Mini Risk Assessment
Giant Woodwasp, *Urocerus gigas* L.
[Hymenoptera: Siricidae]

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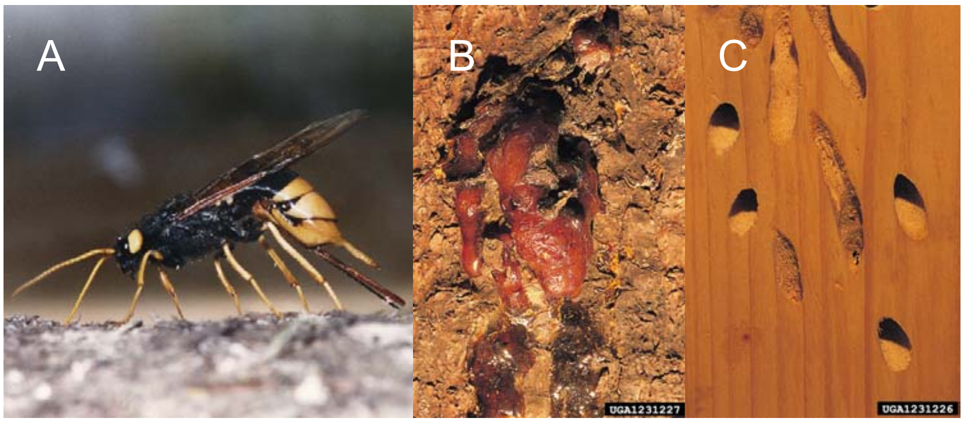

Figure 1. *Urocerus gigas gigas*: (A) Adult female; (B) external damage to tree; and (C) galleries produced by larvae.
[Images from www.forestryimages.org, (A) Paula Klasmer, (B-C) Gyorgy Csoka]

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Introduction

The giant woodwasp or the greater horntail, *Urocerus gigas* L, is considered a secondary pest of conifers throughout the Nearctic and Palearctic regions (Chrystal 1928, Morgan 1968, Kirk 1974, Kendall 2005). *Urocerus gigas*, including all of its known subspecies, occurs in northern Africa, Asia, Europe, North America, and South America (Ciesla 2003). *Urocerus gigas flavicornis* is well established in North America (see Appendix A, 'Geographic Distribution'). Therefore, we restrict our comments and analysis to *U. gigas gigas*, *U. gigas orientalis*, and *U. gigas tibetanus*. Where literature refers to only "*U. gigas*", we assume it is not referring to *U. gigas flavicornis* based on the origins of the reports. *Urocerus gigas* has proven invasive outside the US. For example the species is exotic to Britain but is now well established (Browne 1968).

The risks posed by *U. gigas* have been evaluated previously. In the Exotic Forest Pest Information System, Ciesla (2003) considered the relative risks for this pest high, but very uncertain because the widely distributed North American species, *U. gigas flavicornis*, is not known to cause economic damage. The ecological and economic outcome of competition between an exotic subspecies of *U. gigas* and *U. gigas flavicornis* or other woodboring insects is unknown and adds to the uncertainty (Ciesla 2003). High ratings were assigned for potential establishment and spread, but medium and low ratings were given for economic and environmental impacts, respectively (Ciesla 2003). The purpose of this mini-pest risk assessment is to further evaluate several factors that contribute to risks posed by exotic forms of *U. gigas* and to apply this information to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: High.** *Urocerus gigas* is present throughout much of Asia and Europe: *U. gigas gigas* is reported from Europe and Russia; *U. gigas orientalis* occurs throughout much of Asia, including the Russian Far East; and *U. gigas tibetanus* has only been reported in Tibet (Xizang province, China). Appendix A provides a detailed list of the reported worldwide distribution of this insect. In general, *U. gigas* occurs in warm, dry to cold and temperate climates. The currently reported distribution of *U. gigas* suggests that the pest may be closely associated with biomes characterized as: boreal forests; mediterranean scrub; temperate broadleaf and mixed forests; coniferous forests; and tundra. Excluding boreal forests and tundra (biomes not present in the continental US) we estimate approximately 48% of the continental US would have a suitable climate for *U. gigas*. Although this analysis included no information for *U. gigas flavicornis*, the subspecies considered native to North America, our predicted range includes the current range of the indigenous species. See Appendix A for a more complete description of this analysis.

