Mini Risk Assessment
Soft Wax Scale: *Ceroplastes destructor* Newstead
[Hemiptera: Coccidae]

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Figure 1. Infestation of soft wax scale, *Ceroplastes destructor*.
[Image courtesy of Rosa Henderson, http://www.invasive.org].

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Introduction

Ceroplastes destructor is a serious pest of citrus and more than 150 other plants hosts throughout its range (Ben-Dov 1993, Ben-Dov and Hodgson 1997, CAB 2004). This insect is probably native to Africa but now also occurs in Australasia and Oceania (Ben-Dov 1993, CAB 2004) and is commonly known as the white or soft wax scale (Ben-Dov and Hodgson 1997). At one time, *C. destructor* had been reported in the US (Florida), however this report was likely based on a misidentification of a related indigenous species, *C. dugesii* (CAB 2004). *Ceroplastes destructor* is not known to occur in the US.

Risks posed by *Ceroplastes destructor* for US agriculture and ecosystems have not been evaluated extensively. The purpose of this document is to evaluate several factors that affect the chances for establishment of *C. destructor* and subsequent impacts if it should become established. This information is also applied to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: Low.** *Ceroplastes destructor* is present in much of Africa, Australia, New Zealand, and islands of the South Pacific (Ben-Dov 1993, Qin and Gullan 1994). This scale had been reported previously in the US, Mexico and Colombia, however these records are probably based on misidentified specimens (Qin 2000). Appendix A provides a detailed list of the reported worldwide distribution of this scale. In general, *C. destructor* occurs in dry or tropical climates. The currently reported distribution of *C. destructor* suggests that the pest may be most closely associated with biomes characterized as: tropical and subtropical grasslands, savannas, and shrublands; and tropical and subtropical moist broadleaf forests. Consequently, we estimate that less than 2% of the contiguous US would have a suitable climate for *C. destructor* (Fig. 2). See Appendix A for a more complete description of this analysis.

Figure 2. Predicted distribution (blue) of *Ceroplastes destructor* in the contiguous US.

Figure 2 illustrates where *C. destructor* is most likely to encounter a suitable climate for establishment within the contiguous 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 should be concentrated in the higher risk areas and gradually expanded as needed.

2. **Host Specificity/Availability. Rating: Low/Medium.** *Ceroplastes destructor* is not host specific. It is a polyphagous pest that has been reported on more than 150 host plants, including economically important crops such as citrus and coffee (Table 1). With the exceptions of apple (*Malus* sp.), pear (*Pyrus* sp.) and apricot (*Prunus armeniaca*), most of these plants occur in tropical or semi-tropical areas.

Table 1. Host plants of *Ceroplastes destructor*.

Hosts	References
apricot (*Prunus armeniaca*)	(Qin and Gullan 1994, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
agave (*Agave* sp.)	(Brimblecombe 1956)
Aida micrantha	(Ben-Dov 1993, Ben-Dov et al. 2001)
alahe'e (*Canthium odoratum*)	(Brimblecombe 1956)
amatungulu (*Carissa grandiflora*)	(Brimblecombe 1956)
annona (*Annona* sp.)	(Ben-Dov and Hodgson 1997)
antigonon (*Antigonon* sp.)	(Qin and Gullan 1994)
apple (*Malus* sp.)	(Ben-Dov and Hodgson 1997)
ash, Bennett's (*Flindersia bennettiana)*	(Brimblecombe 1956)
ash, blueberry (*Elaeocarpus reticulatus*)	(Brimblecombe 1956)
ash, cape (*Ekebergia meyeri*)	(Cilliers 1967, Ben-Dov et al. 2001)
ash, golden (*Hodgkinsonia ovatiflora*)	(Brimblecombe 1956)
ash, leopard (*Flindersia collina*)	(Brimblecombe 1956)
Australian redcedar (*Cedrela toona* var. *australis*)	(Brimblecombe 1956)
avocado (*Persea americana*)	(Brain 1920, Brimblecombe 1956, Smith 1973, Williams and Watson 1990, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
bird's eye (*Alectryon connatus)*	(Brimblecombe 1956)
blackthorn (*Bursaria spinosa*)	(Brimblecombe 1956, Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
blue guarri (*Euclea crispa*)	(Ben-Dov 1993, Ben-Dov et al. 2001)
boxthorn, African (*Lycium ferocissimum)*	(Brimblecombe 1956)
Brisbane box (*Tristania conferta*)	(Brimblecombe 1956)

Hosts	References
Burdekin plum (*Pleiogynium cerasiferum*)	(Brimblecombe 1956)
canna (*Canna* sp.)	(Brimblecombe 1956)
Carrizo citrange - rootstock ((×*Citroncirus webberi* (= *Citrus sinensis* × *Poncirus trifoliata*))	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
Cassinia quinquefaria	(Brimblecombe 1956, Qin and Gullan 1994, Ben-Dov et al. 2001)
Celastrus cunninghamii	(Brimblecombe 1956)
cheesewood (*Pittosporum* sp.)[1]	(Milne 1993)
cheesewood, stiffleaf (*Pittosporum crassifolium*)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
chinaberrytree (*Melia azedarach*)	(Brain 1920, Cilliers 1967, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Chinese box orange (*Severina buxifolia*)	(Brimblecombe 1956)
citron (*Citrus medica*)	(Brimblecombe 1956)
citrus (*Citrus* sp.)	(Brimblecombe 1956, CIE 1960, Cilliers 1967, Smith 1970, Fernandes 1988, Williams and Watson 1990, Milne 1993, Qin and Gullan 1994, Lo 1995, Ben-Dov and Hodgson 1997, Blank et al. 1997, Lo and Chapman 1998, Qin and Gullan 1999, Wakgari and Giliomee 1999, CABI/EPPO 2000, Wakgari and Giliomee 2000, Ben-Dov et al. 2001, Lo and Chapman 2001, Wakgari 2001, Wakgari and Giliomee 2001a, c, CAB 2004)
cocoa (*Theobroma cacao*)	(Brimblecombe 1956, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
coffee (*Coffea* sp.)	(Brimblecombe 1956, CIE 1960, Williams and Watson 1990, Ben-Dov and Hodgson 1997, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
coffee, arabica (*Coffea arabica*)	(Fernandes 1988, Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
coffee, robusta (*Coffea canephora* (= *Coffea robusta*))	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
common spikethorn (*Maytenus heterophylla* (=*Gymnosporia buxifolia*))	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
confetti tree (*Maytenus senegalensis*)	(Ben-Dov 1993, Ben-Dov et al. 2001)
coral vine (*Antigonon leptopus*)	(Brimblecombe 1956)

Hosts	References
corky milk vine (*Secamone elliptica*)	(Brimblecombe 1956)
cough bush (*Cassinia laevis*)	(Brimblecombe 1956)
crabapple, European (*Malus sylvestris*)	(Brimblecombe 1956)
crape myrtle (*Lagerstroemia* sp.)	(Brimblecombe 1956)
croton (*Croton* sp.)	(Brimblecombe 1956, Ben-Dov and Hodgson 1997)
current bush (*Carissa ovata*)	(Brimblecombe 1956)
custard apple (*Annona reticulata*)	(Brain 1920)
daisy, Barberton (*Gerbera jamesonii)*	(Brimblecombe 1956)
denhamia, veiny (*Denhamia pittosporoides*)	(Brimblecombe 1956)
denhamia, weeping (*Denhamia obscura)*	(Brimblecombe 1956)
Dissilaria bologhioides	(Brimblecombe 1956)
dune brides-bush (*Pavetta revoluta*)	(Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
Dysoxylum patersoni	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001)
eastern annual saltmarsh aster (*Aster subulatus*)	(Brimblecombe 1956)
eastern baccharis (*Baccharis halimifolia*)	(Brimblecombe 1956)
Elaeodendron australis	(Brimblecombe 1956)
Elaeodendron capensis	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Elaeodendron sp.	(Brimblecombe 1956)
elder, common wild (*Nuxia viscosa* (= *N. congesta*))	(Ben-Dov 1993, Ben-Dov et al. 2001)
elder, water (*Nuxia oppositifolia*)	(Ben-Dov 1993, Ben-Dov et al. 2001)
Euroschinus falcatus	(Brimblecombe 1956)
fig (*Ficus* sp.)	(Ben-Dov and Hodgson 1997)
fig, red leaf (*Ficus congesta*)	(Williams and Watson 1990)
flannel leaf (*Astrotricha floccosa*)	(Brimblecombe 1956)
foldwing (*Dicliptera* sp.)	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
frangipani (*Plumeria acutifolia)*	(Williams and Watson 1990)
gardenia (*Gardenia* sp.)	(Brimblecombe 1956, Smith 1970, Williams and Watson 1990, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
grapefruit (*Citrus paradisi*)	(Brimblecombe 1956, Lo et al. 1996)
groundsel (*Senecio* sp.)	(Smith 1970)
guava, common (*Psidium guajava*)	(Brimblecombe 1956, Smith 1970, Fernandes 1988, Williams and Watson 1990, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Wakgari and Giliomee 1999, 2000, Ben-Dov et al. 2001, CAB 2004)

