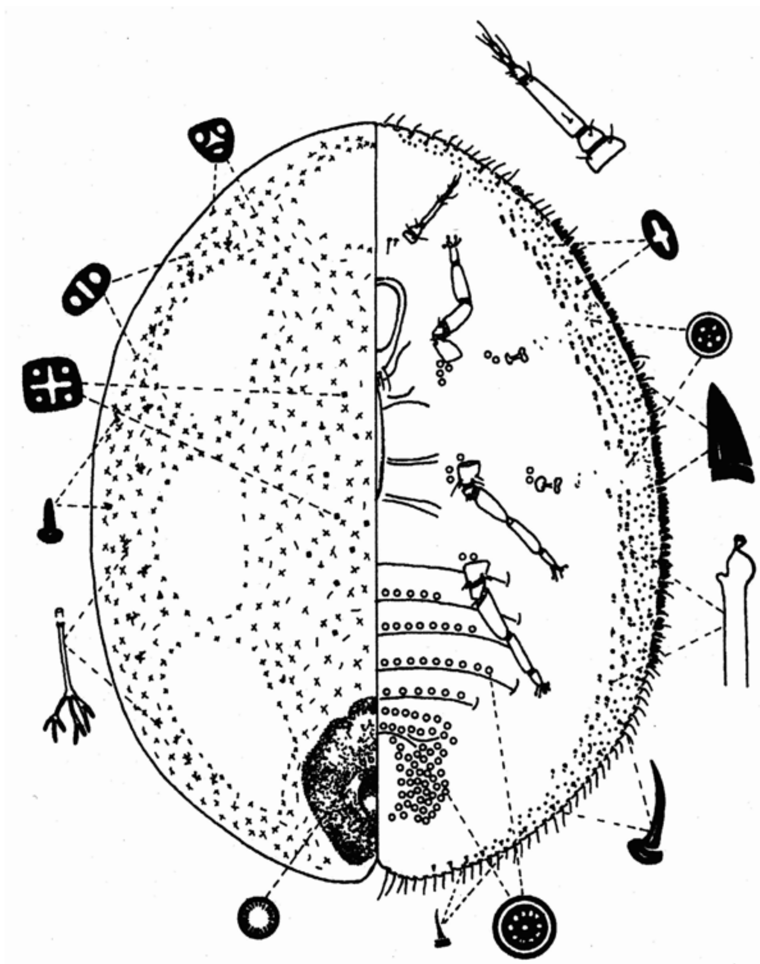


Figure C1. *Ceroplastes japonicus* Green: adult female. [Reproduced from Camporese and Pellizzari (1994)

Margin: stigmatic setae lanceolate with pointed apices, distributed in two rows: a row with 3-4 larger setae extending on dorsum, the others distributed along margin. These setae form a continuous row of 111 (97-148) setae along the body margin. A few marginal bristle-shaped setae (2-7) usually mingled with stigmatic setae (rarely contiguous) may help to distinguish between the anterior and posterior group of stigmatic setae. Marginal bristle shaped setae distributed along the body margin except where stigmatic setae are present. There are 26-30 marginal setae between eye-spots and 45-55 setae from the last stigmatic setae to anal lobe. The last 3-4 setae on anal lobe are distinctly longer than the others.

Dorsum: membranous in young female, with 1 cephalic and 6 lateral clear areas. Dorsal pores scattered, mostly oval trilocular and triangular trilocular; the oval trilocular predominant over other kinds of pores. Some quadrilocular pores present in medio dorsal region. Irregular bilocular pores mainly distributed in submargins. Minute oval pores with filamentous duct distributed in the submargins (these pores are somewhat difficult to detect). Anal plates with 3-4 dorsal and 1 ventral setae. Pre-opercular pores 10 (6-14) just above the anal plates.

Venter: tubular ducts with enlarged inner filament form a submarginal band of 2-3 elements distributed from the eye spot to about the level of the caudal process. Cruciform pores in a submarginal band between the body margin and the band of tubular ducts. Quinquelocular pores in the stigmatic furrow form an irregular band. There are 41 (29-66) quinquelocular disc pores in the anterior band and 50 (24-72) in the posterior band. Multilocular disc pores numerous around the vulva and on sixth abdominal segment. Several multilocular disc pores arranged in a single row in the remaining abdominal segments"(Camporese and Pellizzari 1994). "A few multiocular pores (1-7) near the base of the coxae and near the stigmatic atrium. Submarginal short setae form a row along the body submargin, interrupted by the bands of stigmatic pores. There are an average of 120 submarginal setae from an anal lobe to the opposite one" (Pellizzari and Camporese 1994).

Appendix D. Threatened or endangered plants potentially affected by *Ceroplastes japonicus*.