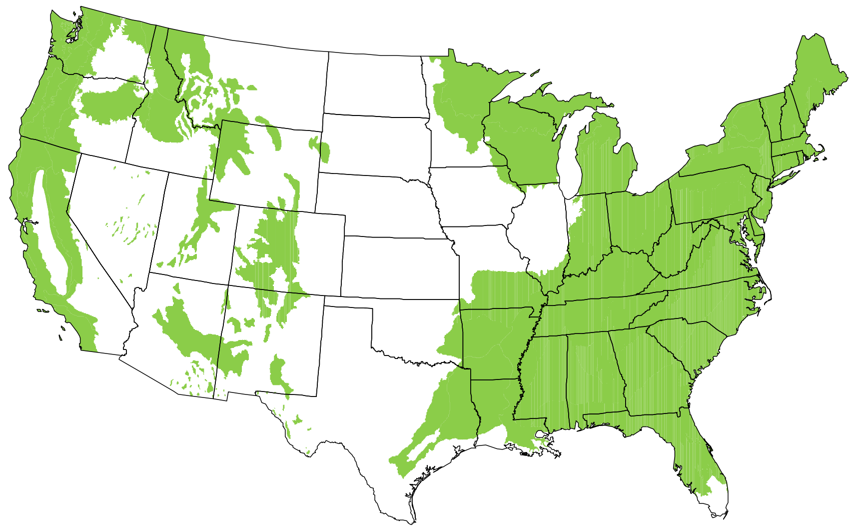

Figure 2. Predicted distribution (green) of exotic forms of *Urocerus gigas* in the contiguous US.

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

2. **Host Specificity/Host Availability. Rating: Medium/High.** *Urocerus gigas* reportedly feeds on 5 or more genera within the family Pinaceae. These plants occur widely in the US and often at high densities (Appendix B). Tables 1A-D summarize hosts of various forms of *U. gigas* as reported in literature. Questionable hosts are noted but are not considered true hosts (i.e., *U. gigas* does not complete its development in these hosts). With the exception of cedar (*Cedrus* spp.), non-hosts involve plant families other than Pinaceae. Dubious host records may also be attributed to taxonomic confusion and misidentification of similar species. Note that *U. gigas taiganus* (Table 1C) was synonomized with *U. gigas gigas* (see 'Taxonomic Recognition').

Table 1A. Host plants of *Urocerus gigas* (organized by common name).

Hosts	**References**
ash (*Fraxinus* sp.)[1]	(Viitasaari 1984, Wermelinger 2003)
cedar (*Cedrus* sp.)[1]	(Ciesla 2003)
cedar (*Chamaecyparis* sp.)[1]	(Ciesla 2003)
cottonwood (*Populus* sp.)[1]	(Viitasaari 1984, Wermelinger 2003)
Douglas-fir (*Pseudotsuga* sp.)	(Ciesla 2003)
Douglas-fir (*Pseudotsuga menziesii*)	(Kirk 1974, Kolk and Starzyk 1996)

Hosts	References
fir (*Abies* sp.)	(Guinet, Browne 1968, Grujic 1976, Starzyk and Luszczak 1982, Starzyk and Fizia 1984, Starzyk and Wójcik 1986, Whiteley 1991, Ciesla 2003)
fir, grand (*Abies grandis*)	(Kirk 1974)
fir, Khingan (*Abies nephrolepis*)	(CAB 2004)
fir, noble (*Abies procera*)	(Kirk 1974)
fir, silver or common (*Abies alba*)	(Chrystal 1928, Hanson 1939, Kirk 1974, Kolk and Starzyk 1996, Wermelinger 2003, CAB 2004)
larch (*Larix* sp.)	(Guinet, Chrystal 1928, Hanson 1939, Browne 1968, Kolk and Starzyk 1996, Ciesla 2003, CAB 2004)
larch, European (*Larix decidua*)	(Kirk 1974, Wermelinger 2003)
pine (*Pinus* sp.)	(Guinet, Hanson 1939, Browne 1968, Grujic 1976, Ciesla 2003, Wermelinger 2003)
pine, Austrian (*Pinus nigra*)	(Nieves Aldrey et al. 1995, CAB 2004)
pine, Monterrey (*Pinus radiata*)	(Ciesla 2003, CAB 2004)
pine, Scots (*Pinus sylvestris*)	(Chrystal 1928, Kirk 1974, Spradbery and Kirk 1981, Kolk and Starzyk 1996, CAB 2004)
spruce (*Picea* sp.)	(Guinet, Chrystal 1928, Hanson 1939, Browne 1968, Grujic 1976, Ciesla 2003)
spruce, Korean (*Picea koraiensis*)	(CAB 2004)
spruce, Norway or common (*Picea abies*)	(Kirk 1974, Kolk and Starzyk 1996, Wermelinger 2003, CAB 2004)
spruce, sitka (*Picea sitchensis*)	(Kirk 1974, Spradbery and Kirk 1981, Kolk and Starzyk 1996)