Hosts	References
Gymnosporia sp.	(Fernandes 1988, Ben-Dov et al. 2001)
Hippocratea parvifolia	(Ben-Dov 1993, Ben-Dov et al. 2001)
hop bush (*Dodonaea* sp.)	(Williams and Watson 1990, Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
hop bush, large-leaf (*Dodonaea triquetra*)	(Brimblecombe 1956)
hopseed bush (*Dodonaea viscosa*)	(Brimblecombe 1956, Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
horseweed (*Conyza* sp.)	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Japanese Euonymus (*Euonymus japonica*)[1]	(Milne 1993)
keraudrenia (*Keraudrenia hillii*)	(Brimblecombe 1956)
kiwi (*Actinidia deliciosa*)	(Ben-Dov et al. 2001, CAB 2004)
kumquat, round (*Fortunella japonica*)	(Brimblecombe 1956)
lemayo (*Rhus simarubaefolia*)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001)
lemon (*Citrus limon*)	(Brimblecombe 1956, Qin and Gullan 1994, Lo 1995, Lo et al. 1996)
lime (*Citrus aurantifolia*)	(Brimblecombe 1956)
lime, Australian desert (*Eremocitrus glauca*)	(Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
lime, Australian round (*Microcitrus australis*)	(Brimblecombe 1956)
long-leaf star-hair (*Astrotricha longifolia =Austrotricha longifolia*)	(Qin and Gullan 1994)
Loranthus bidwilli	(Qin and Gullan 1994, Ben-Dov et al. 2001)
Loranthus congener	(Brimblecombe 1956)
Loranthus sp.	(Brimblecombe 1956)
Maba fasciculosa	(Brimblecombe 1956)
Maesa sp.	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
magnolia (*Magnolia* sp.)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
malay-apple (*Syzygium (=Eugenia) malaccense*)	(Ben-Dov 1993, Wakgari and Giliomee 1998, 1999, Wakgari 2000, Wakgari and Giliomee 2000, Ben-Dov et al. 2001, Wakgari 2001, CAB 2004)Ben-Dov 1997

Hosts	References
mandarin (*Citrus reticulata*)	(Olson et al. 1993, Lo 1995, Wakgari and Giliomee 2001c, CAB 2004)Blank et.al. 1997(Brimblecombe 1956, Qin and Gullan 1994, Lo et al. 1996, Wakgari and Giliomee 1998, 1999, 2000, Ben-Dov et al. 2001, Wakgari and Giliomee 2001a, b)
mandarin, Clementine (Citrus reticulata)	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
mandarin, Satsuma (Citrus reticulata)	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
marguerite (*Chrysanthemum frutescens*)	(Brimblecombe 1956)
mayten (*Maytenus* sp.)	(Ben-Dov et al. 2001, CAB 2004)
Maytenus cymosus	(Cilliers 1967, Ben-Dov et al. 2001)
melia (*Melia* sp.)	(Ben-Dov and Hodgson 1997)
midgen berry (*Austromyrtus dulcis*)	(Brimblecombe 1956)
natal mahogany (*Trichilia emetica*)	(Cilliers 1967, Ben-Dov et al. 2001)
neem (*Azadirachta indica*)	(CAB 2004)
nightshade (*Solanum* sp.)	(Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
northern white lilly pilly (*Achronychia laevis*)	(Brimblecombe 1956)
oleander (*Nerium oleander*)	(Brimblecombe 1956, Smith 1970)
orange	(Olson et al. 1993, Lo 1995, Lo et al. 1996)
orange thorn (*Citriobatus pauciflorus*)	(Brimblecombe 1956)
orange, navel or Valencia (*Citrus sinensis*)	(Brimblecombe 1956, Beattie et al. 1990, Williams and Watson 1990, Ben-Dov 1993, Qin and Gullan 1994, Herron et al. 1995, Ben-Dov et al. 2001, CAB 2004)
orange, sour (*Citrus aurantium*)	(Brimblecombe 1956, Ben-Dov et al. 2001, CAB 2004)
orange, Trifoliate (*Poncirus Trifoliata*)	(Fernandes 1988, Ben-Dov 1993, Wakgari and Giliomee 1999, 2000, Ben-Dov et al. 2001, CAB 2004)
orange, Trifoliate -rootstock (*Poncirus Trifoliata*)	(Beattie et al. 1990)
Otiophora inyangana parrifolia	(Ben-Dov 1993, Ben-Dov et al. 2001)
pear (*Pyrus*)	(CAB 2004)
peppertree, California (*Schinus molle*)	(Brimblecombe 1956, Cilliers 1967, Ben-Dov et al. 2001, CAB 2004)

Hosts	References
persimmon, oriental (*Diospyros kaki*)	(Brimblecombe 1956, Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
Philippia lecana	(Ben-Dov 1993, Ben-Dov et al. 2001)
Philippia sp.	(Ben-Dov et al. 2001)
Pilidostigma rhytispermum	(Brimblecombe 1956)
Platanocephalus morindaefolius	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001)
plum pine (*Podocarpus elatus*)	(Brimblecombe 1956)
plumeria (*Plumeria* sp.)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
prickly alyxia (*Alyxia ruscifolia*)	(Brimblecombe 1956, Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
prickly pine (*Bursaria incana*)	(Brimblecombe 1956)
pummelo (*Citrus maxima*)	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
python tree (*Austromyrtus bidwillii)*	(Brimblecombe 1956)
quinine tree (*Alstonia constricta)*	(Brimblecombe 1956)
rice flower (*Ozothamnus diosmifolius* (*=Helichrysum diosmifolium*))	(Brimblecombe 1956)
rose apple (*Owenia venosa*)	(Brimblecombe 1956)
rosemallows (*Hibiscus* sp.)	(Brimblecombe 1956, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
Rough lemon - rootstock (*Citrus jambhiri* 'Rough Lemon')	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
sandfly zieria (*Zieria smithii*)	(Qin and Gullan 1994, Ben-Dov et al. 2001)
sapodilla (*Achras zapota*)	(Brimblecombe 1956)
scentless rosewood (*Synoum glandulosum*)	(Qin and Gullan 1994, Ben-Dov et al. 2001)
schefflera (*Schefflera* sp.)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
scrub wilga (*Geijera salicifolia*)	(Brimblecombe 1956)
stopper (*Eugenia* sp.)	(Ben-Dov and Hodgson 1997)
strawflower (*Helichrysum* sp.)	(Brimblecombe 1956)
strychnine tree (*Strychnos arborea*)	(Brimblecombe 1956)
sugar-plum (*Uapaca* sp.)	(Ben-Dov 1993, Ben-Dov et al. 2001)
sumach (*Rhus* sp.)	(Qin and Gullan 1994, Ben-Dov et al. 2001, CAB 2004)
swamp box (*Tristania suaveolens*)	(Brimblecombe 1956)

Hosts	References
Swingle citrange - rootstock	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
Syzygium sp.	(Ben-Dov et al. 2001, CAB 2004)
tall cigar plant (*Cuphea micropetala*)	(Brimblecombe 1956)
tallow-wood (*Phebaleum squameum*)	(Brimblecombe 1956)
tangelo (*Citrus* × *tangelo* [= *paradisi* × *reticulat*a])	(Lo 1995, Lo et al. 1996)
tangelo, Seminole (*Citrus paradisi* × *C. reticula*)	(Olson et al. 1993, Blank et al. 1997)
tea (*Camellia sinensis*)	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)
Thunberg's gardenia (*Gardenia thunbergia*)	(Wakgari and Giliomee 1999, 2000)
Troyer citrange - rootstock (*Poncirus trifoliata* × *Citrus sinensis*)	(Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
tuckeroo (*Cupaniopsis anacardiodes*)	(Brimblecombe 1956)
umbrella tree (*Cussonia spicata*)	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Walter's viburnum (*Viburnum obovatum*)	(Brimblecombe 1956)
water berry (*Syzygium cordatum*)	(Ben-Dov 1993, Ben-Dov et al. 2001)
watergum (*Eugenia coolminiana*)	(Brimblecombe 1956)
wattles (*Acacia* sp.)	(CAB 2004)
waxflower (*Eriostemon myoporoides*)[1]	(Milne 1993)
willow, Australian (*Geijera parviflora*)	(Brimblecombe 1956)
yellow boxwood (*Planchonella pohlmaniana*)	(Brimblecombe 1956)
yellow pittosporum (*Pittosporum revolutum*)	(Brimblecombe 1956)
yellow wood (*Flindersia xanthoxyla*)	(Brimblecombe 1956)

1. Artificially infested for a field trial (Milne 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. destructor* will have to be based 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, a survey targeting this insect will probably involve considerable time and labor. If only a limited effort can be expended, chances of finding low densities of the insect are poor.

   Both branches and leaves should be collected to find this insect. In research applications where *C. destructor* is relatively common, 5-10 minutes were spent per tree searching leaves and young wood for scales (Lo et al. 1996). In orchard blocks (ca. 1 ha=0.4 acres), researchers collected 1 arbitrarily selected branch per tree for adult scales and 50 leaves for immature stages (Lo and Chapman 2001).