Ceroplastes japonicus has the potential to adversely affect threatened and endangered plant species. However, because *C. japonicus* is not known to be established in the US and threatened and endangered plant species do not occur outside the US, it is not possible to confirm the host status of these rare plants from the scientific literature. From available host records, *C. japonicus* is known to feed on species within at least 27 families (Aceraceae, Apocynaceae, Aquifoliaceae, Araliaceae, Berberidaceae, Buxaceae, Celastraceae, Cornaceae, Cycadaceae, Ebenaceae, Ehretiaceae, Elaeagnaceae, Elaeocarpaceae, Hydrangeaceae, Lauraceae, Magnoliaceae, Moraceae, Myrtaceae, Pittosporaceae, Podocarpaceae, Punicaceae, Rhamnaceae, Rosaceae, Rutaceae, Salicaceae, Theaceae, and Ulmaceae). From these host records, we infer that threatened and endangered plant species which are closely related to known host plants might also be suitable hosts (Table D1). For our purposes, closely related species belong to the same genus.

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	**Common Name**	**Federal**	**State**
Acer sp., *A. japonicum*, *A. negundo, A. palmatum*, *A. psuedoplatanus*, *A. saccharinum*	*Acer nigrum*	black maple		NH (T)
	A. pensylvanicum	striped maple		OH (E)
	A. spicatum	mountain maple		KY (E)
Berberis sp.	*Berberis canadensis*	American barberry		IL (E) IN (E) KY (E) MD (E)
Mahonia aquifolium[2]	*Mahonia nevinii* [=*Berberis nevinii* [= *Odostemon nevinii*]]	Nevin's barberry	E	CA (E)
	M. pinnata spp. *insularis* [=*Berberis pinnata* ssp. *insularis*]	island barberry	E	CA (E)
	M. repens [= *Berberis amplectens* [= *Berberis aquifolium* var. *repens* [= *Berberis pumila* [= *Berberis repens* [= *Berberis sonnei* [= *Mahonia amplectens* [= *Mahonia pumila* [= *Mahonia sonnei* [= *Odostemon pumilus* [= *Odostemon repens*]]	creeping barbarry	E	CA (E)

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.				
	Threatened and/or Endangered Plant		**Protected Status[1]**	
Reported Hosts	**Scientific Name**	**Common Name**	**Federal**	**State**
Cornus mas	*Cornus alternifolia*	alternateleaf dogwood		FL (E)
	C. amomum	silky dogwood		IN (E)
	C. canadensis	bunchberry dogwood		IA (T) IL (E) IN (E) MD (E) OH (T)
	C. drummondii	roughleaf dogwood		NY (E)
	C. florida	flowering dogwood		ME (E) VT (T)
	C. obliqua [= *C. amomum* var. *schuetzeana*]	silky dogwood		NJ (E)
	C. rugosa	roundleaf dogwood		MD (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)
	C. 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)

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.				
Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Crataegus viridis	green hawthorn		IN (T)
Diospyros sp., *D. kaki*	*Diospyros virginiana*	common persimmon		NY (T)
Euonymus sp., *E. japonicus*	*Euonymus americana*	strawberry bush		IL (E) NY (E)
Hydrangea hortensia	*Hydrangea arborescens*	wild hydrangea		FL (E) NY (E)
Ilex sp., I. aquifolium, I. cochica, I. cornuta, I. integra, I. latifolia	*Ilex collina*	Longstock holly		NC (T) VA (E)
	I. glabra	inkberry		CT (T) ME (T)
	I. krugiana	tawnyberry holly		FL (E)
	I. montana	mountain holly		MA (T) NJ (E)
	I. opaca	American holly		PA (T)
	I. verticillata	common winterberry		AR (T) IA (E)
Magnolia sp., *M. grandiflora*	*Magnolia acuminata*	cucumber-tree		FL (E) IN (E)
	M. ashei	Ashe's magnolia		FL (E)
	M. macrophylla	bigleaf magnolia		AR (E) OH (E)
	M. pyramidata	pyramid magnolia		FL (E)
	M. tripetala	umbrella-tree		IN (E)
	M. virginiana	sweetbay		MA (E) NY (E) PA (T) TN (T)
Malus sp., *M. domestica*	*Malus angustifolia*	southern crabapple		FL (T) IL (E)