1. Dubious record - plant (except *Cedrus*) is not in the family Pinaceae. Cedar may be a host.

Table 1B. Host plants of *Urocerus gigas gigas* (organized by common name).

Hosts	References
ash (*Fraxinus* sp.) [1]	(Smith 1978, Viitasaari 1984, Savela 2000)
cedar (*Cedrus* sp.) [1]	(Savela 2000)
cedar, Lebanese (*Cedrus libani*) [1]	(Smith 1978)
cedar (*Chamaecyparis* sp.) [1]	(Savela 2000)
cedar, Port Orford (*Chamaecyparis lawsoniana*) [1]	(Smith 1978)
cottonwood (*Populus* sp.) [1]	(Smith 1978, Savela 2000)
deodar (*Cedrus deodara)* [1]	(Smith 1978)
Douglas-fir (*Pseudotsuga* sp.)	(Savela 2000)
Douglas-fir (*Pseudotsuga menziesii*)	(Smith 1978)
fir (*Abies* sp.)	(Smith 1978, Savela 2000)
fir, silver (*Abies alba* (= *Abies pectinata*))	(Smith 1978)

Hosts	References
fir, grand (*Abies grandis*)	(Smith 1978)
fir, noble (*Abies procera*)	(Smith 1978)
fir, Siberian (*Abies sibirica*)	(Smith 1978)
larch (*Larix* sp.)	(Smith 1978, Savela 2000)
larch, European (*Larix decidua*)	(Smith 1978)
larch, Siberian (*Larix sibirica*)	(Smith 1978)
Picea excelsa septentrionalis	(Smith 1978)
pine (*Pinus* sp.)	(Smith 1978, Savela 2000)
pine, Austrian (*Pinus nigra* (= *Pinus austriaca*))	(Smith 1978)
pine, jack (*Pinus banksiana*)	(Smith 1978)
pine, Scots (*Pinus sylvestris*)	(Smith 1978, Savela 2000)
pine, Siberian (*Pinus sibirica*)	(Smith 1978)
pine, Swiss stone (*Pinus cembra*)	(Smith 1978)
spruce (*Picea* sp.)	(Smith 1978, Savela 2000)
spruce, blue (*Picea pungens*)	(Smith 1978)
spruce, Norway (*Picea abies* (= *Picea excelsa*))	(Smith 1978, Savela 2000)
spruce, Serbian (*Picea omorica*)	(Smith 1978)
spruce, Siberian (*Picea obovata*)	(Smith 1978)
spruce, sitka (*Picea sitchensis*)	(Smith 1978)
willow (*Salix* sp.) [1]	(Smith 1978, Viitasaari 1984, Savela 2000)

1. Dubious record – plant (except *Cedrus*) is not in the family Pinaceae. Cedar may be a host.

Table 1C. Host plants of *U. gigas taiganus*[2] (organized by common name).

Hosts	References
birch (*Betula* sp.) [1]	(Smith 1978)
cedar, Siberian or Siberian pine (*Pinus sibirica*)	(Smith 1978)
fir (*Abies* sp.)	(Smith 1978)
fir, Faber's (*Abies fabri*)	(Ye et al. 2003)
fir, silver (*Abies alba*)	(Smith 1978)
larch (*Larix* sp.)	(Smith 1978, Wang et al. 2001)
larch, Dahurian (*Larix gmelinii* (= *Larix dahurica*))	(Smith 1978, Ye et al. 2003, CAB 2004)
larch, Siberian (*Larix sibirica*)	(Smith 1978)
pine (*Pinus* sp.)	(Smith 1978)
pine, Scots (*Pinus sylvestris*)	(Smith 1978)
pine, stone (*Pinus* sp.)	(Smith 1978)
spruce (*Picea* sp.)	(Smith 1978)
spruce, dragon (*Picea asperata*)	(Ye et al. 2003)

1. Dubious record – plant is not in the family Pinaceae.
2. *Urocerus gigas taiganus* was placed in synonymy with *U. gigas gigas* (see 'Taxonomic Recognition').