Branches with at least 10 leaves have also been used (Wakgari and Giliomee 2001b). In research applications, sampling effort was seems to have been determined by logistical and constraints rather than statistical concerns.

Dispersion patterns for adults and immatures have not been described for *C. destructor*, though it is likely that populations are aggregated as with other scales (e.g., Wu et al. 1991, Liu et al. 2003). Aggregation is problematic when sampling is conducted to estimate insect densities with a high degree of precision. Aggregation is less of a concern when the goal of sampling is simply to detect a pest. If we can assume that (i) an orchard is relatively large, (ii) inspection of tree always locates *C. destructor* when it is present on a tree, and (iii) trees are selected at random, simple binomial statistics can be used to calculate the number of trees that should be inspected to achieve a desired probability of locating *C. destructor* when it is present in an orchard. Figure 3 illustrates how the number of required samples changes as the proportion of trees with *C. destructor* and/or the desired probability of detecting at least one infested tree changes. In general, more samples are required as the desired probability of detection increases and as the proportion of plants with insects decreases (i.e., the insects become rarer in the environment).

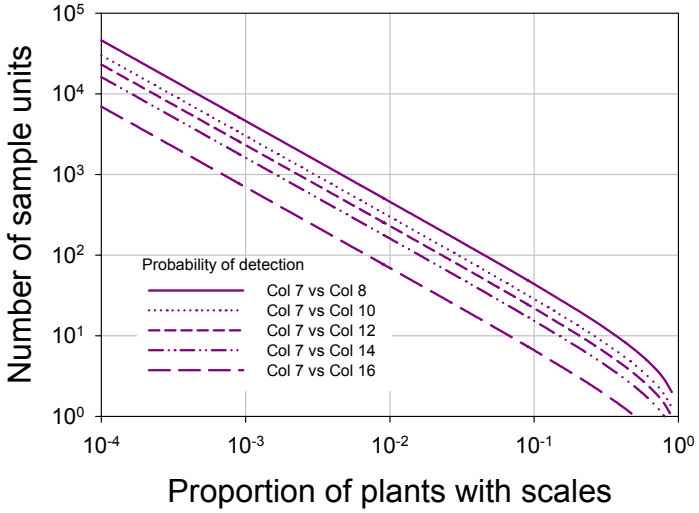

Figure 3. Required number of trees to be inspected to detect *Ceroplastes destructor* when it is present in an area in relation to the proportion of trees with scales and the desired probability of detecting *C. destructor* when it is present. This figure assumes random sampling from a large environment.

4. **Taxonomic Recognition. Rating: Medium.** *Ceroplastes destructor* has been confused with closely related species such as *C. ceriferus* and *C. sinensis* in Australia and with *C. dugesii* in the US and Mexico (Qin 2000, CAB 2004). Several *Ceroplastes* spp. occur in the US (USDA 2005b): *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* (FL), and *C. floridensis* (FL).

Early instars may be particularly difficult to distinguish (Wakgari and Giliomee 1998)

Ceroplastes destructor may be distinguished from other species by close examination of morphological characters of young adult females (Wakgari and Giliomee 1998). The adult male is not described as it is unknown (Qin and Gullan 1994, Wakgari and Giliomee 1998). Adult and immature stages of *C. destructor* have been fully described by Wakgari and Giliomee (1998) and Williams and Watson (1990). Immature stages may only be distinguished by using slide-mounted specimens. Qin and Gullan (1994) reviewed the taxonomy and compared the morphology of seven Australian species of wax scales, including adult females of *C. destructor*, *C. insulanus* and *C. sinensis*, and immature stages of *C. sinensis*. Variation in morphological characters of the adult females may be attributed to age and geographical distribution of specimens examined.

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

5. **Entry Potential. Rating: Low.** An interception of *C. destructor* has never been reported by USDA-APHIS in the Port Information Network-309 Database (USDA 2005a). "*Ceroplastes* sp." have been intercepted at least 171 times at US ports of entry between 1985 and 2004 (incomplete records complicate the accuracy of this count). Annually, only about 8.6 (±1.1 standard error of the mean) interceptions of the genus have been reported nationally (USDA 2005a). The majority of interceptions have been associated with baggage from international airline passengers (63%), permit cargo (22%), and general cargo (6%). The majority of interceptions were reported from JFK International airport, NY (21%), Miami, FL (12%), Los Angeles, CA (11%), and Elizabeth, NJ (7%). 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 "*Ceroplastes* sp." have been reported from 82 plant taxa (USDA 2005a). Interceptions were most common on various *Citrus* spp. (15%), *Ficus carica* (11%), and *Laurus nobilis* (4%).

   The low rating for this risk element is associated with substantial uncertainty. It is conceivable that *C. destructor* arrived more frequently than available records suggest. It is possible that *C. destructor* was 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. destructor*, a high rating would be warranted.

6. **Destination of Infested Material. Rating: Medium.** When an actionable pest is intercepted, officers ask for the intended final destination of the conveyance. Materials infested with "*Ceroplastes* sp." were destined for 20 states, including the District of Columbia (USDA 2005a). The most commonly reported destinations were California (22%), New York (20%), Florida (18%), New Jersey (10%), Texas (7%), and Massachusetts (5%). Only a portion of Texas and Florida have a climate and hosts that are likely to be suitable for establishment by *C. destructor*.

7. **Potential Economic Impact. Rating: High.** *Ceroplsates destructor* is a major pest of *Citrus* spp. in the Eastern and Western Cape Provinces of South Africa, but is of only minor economic importance to citrus crops in other African countries (Ben-Dov and Hodgson 1997). *Ceroplastes destructor* was a major pest of citrus in Australia until the 1970's. It is now considered only a minor pest in Australia (specifically, New South Wales, Queensland, and Western Australia) and New Zealand, partially because of the introduction of natural enemies from Africa (Brimblecombe 1956, Smith 1973, Ben-Dov and Hodgson 1997, Wakgari and Giliomee 1998, Lo and Chapman 2001, Wakgari 2001, CAB 2003, USDA 2005b).

   Scales cause direct plant injury by feeding on plants and depleting nutrients necessary for growth, and may ultimately impact yield and overall plant health. Indirect damage is caused by the introduction of scale-vectored pathogens and excreted honeydew that covers plant surfaces. Honeydew serves as a food source for ants and other insects and supports the growth of sooty mold. Sooty mold may inhibit photosynthesis, lower fruit quality and reduce yield (Brimblecombe 1956, Olson et al. 1993, Ben-Dov and Hodgson 1997, Blank et al. 1997, Wakgari and Giliomee 1998, Wakgari 2000). Scales settle to feed on leaf surfaces (typically near the midrib), leaf petioles, young stems, or flowers (CAB 2004). Immature crawlers tend to settle on foliage while later stages move to young twigs and remain there for the remainder of their development (Olson et al. 1993, Wakgari and Giliomee 1998, Wakgari 2001, Wakgari and Giliomee 2001a, b).

8. **Potential Environmental Impact. Rating: High.** In general, newly established species may adversely affect the environment by reducing biodiversity, disrupting ecosystem functions, jeopardizing endangered or threatened plants, degrading critical habitat, or stimulating use of chemical or biological controls. *Ceroplastes destructor* 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, in this case *Citrus* spp, destined for fresh markets is likely to stimulate greater use of either chemical or

biological controls to ensure market access. As mentioned under 'Potential Economic Impact,' biological controls were successful in Australia and New Zealand, so it seems likely that biological controls would be pursued in the US if the insect were to become established.

Ceroplastes destructor has an extensive host range, feeding on numerous trees, shrubs and ornamental plants [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. destructor*. Plants listed in Appendix D might be suitable hosts for *C. destructor*, and thus, could be adversely affected by this insect.

9. **Establishment Potential. Rating: Medium.** Our coarse analysis suggests that <2% of the US has a climate that could support populations of *C. destructor* (Fig. 2). However, known host plants (especially citrus) are common and abundant in, or adjacent to, these climatically suitable areas. Thus, upon arrival into the United States, the chances for establishment are relatively high. However, we note that the likelihood for introduction seems low based on current interception records. Very few *Ceroplaste*s spp. are intercepted each year.

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

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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 only those that occur in the US.

Table A1. Reported geographic distribution of *Ceroplastes destructor*.