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.				
Reported Hosts	**Threatened and/or Endangered Plant**		**Protected Status**[1]	
	Scientific Name	**Common Name**	**Federal**	**State**
	Malus glaucescens	Dunbar crabapple		NY (E)
Morus sp.	*Morus rubra*	red mulberry		CT (E) MA (E) MI (T) VT (T)
Prunus sp., *Prunus armeniaca*, *P. avium*, *P. cerasus*, *P. domestica*, *P. laurocerasus,* *P. mume, P. persica,* *P. yedoensis*	*Prunus alleghaniensis*	Allegheny plum		MD (T) NJ (E) PA (T)
	P. americana	American plum		NH (T) VT (T)
	P. angustifolia	Chicasaw plum		NJ (E)
	Prunus 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)
	P. 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* [= *P. pumilla var. cuneata*]	Sesquehana sandcherry		OH (T)
Salix sp., *S. babylonica,* *S. glandulosa, S. saidaeana*	*Salix arctophila*	northern willow		ME (E)
	S. argyrocarpa	Labrador willow		ME (E) NH (T)
	S. bebbiana	Bebb willow		MD (E)

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Salix 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)
	S. 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)

Table D1: Threatened and endangered plants in the conterminous US that are potential hosts for *Ceroplastes japonicus*.				
	Threatened and/or Endangered Plant		**Protected Status[1]**	
Reported Hosts	**Scientific Name**	**Common Name**	**Federal**	**State**
	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)
	S. 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)
Trachelospermum asiaticum	*Trachelospermum difforme*	climbing dogbane		MD (E)
U. campestris, U. minor	*Ulmus thomasii*	rock elm		IL (E) NY (T) OH (T)
Ziziphus sp., Z. jujuba	*Ziziphus celata*	Florida jujube		FL (E)

Source of threatened and endangered species: National Plants Database (USDA NRCS 2004)

1. E= Endangered; T=Threatened.
2. Some species in the genus *Berberis* were assigned to the genus *Mahonia*; as a result we have included both genera in the list of potentially threatened and endangered plants.

Appendix E. Biology of *Ceroplastes japonicus*

Despite the economic importance of *C. japonicus*, remarkably little is known about its basic biology. A more thorough understanding of the impacts of hosts and temperatures on mortlaity and fecundity schedules would improve predictive models for regional surveys and would help to refine management options. Additional research is needed.

Population phenology

In China and Italy, *C. japonicus* has one generation annually. *Ceroplastes japonicus* has the following developmental stages: egg, nymph (3 nymphal instars), and adult. Mated females overwinter (Longo 1985, Park et al. 1992, Ben-Dov and Hodgson 1997). In Italy oviposition occurs in May and June. Eggs hatch in June, followed by the first and second molts occurring in July and August, respectively. Adult females appear in September and shortly thereafter prepare to overwinter (Longo 1985, Pellizzari and Camporese 1994, CAB 2003).

In Korea, oviposition occurs from late May to mid-July, and peaks in late May. Eggs hatch and crawlers occur from early June to early August. Adults appear in mid-October.

Parasitoids, predators, and temperature affect mortality at all life stages; mortality is density dependent (Kozar et al. 1982, Kravchenko 1991, Miyanoshita and Kawai 1992, Japoshvili 2001).

Stage specific biology

Table E1 provides relative sizes of each life stage of *C. japonicus* (modified from Park et al. 1992).

Table E1. Measurements of each life stage of *Ceroplastes japonics*

Body sizes (mm)		
Stage	Length	Width
Egg	0.29±0.010	0.15±0.006
1st instar nymph	0.36±0.015	0.17±0.012
2nd instar nymph	1.67±0.123	1.05±0.099
3rd instar nymph	2.23±0.141	1.44±0.126
Adult female	3.05±0.289	2.06±0.208

Adult

Park et al. (1992) observed the onset of oviposition 4 days after birth when individuals were held at a constant 25°C. Females laid 924±365 eggs on persimmon, *Diospyros* sp. (Park et al. 1992). Most reproduction is complete within the next 7.5 days (Park et al. 1992). At 30°C, the oviposition rate decreased, and hatching increased.

Host selection (species, quality, etc.) may impact fecundity and also feeding behavior, particularly the duration of feeding for each developmental stage and the timing of the transition from leaves to twigs (Camporese and Pellizzari 1998). The average number of eggs laid per female has been reported for *Hedera* sp.(1093 eggs); *Ilex* sp. (947); *Citrus* *trifoliata* (937); and *Laurus nobili*s (691) (Longo 1985, Pellizzari and Camporese 1994, CAB 2003).

Egg

A total of 316.5 degree days above a developmental temperature threshold of 8.1°C is required for the completion of egg development on persimmon (Park et al. 1992).

In a similar study, Yang et al. (1996) determined that egg development on tea required 199.2 accumulated degree days above a temperature threshold of 15.5°C, and on jasmine required 216.4 accumulated degree days above a threshold of 15.0°C.

Nymph

Ceroplastes japonicus disperses most extensively during the first instar crawler stage; winds and animals aid dispersal (CAB 2003).