Table 1D. Host plants of *Urocerus gigas orientalis* (organized by common name).

Hosts	References
fir (*Abies* sp.)	(Smith 1978)
fir, Japanese silver (*Abies firma*)	(Smith 1978)
fir, Sakhalin (*Abies sachalinensis*)	(Smith 1978)
larch (*Larix* sp.)	(Smith 1978)
larch, Japanese (*Larix kaempferi*)	(Smith 1978)
pine, Japanese red (*Pinus densiflora*)	(Smith 1978)
spruce, Yeddo (*Picea jezoensis*)	(Smith 1978)

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

3. **Survey Methodology. Rating: Low.** Surveys for *U. gigas* will have to rely primarily on visual inspection methods. Currently no pheromones have been identified for *U. gigas*; however, siricids may respond to other volatile organic compounds. For example, *Sirex noctilio* was recently captured for the first time in the US in a funnel trap baited with cis-verbenol, ipsdienol, and methyl butenol (Hoebeke et al. 2005). The attractiveness of these compounds to *U. gigas* has not been tested, so they cannot be recommended at this time for general surveys.

   Surveys for *U. gigas* in Europe utilized visual inspections of dead or dying tree material (Starzyk and Luszczak 1982, Mihalciuc et al. 2001). For a regional survey in Ireland, standing or fallen dead trees were inspected for exit holes (Fig. 3), galleries and larvae (Kirk 1974). Then, 1-m-long [~3 ft] logs were cut from standing timber, and insects reared in outdoor insectaries (Kirk 1974). More than 80% of exit holes produced by *U. gigas taiganus* occur within 3 m [~10ft] of the ground (Wang et al. 2001). Visual surveys are likely to be labor intensive. A regional survey in Finland relied on >300 volunteers to search for several insects, including *U. gigas* (Hyönteiskartoitus/Insektkartering-81 1984, 1985, 1988, 1990, 1996).

   When examining trees, extreme care must be taken with specimen identification. Multiple siricid species (e.g., *U. gigas* and *Sirex cayaneus*) may attack the same tree (Chrystal 1928). In general, *U. gigas* seems to prefer larger trees (i.e., greater than the pole stage) compared with other siricids (Chrystal 1928). Aside from careful taxonomic evaluation of adult specimens, the presence of tunnels that penetrate deep into wood of host trees provide the most definitive sign of infestation by *U. gigas* (Ciesla 2003).

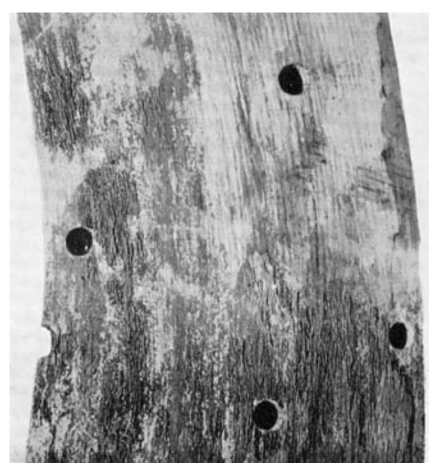

Figure 3. Exit holes produced by adult *U. gigas*.
[Reproduced from Chrystal (1928).]

If we can assume that (i) a forest contains a very large number of dead or dying trees; (ii) inspection of tree always locates *U. gigas* when it is present, and (iii) trees are selected at random, simple binomial statistics can be used to calculate the number of tress that should be inspected to achieve a desired probability of finding *U. gigas* when it is present in a forest. Figure 4 illustrates how the number of required samples changes as the proportion of trees with *U. gigas* 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).

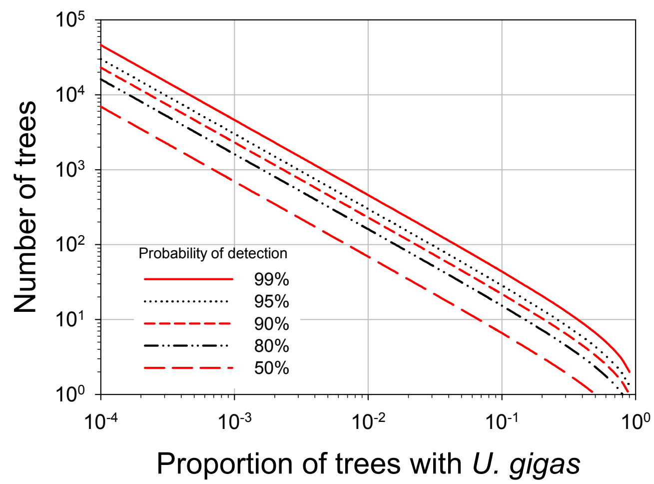

Figure 4. Required number of trees to be inspected in relation to the proportion of trees with entrance holes and the desired probability of detecting *U. gigas* when it is present. This figure assumes random sampling from a large environment.