Location	**References**
Africa	(Smith 1970, Olson et al. 1993, Qin and Gullan 1994, Ben-Dov and Hodgson 1997, Blank et al. 1997, Lo and Chapman 1998, Wakgari and Giliomee 1998, Qin 2000)
Africa (southern)	(Wakgari and Giliomee 2001b)
Africa (tropical)	(Williams and Watson 1990)
Africa, Sub-Sahara	(Fernandes 1988, Wakgari and Giliomee 1999, 2000)
Angola	(Ben-Dov 1993, Ben-Dov and Hodgson 1997, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
Angola (Abiom, Nova Lisboa, Tchivinguiro, Chianga, Sá da Bandeira, Luso)	(Fernandes 1988)
Australia	(Fernandes 1988, Herron et al. 1995, Lo et al. 1996, Ben-Dov and Hodgson 1997, Blank et al. 1997, Lo and Chapman 1998, Qin 2000, Wakgari and Giliomee 2000, Lo and Chapman 2001, Wakgari 2001)
Australia (Australian Capital Territory - Jervis Bay)	(Qin and Gullan 1994)
Australia (Australian Capital Territory)	(Ben-Dov et al. 2001)
Australia (costal, northwestern)	(Ben-Dov and Hodgson 1997)
Australia (eastern)	(Milne 1993)

Location	References
Australia (New South Wales)	(Olson et al. 1993, Qin and Gullan 1999, CAB 2004) (Cilliers 1967, Williams and Watson 1990, Ben-Dov 1993, Milne 1993, Lo et al. 1996, Blank et al. 1997, CABI/EPPO 2000, Wakgari and Giliomee 2000, Ben-Dov et al. 2001)
Australia (NSW - Dural, Sydney)	(Qin and Gullan 1994)
Australia (NSW - Gosford district)	(CIE 1960)
Australia (NSW - Somersby)	(Beattie et al. 1990, Qin and Gullan 1994)
Australia (Queensland - Beenleigh, Brisbane, Bouldercombe, Brookfield, Buderim, Bundaberg, Burret, Caboolture, Canungra, Coolangatta, Cooroy, Druce, Eidsvold, Fletcher, Forest Hill, Fraser Island, Gatton, Gayndah, Green Island, Gympie, Howard, Imbil, Ipswich, Landers Pocket, Milbong, Mt. Morgan, Nambour, North Aramara, Palmwoods, Pechey, Pikedale, Pittsworth, Redland Bay, Sunnybank, Swingle, Tamborine, Tamborine Mtn., Terrica, Toowoomba, Tugun, Wongabel, Yandina, Yarraman)	(Brimblecombe 1956)
Australia (Queensland - Bribie, Brisbane, Cooloola Natl Park, Cooroy, Gayndah, Glen Alpin, Indooroopilly, Marmor, Mt. Walker, Palmwoods, Terrica, Toowoomba)	(Qin and Gullan 1994)
Australia (Queensland - Burnett, Palmwoods-Beerwah, Howard, Lockyer, Byfield, Kuranda)	(Smith 1970)
Australia (Queensland - northern)	(Brimblecombe 1956)
Australia (Queensland - southeastern costal)	(CIE 1960)
Australia (Queensland – southeastern)	(Smith 1973)
Australia (Queensland)	(Cilliers 1967, Smith 1970, Williams and Watson 1990, Ben-Dov 1993, Olson et al. 1993, Lo et al. 1996, Ben-Dov and Hodgson 1997, Blank et al. 1997, Qin and Gullan 1999, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
Australia (Western - Hills District from Chittering in the north to Armadale in the south)	(CIE 1960)
Australia (Western)	(Brimblecombe 1956, Cilliers 1967, Qin and Gullan 1994, 1999, CABI/EPPO 2000, CAB 2004)
Bechuanaland (now Botswana)	(Brain 1920, CIE 1960)
Botswana	(CABI/EPPO 2000, CAB 2004)
British Cameroon (Santa)	(CIE 1960)
Cameroon	(Ben-Dov 1993, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)

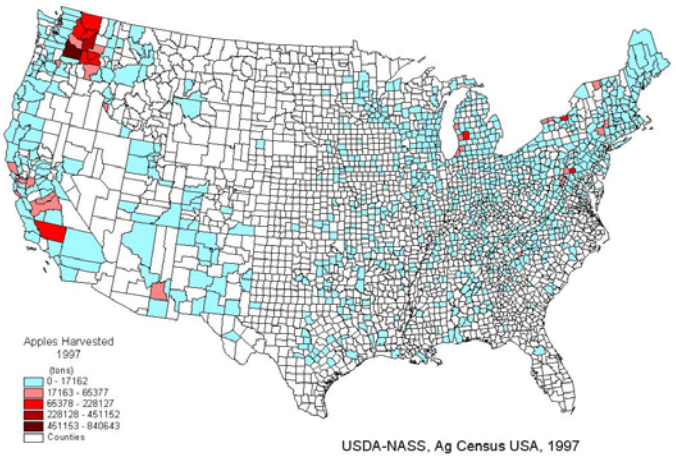
Location	References
Congo	(Fernandes 1988, Ben-Dov 1993, Ben-Dov and Hodgson 1997, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
Congo (Kivu Province)	(CIE 1960)
Congo, Democratic Republic of	(CABI/EPPO 2000, CAB 2004)
Congo, Democratic Republic of (Lumbashi)	(Qin and Gullan 1999)
Côte d'Ivoire (or Ivory Coast)	(Ben-Dov 1993, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
East Africa	(CAB 2004)
Eritrea	(CAB 2004)
India[1]	(Avasthi and Shafee 1986, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001)
Kenya	(CIE 1960, Fernandes 1988, Ben-Dov 1993, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
Madagascar	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Madagascar (Tsimbazaza)	(CIE 1960, CABI/EPPO 2000)
Malawi (previusly Nyasaland)	(CIE 1960, CAB 2004)
Malawi (Zomba)	(CABI/EPPO 2000)
Mexico [2]	(CIE 1960, Ben-Dov and Hodgson 1997)
Mozambique	(Fernandes 1988, Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Mozambique (Musapa Gap)	(CABI/EPPO 2000)
New Zealand	(Ben-Dov 1993, Qin and Gullan 1994, Ben-Dov and Hodgson 1997, Wakgari and Giliomee 1998, 1999, CABI/EPPO 2000, Qin 2000, Wakgari and Giliomee 2000, Ben-Dov et al. 2001, Wakgari 2001, CAB 2004)
New Zealand (Auckland)	(CIE 1960, Olson et al. 1993, Lo 1995, Lo et al. 1996)
New Zealand (Bay of Plenty)	(Olson et al. 1993, Lo 1995, Lo et al. 1996)
New Zealand (Gisborne)	(Olson et al. 1993, Lo 1995, Lo et al. 1996)
New Zealand (Kerikeri district, Northland)	(CIE 1960, Olson et al. 1993, Lo 1995, Lo et al. 1996, Blank et al. 1997, Lo and Chapman 1998, 2001)
New Zealand (North Island)	(CIE 1960)
New Zealand (Northland)	(Lo et al. 1996, Lo and Chapman 1998)
New Zealand (Waikato)	(Lo 1995, Lo et al. 1996)
New Zealand (Whangarei)	(Lo and Chapman 1998)
Norfolk Island	(Williams and Watson 1990, Ben-Dov 1993, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
Papua New Guinea	(Williams and Watson 1990, Ben-Dov 1993, Ben-Dov and Hodgson 1997, Ben-Dov et al. 2001, CAB 2004)

Location	References
Papua New Guinea (Central Province, Chimbu (Simbu), Eastern Highlands, Morobe, Western Highlands)	(Williams and Watson 1990)
Papua New Guinea (Morobe - Wau)	(CIE 1960)
Papua New Guinea (Mt Hagan)	(CABI/EPPO 2000)
Rhodesia	(Fernandes 1988)
San Thomé	(CIE 1960)
Sao Tome and Principe	(CABI/EPPO 2000, CAB 2004)
Solomon Islands	(Ben-Dov 1993, Ben-Dov et al. 2001, CAB 2004)
Solomon Islands (Kolombangara)	(Williams and Watson 1990, CABI/EPPO 2000)
South Africa	(Fernandes 1988, Ben-Dov 1993, Lo et al. 1996, Ben-Dov and Hodgson 1997, Lo and Chapman 1998, Qin and Gullan 1999, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
South Africa (Cape Province - Cape Town)	(CIE 1960)
South Africa (Drakenstein)	(Wakgari and Giliomee 1998, 2001b, c)
South Africa (Eastern Cape Province)	(Wakgari and Giliomee 2000, 2001a)
South Africa (Elgin)	(Wakgari and Giliomee 1998)
South Africa (Grabouw region)	(Wakgari 2001, Wakgari and Giliomee 2001b)
South Africa (Grahamstown in Cape Province, Naboomspruit in Transvaal)	(Cilliers 1967)
South Africa (Stellenbosch)	(Wakgari and Giliomee 1998, Wakgari 2000, Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b)
South Africa (town of Nelspruit)	(Brain 1920, CIE 1960)
South Africa (Western Cape Province)	(Wakgari and Giliomee 1998, 1999, 2000, Wakgari 2001, Wakgari and Giliomee 2001a, b, c)
South Pacific	(Qin and Gullan 1994)
Southern Rhodesia (Embeza, Fort Rixon, Old Umtali Mission, Sinoia, Vumba)	(CIE 1960)
Sudan	(CAB 2004)
Sudan (Equatoria - Kagelu)	(CIE 1960)
Sudan (Yei)	(CABI/EPPO 2000)
Tanganyika (now Tanzania) (Kilimanjaro)	(CIE 1960, CABI/EPPO 2000)
Tanzania	(CAB 2004)
U.S.A. (Florida)[2]	(CIE 1960)
Uganda	(Brimblecombe 1956, CIE 1960, Fernandes 1988, Ben-Dov 1993, Qin and Gullan 1994, Ben-Dov and Hodgson 1997, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)
West Africa	(CAB 2004)
Zaire	(Ben-Dov and Hodgson 1997)
Zambia	(Ben-Dov 1993, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)