4. **Taxonomic Recognition. Rating: Low.** *Urocerus gigas* may be easily confused with other siricids having similar behavior, plant hosts and geographic distribution. *Urocerus gigas flavicornis* is native to North America and is widespread (Smith 1978, Smith and Schiff 2002). Benson (1943) commented on the general lack of morphological differences between *U. gigas gigas* and *U. gigas flavicornis* but implied that ovipositor length might be a useful character. Over time, subspecies of *U. gigas* have been distinguished by geographic origins, coloration, the presence or absence of "eye" spots, ovipositor length, body size, and hair length pubescence (Bradley 1913, Benson 1943, 1951, Smith 1978, Smith and Schiff 2002). As Smith (1978) explains:

> "***Urocerus gigas*** and its subspecies are probably the most commonly found forms of siricids in Eurasia, as the numerous literature references attest... The subspecies are separated only by coloration which is consistent within certain geographical areas, though those of Eurasia undoubtedly overlap and intermediates are frequent. Since the subspecies were created by Benson (Benson 1943), much of the literature prior to that time may be difficult to place to the correct form. Some of the literature listed under ***gigas gigas***, therefore, may pertain to one of the other subspecies; however, I doubt that it makes much difference as to which subspecies the articles pertain. In general, the typical subspecies is found in Europe; ***orientalis*** is found in eastern China, eastern Siberia, and Japan; ***tibetanus*** is found in the

Himalayas; and ***taiganus*** is more northern, occurring from Scandinavia through Siberia."

Suspect specimens of *U. gigas* must be identified by a highly trained taxonomist.

For a more detailed description of the morphology and taxonomy of *U. gigas* see Appendix C.

5. **Entry Potential. Rating: Low.** Officers with USDA-APHIS and Department of Homeland Security did not report an interception of *Urocerus gigas* nor any other *Urocerus* sp. at US ports of entry from 1985-2004 (USDA 2005). These records may not reflect the true potential for entry of *U. gigas*. As a wood borer, larvae may be difficult to find during routine insecptions. Moreover, siricids can be extremely difficult to identify, particularly when specimens are eggs or larvae. Interceptions of "Siricidae; species of" were reported much more frequently. Unspecified siricids were intercepted at least 115 times between 1985-2004 (incomplete records complicate the accuracy of this count) (USDA 2005); on average, 5.8 (±1.3 standard error of the mean) interceptions were reported annually. Most interceptions were associated with general cargo (86%) and permit cargo (6%). The greatest percentages of siricid interceptions came from Atlanta, GA (39%), Chicago, IL (13%), Erlanger, KY (12%), and Long Beach, CA (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.

   Perhaps not surprisingly, virtually all interceptions were associated with some form of solid wood packing. Crating is mentioned in 41% of all interceptions, and dunnage is mentioned in another 12%.

   It is unlikely that all unidentified specimens of Siricidae were *U. gigas*, but even if they had been, *U. gigas* would still have an apparent low potential for entry, relative to other exotic insects. Although we assign a low rating to this risk element, we recognize that not all pathways for the introduction of forest pests have been studied with any detail. Consequently, a great deal of uncertainty is associated with our rating. Outside the US, arrival of *U. gigas* has been noted in Australia and New Zealand in commercial shipments of timber (Morgan 1968).

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 "Siricidae; species of" were destined for 20 states within the contiguous US. The most commonly reported destinations were Georgia (23%), California (13%), Illinois (13%), Tennessee (8%), Kentucky (7%), and Ohio (5%) (USDA 2005). Some portion of each of state identified as the intended final destination has a climate and hosts that would be suitable for establishment by *Urocerus gigas*.

7. **Potential Economic Impact. Rating: Low.** Throughout its range, *Urocerus gigas* is considered a secondary pest of Pinaceae [see 'Host Specificity']. *Urocerus gigas* typically damages conifers that have been injured previously by fire, weakened by insects or pathogens, or felled for timber (Chrystal 1928, Morgan 1968, Ebeling 2002, Smith and Schiff 2002, Ciesla 2003).The economic impact of *U. gigas* is difficult to measure, especially because it often occurs with other primary and secondary attackers (Chrystal 1928, Grujic 1976, Starzyk and Luszczak 1982, Starzyk and Fizia 1984, Starzyk and Wójcik 1986, Smith and Schiff 2002). For example, on larch, *U gigas* may follow attacks by *Ips cembrae* and infection by *Certocystis laricicola* (Redfern et al. 1987). Because siricids in general may predispose already stressed trees to further damage by ambrosia and bark beetles, decay fungi and other microorganisms (Kozlowski et al. 1991), it is not clear how much damage may be attributed solely to *U. gigas* (Redfern 1989). Intense siricid attacks are rarely reported from the Northern Hemisphere, but when they do occur, they are often associated with events that damage trees (Morgan 1968).

   The damage caused by symbiotic fungi associated with *U. gigas* may be more significant than the damage caused by the insects themselves. Fungi vectored by siricids are pathogenic; economic losses result from tree death, reduced growth, and reduced quality (Morgan 1968, Manion 1991). Arrival of *U. gigas* may bring *Amylostereum chailletii*, a sapwood decay fungus (Talbot 1977, Redfern et al. 1987). Artificial inoculation studies suggest that this fungus is only a weak pathogen (Redfern et al. 1987), but when the pathogen occurs with mucus from a siricid, the combination is deadly (Talbot 1977). Whether foreign subspecies of *U. gigas* carry different strains of *A. chailletii* than *A. gigas flavicornis* and whether those strains are more or less pathogenic remains to be determined. Thus, a substantial degree of uncertainty is associated with the rating for this element.

8. **Potential Environmental Impact. Rating: Medium.** In general, newly established species may adversely affect the environment by reducing biodiversity, disrupting ecosystem function, jeopardizing endangered or threatened plants, degrading critical habitat, or stimulating the use of chemical or biological controls. Exotic subspecies of *U. gigas* are likely to affect the environment in some, but not all, of these ways.

   Because *U. gigas* is not known to adversely impact healthy trees or cause significant mortality on its own, this insect does not seem to have the potential to directly alter the structure or function of forests. Indirect effects stem from symbiotic fungi vectored by *U. gigas* (see 'Economic Impact'), but these effects are highly uncertain. Chemical controls have been proposed for the control of Siricids (discussed in Morgan 1968), however, the complexity of the terrain and difficulty of exposing a wood boring insect to an adequate dose of toxin makes many insecticides impractical, especially over large areas. Biological control is a much more likely option (Chrystal 1928, Morgan 1968). Previous experience with *Sirex noctilio* demonstrates that entomopathogens might be introduced (Talbot 1977). In previous years, generalist agents were often introduced to control other forest pests, often with significant, impacts on non-target species (reviewed in Syrett 2002). Current screening protocols limit the likelihood of these severe impacts to non-target species (reviewed in Hoddle and Syrett 2002).

Urocerus gigas has the potential to adversely affect threatened and endangered plants. This insect utilizes several coniferous hosts within the family Pinaceae [see 'Host Specificity']. Appendix D summarizes federally listed threatened or endangered plant species (USDA 2001) found within plant genera known to be hosts (or potential hosts) for *U. gigas*. Plants listed in Appendix D might be suitable hosts for *U. gigas*, and thus, could be adversely affected by this insect.

9. **Establishment Potential. Rating: High.** A significant portion of the US has a suitable climate and host plants that would support establishment by *U. gigas*. Competition with the native *U. gigas flavicornis* might prevent the establishment of a new subspecies (Ciesla 2003), but the outcomes of these interactions are highly speculative. The low apparent rate of arrival tempers the potential for establishment.

   See Appendix E for a more detailed description of the biology of *Urocerus gigas*.