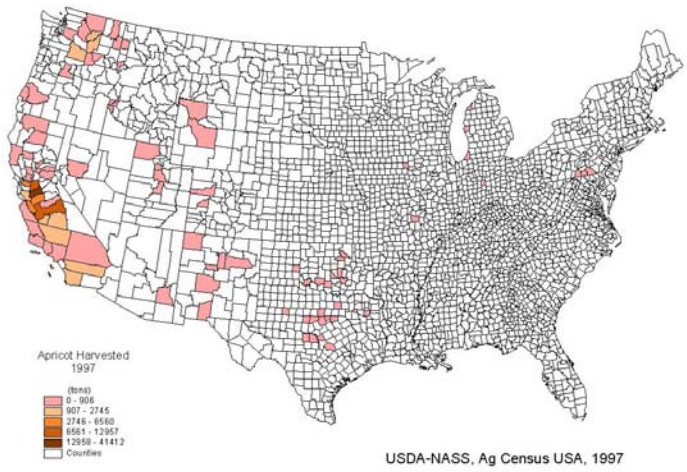
Location	References
Zimbabwe	(Ben-Dov 1993, Ben-Dov and Hodgson 1997, CABI/EPPO 2000, Ben-Dov et al. 2001, CAB 2004)

1. The record of the pest in India (Avasthi and Shafee 1986) is likely a misinterpretation of an earlier publication by Subba Rao 1965 (Qin 2000, CAB 2004).
2. Doubtful record; likely a misidentification of *Ceroplastes dugesii* (Qin 2000, CAB 2004).

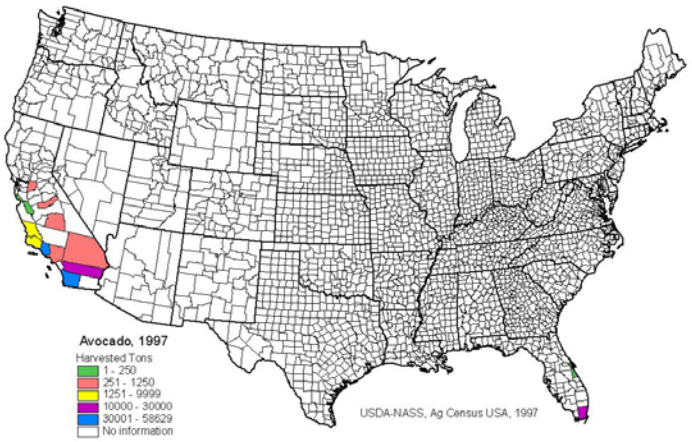
Appendix B. Host distribution for *Ceroplastes destructor* in the contiguous US



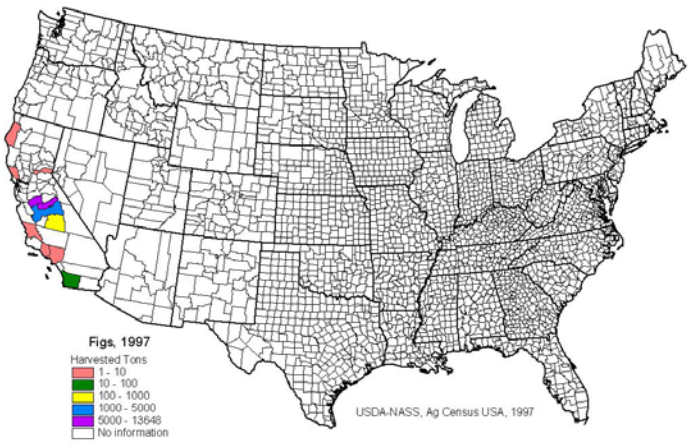
Map 1. Apple (*Malus domestica*)



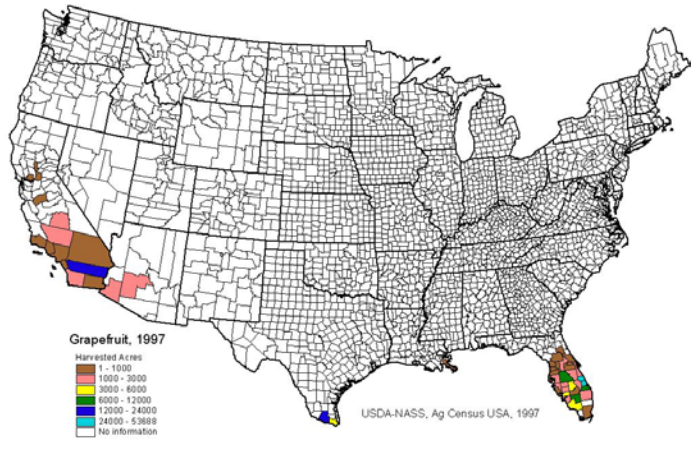
Map 2. Apricot (*Prunus armeniaca*)



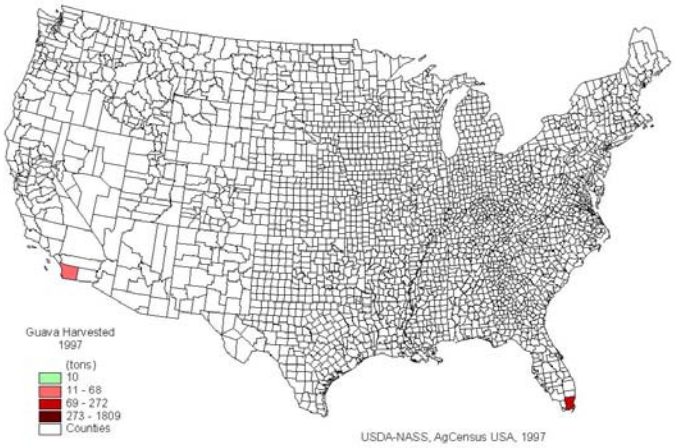
Map 3. Avocado (*Persea americana*)



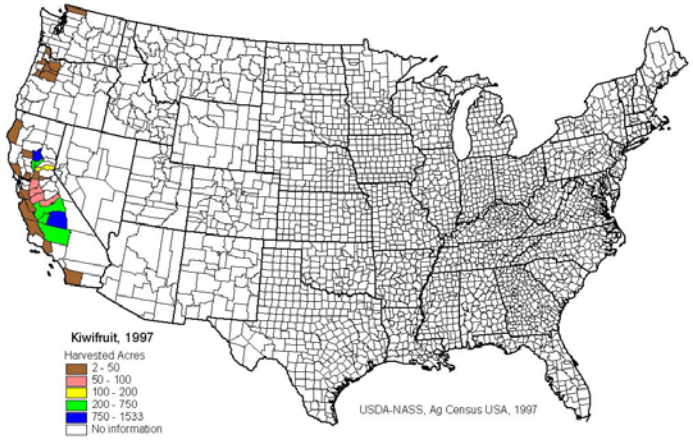
Map 4. Fig (*Ficus carica*)



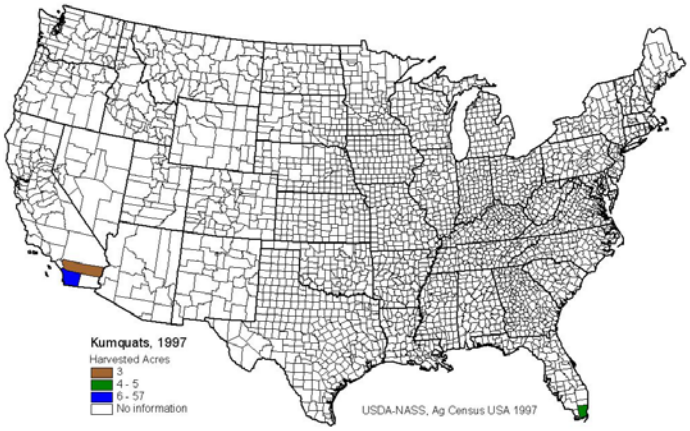
Map 5. Grapefruit (*Citrus ×paradisi* [*maxima* × *sinensis*])



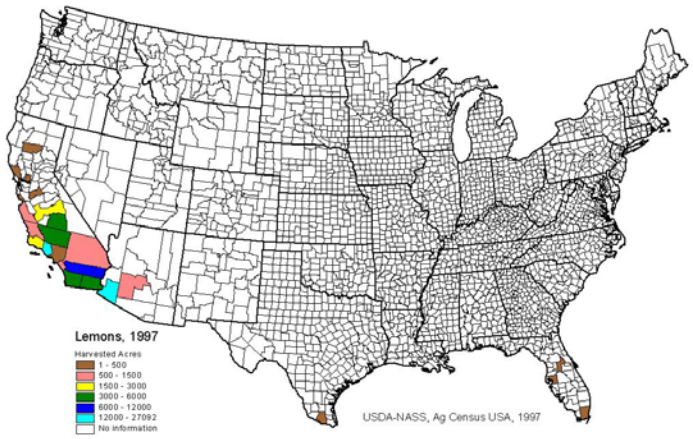
Map 6. Guava (*Psidium guajava*)



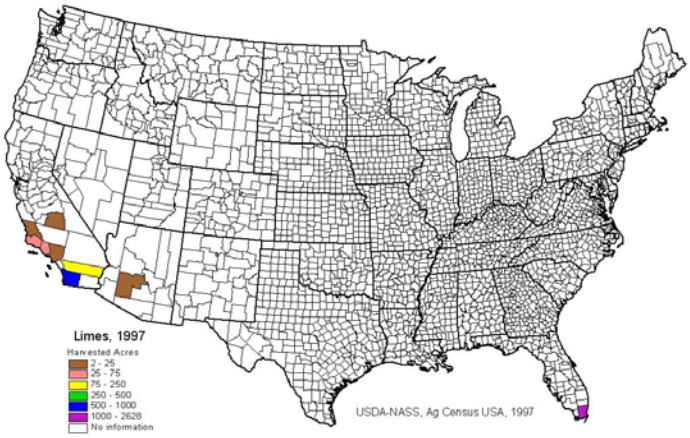
Map 7. Kiwi (*Actinidia chinensis*)



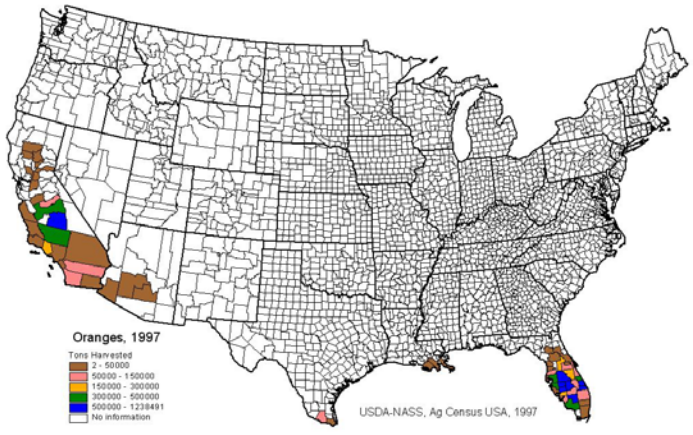
Map 8. Kumquat (*Fortunella* spp.)



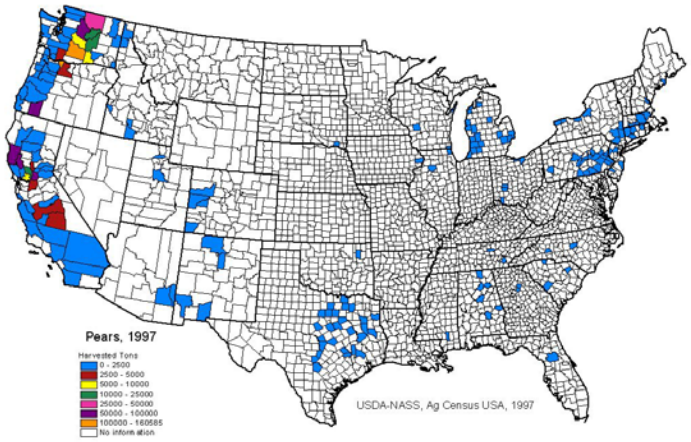
Map 9. Lemon (*Citrus limon*)



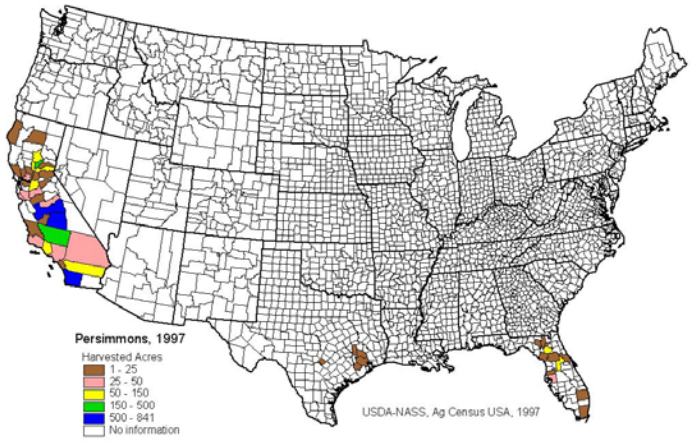
Map 10. Lime (*Citrus aurantifolia*)



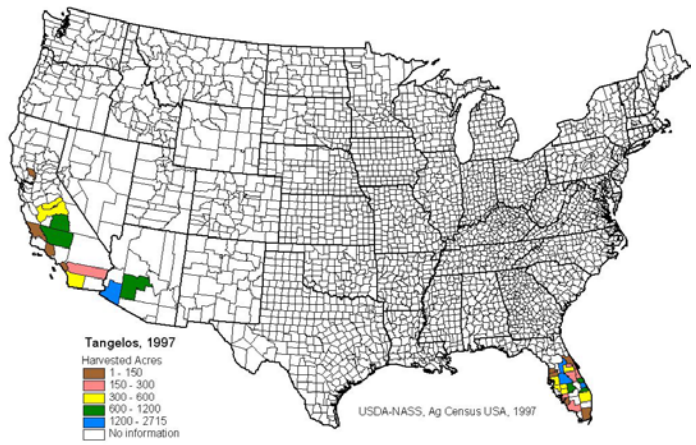
Map 11. Orange (*Citrus* spp.)



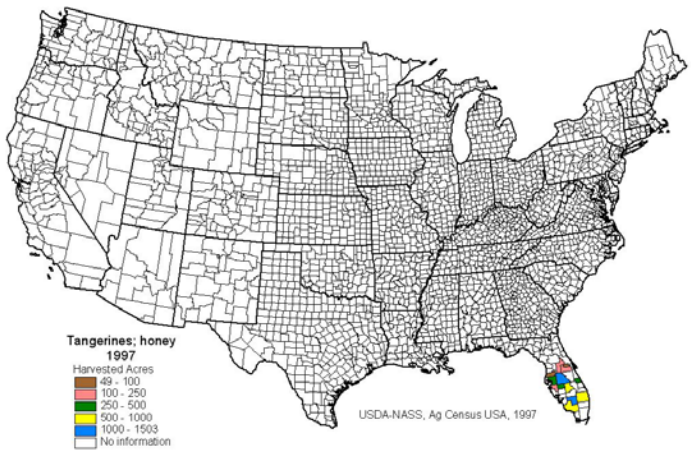
Map 12. Pear (*Pyrus communis*)



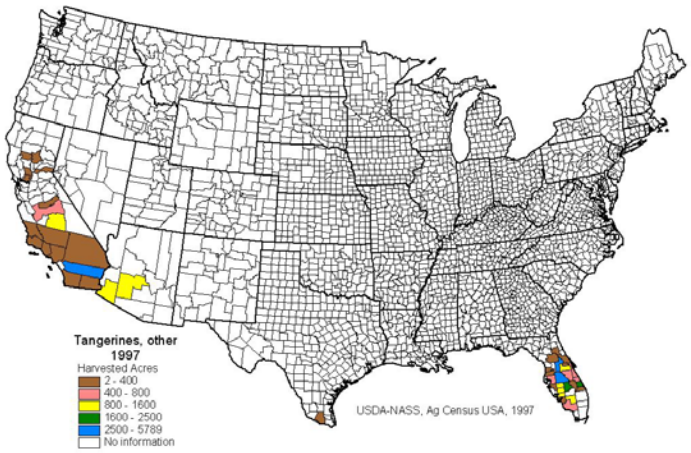
Map 13. Persimmon (*Diospyros* spp.)



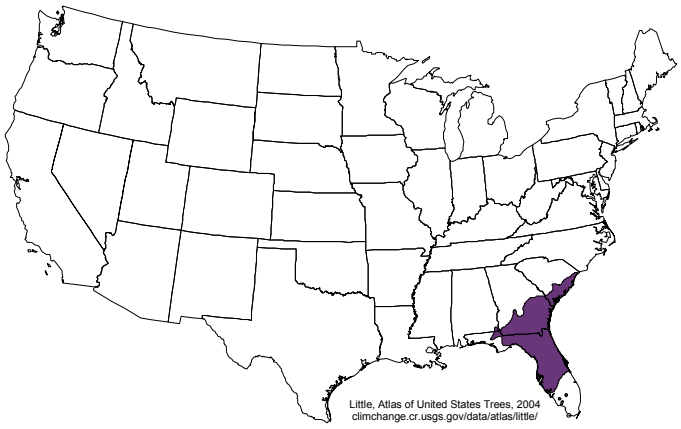
Map 14. Tangelo (*Citrus reticulata x paradisi*)



Map 15. Tangerine, honey (*Citrus reticulata*)



Map 16. Tangerine, other (*Citrus reticulata*)



Map 17. Walter's viburnum (*Viburnum obovatum*)

Appendix C. Taxonomy and morphology of *Ceroplastes destructor* Newstead

Synonyms

The following synonyms have been reported. [Numerous misidentifications are mentioned with synonymy in cited literature but not are not included here](Williams and Watson 1990, Ben-Dov 1993, Qin and Gullan 1994, Wakgari and Giliomee 1998, Qin and Gullan 1999, Ben-Dov et al. 2001, CAB 2003, 2004, USDA 2005b):
Gascardia destructor
Gascardia postperlucidus
Ceroplastes postperlucidus

Diagnostic features

For complete accuracy, the following morphological description of the adult female is quoted from Wakgari and Giliomee (1998):

"Field characters of adult female [Fig. C1]

Body. Completely embedded in white, creamy-white or dirty-white wet wax forming irregular ridges and furrows; wax-covered body oval in dorsal view, averaging about 5.2 mm in length and 3.4 mm wide. Dry wax of first and second instars discernible only in young adults as a small central cap. Lateral rays of third instar seen only in young adult as small dots around margin. Spiracular wax bands present as a thin white thread arising from each spiracular furrow and extending over dorsum. Although caudal process appears to be completely immersed in wet wax when viewed dorsally, closer examination reveals it to be exposed and raised slightly from host surface. This facilitates easy expulsion of honeydew. Denuded adult reddish-brown with a long, sclerotized caudal process. Six lateral, one dorsomedial and one anterodorsal tubercle on dorsum.

Characters of slide-mounted adult female [Fig. C1]:

Body. Oval with some marginal indentations; body 2.5-6.4 (4.5) mm in length and 1.5-4.3 (2.8) mm wide measured dorsally; eye-spots visible as black spots dorsolaterally on each side of head region.

Margin. Marginal setae bristle-like, each 7.8-18.2 (12.8) µm long with basal boss 4.6-5.4 (5) µm wide. Thirty two to fifty three marginal setae, distributed as follows: 4-9 between eye-spots; 2-5 between eye-spots and anterior spiracular furrow on each side; 4-7 between anterior and posterior spiracular furrows on each side; and 6-14 between posterior spiracular furrow and anal cleft on each side. Forty eight to fifty seven (53) conical or bullet-like spiracular setae in each anterior spiracular groove and 49-61 (58) in each posterior groove, arranged in 4-6 irregular rows; each 11-18 (15) µm long with basal boss 10-17 (14) µm wide.

Dorsum. Membranous in young adult, with one anterior and six lateral clear areas. Dorsal pores randomly scattered: oval trilocular, triangular trilocular, and a few quadrilocular and bilocular types distributed dorsomedially and submarginally; maximum dimension of each pore about 5-6 µm, with short inner filaments discernible only under higher magnifications. Dorsal setae cylindrical, some with capitate apices, scattered over dorsum except in dorsal clear areas, each 7-9 µm long with basal boss 4-5 µm wide.

Anal plates 85-150 (113) µm long, combined width 112-121(117) µm, with four pairs of dorsal setae, a pair of ventral setae and four pairs of fringe setae.

Venter. Ventral setae bristle-like, sparsely distributed across venter, each 8-14 µm long with basal boss 4-6 (5) µm wide. Submarginal setae more than 100 in number, each 8-13 (11) µm in length with basal boss 4-5 µm wide. Quinquilocular disc pores in spiracular furrows 58-78 (63) per groove, arranged in 6-8 irregular rows between spiracular setae and spiracular atrium. A pair of short and pair of long prevulvar setae present anterior to vulva, short pair 42-49 (45) µm long and long pair 55-75 (65) µm long. Cruciform pores distributed in submarginal area around entire body. Multilocular disc pores present in rows around vulva and, as seen in well-prepared slides, on heavily sclerotized caudal process, each with 10-12 loculi. Tubular ducts sparsely distributed anterior to vulva and submarginally on abdominal region.

Antennae six-segmented, each 185-244 (216) µm long.

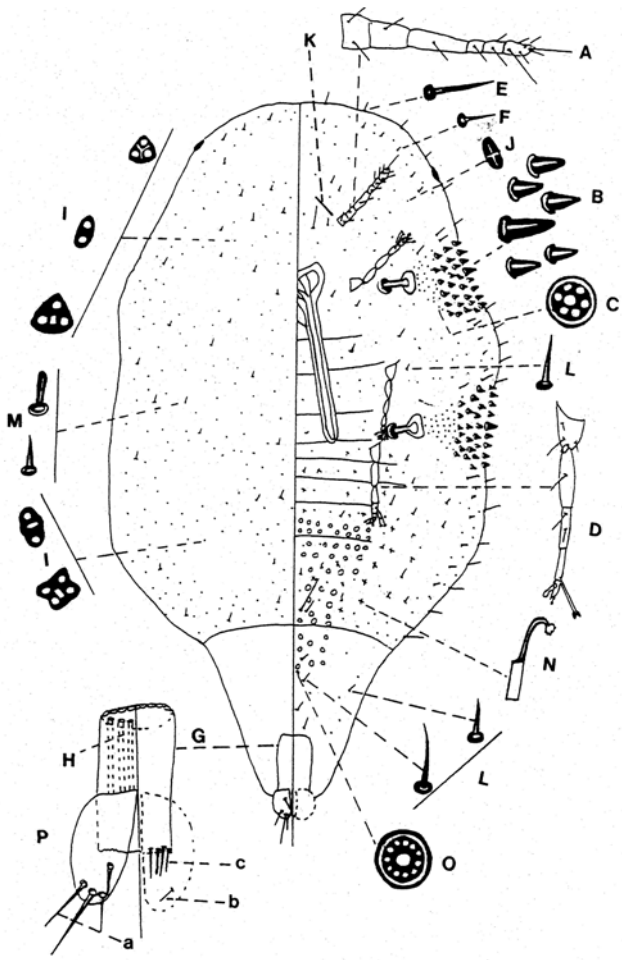
Setae and pores. Two pairs of interantennal setae present, longer pair 56-77 (66) µm long, shorter pair 11-19 (16) µm long.

Legs without tibiotarsal sclerosis, tarsus with equal-sized pair of digitules and claw with one of digitules slender, other stout; both tarsal and claw digitules well developed and apically knobbed; claw without denticles. Leg lengths in µm:

Segments	**First leg**	**Second leg**	**Third leg**
Coxa	35-56 (47)	41-55 (48)	32-47 (43)
Trochanter + femur	65-84 (74)	87-95 (94)	85-123 (110)
Tibia + tarsus	96-114 (103)	107-126 (112)	85-123 (110)
Claw	12-17 (15)	12-17 (15)	11-18 (15)
Tarsal digitules	27-34 (32)	22-35 (32)	24-35 (32)
Claw digitules	19-28 (23)	16-22 (20)	15-22 (19)
Total	243-333 (294)	285-354 (321)	247-347 (312)

Figure C1. *Ceroplastes destructor* adult female: **A**, antenna; **B**, spiracular setae; **C**, quinquilocular pore; **D**, leg; **E**, marginal seta; **F**, submarginal seta; **G**, anal ring; **H**, anal ring setae; **I**, dorsal pores; **J**, cruciform pore; **K**, interantennal setae; **L**, ventral setae; **M**, dorsal setae; **N**, tubular duct; **O**, multilocular pore; **P**, anal plates: **a**, dorsal setae; **b**, ventral seta; **c**, fringe setae."

[Image reproduced from Wakgari and Giliomee (1998).]



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

Ceroplastes destructor has the potential to adversely affect threatened and endangered plant species. However, because *C. destructor* 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. destructor* is known to feed on over 150 hosts within 27 families (Acanthaceae, Actinidiaceae, Anacardiaceae, Apocynaceae, Araliaceae, Celastraceae, Compositae, Ebenaceae, Ericaceae, Euphorbiaceae, Hippocrateaceae, Lauraceae, Loganiaceae, Loranthaceae, Magnoliaceae, Malvaceae, Meliaceae, Myrsinaceae, Myrtaceae, Pittosporaceae, Rosaceae, Rubiaceae, Rutaceae, Sapindaceae, Solanaceae, Sterculiaceae, and Theaceae). A known host, *Symphyotrichum subulatum*, is considered endangered in Maine and threatened in New York (Table D1). 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 *Ceroplastes destructor*.

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Acacia sp.	*Acacia choriophylla*	cinnecord		FL (E)
Agave sp.	*Manfreda virginica* [= *Agave virginica*]	false aloe		OH (T)
Baccharis halimifolia	*Baccharis vanessae*	Encinitis false willow	T	CA (E)
Conyza sp.	*Conyza ramosissima*	dwarf horseweed		OH (T)
Croton sp.	*Croton alabamensis*	Alabama croton		TN (E)
	C. glandulosus	vente conmigo		OH (T)
	C. willdenowii	Willdenow's croton		IN (E)
Dicliptera sp.	*Dicliptera brachiata*	branched foldwing		IN (E)
Diospyros kaki	*Diospyros virginiana*	common persimmon		NY (T)
Eugenia sp., E. coolminiana	*Eugenia confusa*	redberry stopper		FL (E)
	E. rhombea	red stopper		FL (E)
Euonymus japonica[2]	*Euonymus americana*	strawberry bush		IL (E) NY (E)
Hibiscus sp.	*Hibiscus moscheuttos* ssp. *lasiocarpos* [= *H. lasiocarpus*]	crimsoneyed rosemallow		IN (E)

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

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Magnolia sp.	*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. sylvestris*	*Malus angustifolia*	southern crabapple		FL (T) IL (E)
	M. glaucescens	Dunbar crabapple		NY (E)
Persea americana	*Persea borbonia*	redbay		MD (E)
	P. palustris	swamp bay		AR (E)
	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 *Ceroplastes destructor*.

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	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)
Rhus sp., *R. simarubaefolia*	*Rhus aromatica* var. *arenaria*	fragrant sumac		IN (T)
	R. michauxii	false poison sumac	E	FL (E) GA (E) NC (E)
Senecio sp.	*Packera antennariifolia* [= *Senecio antennariifolius*]	shalebarren ragwort		PA (E)
	P. cana [= *S. canus*]	woolly groundsel		MN (E)
	P. franciscana [= *S. franciscanus*]	San Francisco Peaks ragwort	T	
	P. indecora [= *S. indecorus*]	elegant groundsel		MI (T) WI (T)
	P. layneae [= *S. layneae*]	Layne's ragwort	T	
	P. millefolia [= *S. millefolium*]	piedmont ragwort		GA (T) NC (T)
	P. paupercula [= *Senecio pauperculus*]	balsam groundsel		CT (E) NH (T) OH (T)
	P. schweinitziana [= S. schweinitzianus]	Schweinitz's ragwort		NC (E) TN (T)
	S. ertterae	Ertter's ragwort		OR (T)
Symphyotrichum subulatum [= *Aster subulatus*][3]	*Symphyotrichum anticostense*	Anticosti island aster		ME (E)

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

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Symphyotrichum boreale	northern bog aster		IA (T) NJ (E) NY (T) PA (E) WA (E)
	S. ciliolatum	Lindsey's aster		NH (T) NY (E)
	S. concolor	eastern silver aster		KY (T) MA (E) MD (E) NY (E)
	S. depauperatum	serpentine aster		MD (E) PA (T)
	S. divaricatum	southern annual saltmarsh aster		ME (T)
	S. drummondii var. *drummondii*	Drummond's aster		OH (T)
	S. drummondii var. *texanum*	Drummond's aster		KY (T)
	S. dumosum var. *dumosum*	rice button aster		IA (E) OH (T)
	S. ericoides var. *ericoides*	white heath aster		TN (T)
	S. georgianum	Georgia aster		NC (T)
	S. jessicae	Jessica's aster		WA (E)
	S. laeve var. *concinnum*	smooth blue aster		MD (E) NY (E)
	S. lanceolatum ssp. *lanceolatum* var. *interior*	white panicle aster		NY (E)
	S. lateriflorum var. *hirsuticaule*	calico aster		NY (E)
	S. novi-belgii var. *crenifolium*	Newfoundland aster		NH (E)
	S. novi-belgii var. *novi-belgii*	New York aster		PA (T)
	S. oblongifolium	aromatic aster		OH (T)

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

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Symphyotrichum ontarione	bottomland aster		OH (E)
	S. oolentangiense var. *oolentangiense*	skyblue aster		NY (E)
	S. parviceps	smallhead aster		NC (E)
	S. patens var. *patens*	late purple aster		NH (T)
	S. pilosum var. *pringlei*	Pringle's aster		NY (T)
	S. praealtum var. *praealtum*	willowleaf aster		NJ (E) TN (E)
	S. pratense	barrens silky aster		AR (T) TN (T)
	S. priceae	lavender oldfield aster		KY (T)
	S. puniceum var. *puniceum*	purplestem aster		NJ (E) NY (E) PA (T)
	S. sericeum	western silver aster		MI (T)
	S. shortii	Short's aster		MN (T)
	S. subulatum[3]	eastern annual saltmarsh aster		ME (E) NY (T)
	S. tenuifolium	perennial saltmarsh aster		NH (E)
Viburnum obvatum	*Viburnum bracteatum*	bracted arrowwood		GA (E) TN (E)
	V. dentatum var. *venosum*	southern arrowwood		NY (T)
	V. edule	squashberry		MI (T) NY (T) VT (T) WI (E)
Viburnum obvatum	*V. lantaoides* [= *V. alnifolium*]	hobblebush		KY (E) NJ (E)

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

Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Viburnum molle	softleaf arrowwood		IL (T) KY (T) OH (E)
	V. nudum	possumhaw		KY (E) PA (E)
	V. nudum var. *cassinoides* [= *V. cassinoides*]	withe-rod		IN (E)
	V. nudum var. *nudum*	possumhaw		NY (E)
	V. opulus var. *americanum* [= *V. trilobum*]	American cranberrybush		IN (E) OH (T)
	V. rafinesquianum	downy arrowwood		MA (T) NH (E)
	V. rafinesquianum var. *rafinesquianum*	downy arrowwood		KY (T)

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

1. E= Endangered; T=Threatened
2. Artificially infested for a field trial (Milne 1993)
3. Name change; genus revision. A known host, *Symphyotrichum subulatum*, is considered endangered in Maine and threatened in New York

Appendix E. Biology of *Ceroplastes destructor*

Population phenology

*C. destruct*or has 1-2 generations annually. In New South Wales and Queensland Australia, 2 generations can occur (Smith 1970, 1973, Wakgari and Giliomee 1998, CAB 2003, USDA 2005b).

In Western Cape Province, South Africa, adults occur from March to September. Oviposition takes place from September to mid-December. First instars emerge from mid-November to mid January; second instars from mid-January to February; and third instars from late February to late July. Adults are present from mid-April to late September. *Ceroplastes destructor* may overwinter as a third-instar or adult (Wakgari and Giliomee 2000, Wakgari 2001).

In North Island, New Zealand, one generation occurs annually. Adults begin to lay eggs in November, and crawlers begin to emerge in early December. First and second instars occur from December to January. First instars temporarily settle on leaves early in December, and second and third instars move between January and April and permanently settle on twigs (Lo et al. 1996, CAB 2003, USDA 2005b). Lo and Blank (1996) describe differences in phenology between *C. destructor* and *C. sinensis* on citrus in New Zealand. In general, *C. destructor* began to develop earlier in the season and developed faster than *C. sinensis*.

Scale development is dependent on several factors, including host species, temperature, and water availability. Mortality has been observed to be density dependent and attributed to several factors such as presence and density of parasitoids and other predators, scale population density, and prolonged periods of extreme temperatures (e.g., >35°C) (Beattie et al. 1990, Milne 1993, Lo 1995, Lo et al. 1996, Ben-Dov and Hodgson 1997, Lo and Chapman 1998, Wakgari and Giliomee 1998, 2000, Lo and Chapman 2001, Wakgari and Giliomee 2001a, b).

Stage specific biology

Life history, including development, fecundity, fertility, mortality, and dispersal of *C. destructor* have been investigated by Wakgari (2000), Wakgari and Giliomee, (1998, 1999, 2000, 2001b), Beattie et al. (1990), Milne (1993), Lo et al., (1995, 1996), Olson et al. (1993), and others (CAB 2003, USDA 2005b).

Adult

Males are unknown for this species, and reproduction is likely parthenogenic (Qin and Gullan 1994). Adults tend to occur on stems that are less than 2-year old (Wakgari and Giliomee 1998, Wakgari 2000, CAB 2003, USDA 2005b).

Egg

Eggs are laid in a protective concave-shaped chamber area underneath the female. Oviposition patterns (e.g., eggs laid per female per day, total number of eggs produced, duration of oviposition, and time to first hatch) vary depending on a number of factors

including scale species, body size, and host selection. An adult female will lay between 37-6,355 (reported average is typically 1,750-1,775) eggs in her lifetime. Oviposition is usually spread over 10-14 days, but tends to be shorter for smaller females than larger females occurring on the same host. Newly deposited eggs will hatch in 16-31 days (Wakgari and Giliomee 1998, 1999, Wakgari 2000, Wakgari and Giliomee 2000, Wakgari 2001, Wakgari and Giliomee 2001b). After egg-hatch, crawlers remain under protective cover of the female for up to 2 days before dispersing and settling to feed.

Nymph

There are typically three instars; however, four instars have been reported in New Zealand (Beattie et al. 1990, Olson et al. 1993, Lo 1995, Wakgari and Giliomee 1998, CAB 2003). Dispersal occurs in the first and third instar crawler stage. Scales may settle to feed on leaf surfaces (typically near the midrib), leaf petioles, young stems, or flowers. Settling location and duration varies by life stage and may depend on host availability and quality, population density and development stage of the scale. Immature crawlers tend to settle on foliage while later stages move to young twigs and remain there for the remainder of their development (Olson et al. 1993, Wakgari and Giliomee 1998, Wakgari 2001, Wakgari and Giliomee 2001a, b).

Development time from crawler to third instar requires about 5 months and 800 accumulated degree days above a 12°C base; a minimum of 1250 accumulated degree days above the same base temperature is needed to complete a generation (1st instar crawler-1st instar crawler).

Dispersal occurs in the first and third instar crawler stage. The dispersal rate, pattern and distance depend largely on population density, host availability, location on host (height or distance from the soil surface), and other environmental factors including wind speed, humidity and temperature (Wakgari and Giliomee 1999, Wakgari 2000, Wakgari and Giliomee 2000, USDA 2005b)