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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 *Urocerus gigas*:

Locations	References
Argentina	(Ciesla 2003)
Australia[1]	(Chrystal 1928)
British Isles	(Kendall 2005)
Chile	(Ciesla 2003)
England	(Chrystal 1928, Hanson 1939, Browne 1968, Redfern 1989, CAB 2004)
England (Ascot)	(Spradbery and Kirk 1981)
England (Banffshire)	(Leverton 1991)
England (Berkshire)	(Chrystal 1928)
England (Kent)	(Chrystal 1928)
England (London)	(Chrystal 1928)
England (North Devon – South Molton)	(Chrystal 1928)
England (Norwich)	(Chrystal 1928)
England (Sheffield)	(Whiteley 1991)
England (Tubney Wood)	(Chrystal 1928)
England (Wiltshire)	(Chrystal 1928)
England (Windsor Forest)	(Spradbery and Kirk 1981)
Europe	(Browne 1968, Kolk and Starzyk 1996, Kendall 2005)
Europe (central)	(Benson 1943)
Finland	(CAB 2004)
Finland (central)[2]	(Hyönteiskartoitus/Insektkartering-81 1984, 1985, 1988, 1990, 1996)
Finland (southern coastal)[3]	(Hyönteiskartoitus/Insektkartering-81 1984, 1985, 1988, 1990, 1996)

Locations	References
Germany	(Hanson 1939)
Ireland	(CAB 2004)
Ireland (County Antrim - Glenarm)	(Kirk 1974)
Ireland (County Down - Newcastle)	(Kirk 1974)
Ireland (County Kerry - Kenmare)	(Kirk 1974)
Ireland (County Kerry - Muckross)	(Kirk 1974)
Ireland (County Kerry - Parknasilla)	(Kirk 1974)
Ireland (County Kerry - Ross Duhn Island)	(Kirk 1974)
Ireland (County Londonderry - Ballykelly)	(Kirk 1974)
Ireland (County Tyrone - Baronscourt)	(Kirk 1974)
Ireland (County Tyrone - Gortin Glen)	(Kirk 1974)
Ireland (County Wicklow - Glencree)	(Kirk 1974)
Ireland (County Wicklow - Glenmalure)	(Kirk 1974)
Northern Africa	(Browne 1968)
northern Asia up to the Altai Mountains	(Kolk and Starzyk 1996)
Northern Ireland	(CAB 2004)
Poland	(CAB 2004)
Poland (Krynica)	(Starzyk and Luszczak 1982, Starzyk and Fizia 1984, Starzyk and Wójcik 1986)
Romania	(Mihalciuc et al. 2001)
Russia (Siberia)	(CAB 2004)
Scotland	(Chrystal 1928)
Serbia	(Grujic 1976)
Spain (Lérida)	(Nieves Aldrey et al. 1995)

1. Intercepted; not established (Chrystal 1928).
2. Occurs in boreal forest/taigas.
3. Occurs in temperate broadleaf and mixed forests.

Table A1. Reported geographic distribution of *Urocerus gigas gigas*:

Locations	References
Albania	(Smith 1978)
Argentina (Chebut Province, Rio Negro Province, Neuqué Province)	(Ciesla 2003)
Algeria	(Benson 1943, Smith 1978, Savela 2000, Ciesla 2003)
Australia[1]	(Benson 1943)
Austria	(Smith 1978)
Belgium	(Smith 1978)
Bulgaria	(Smith 1978)
Chile	(Smith 1978, Savela 2000, Ciesla 2003)
Cyprus	(Smith 1978)

Locations	References
Czechloslovakia	(Smith 1978)
Denmark	(Smith 1978)
England	(Smith 1978)
Europe	(Benson 1951, Savela 2000, Ciesla 2003)
Europe (central, southern)	(Benson 1943)
Finland	(Smith 1978)
France	(Smith 1978)
Germany	(Smith 1978)
Greece	(Smith 1978)
Hungary	(Smith 1978)
Iceland	(Smith 1978)
Ireland	(Smith 1978)
Israel[1]	(Smith 1978)
Italy	(Smith 1978)
Japan	(Savela 2000)
Korea	(Savela 2000)
Latvia	(Smith 1978)
Lithuania	(Smith 1978)
Netherlands	(Smith 1978)
North Africa	(Benson 1951)
Norway	(Smith 1978)
Poland	(Smith 1978)
Reunion[1]	(Smith 1978)
Romania	(Smith 1978)
Russia (Kamchatka)	(Savela 2000, Ciesla 2003)
Russia (Kurile Islands)	(Savela 2000)
Russia (Siberia)	(Savela 2000, Ciesla 2003)
Scandinavia (south)	(Benson 1951)
Scotland	(Smith 1978)
Sicily	(Smith 1978)
South Africa[1]	(Smith 1978)
South America	(Benson 1943)
Spain	(Smith 1978)
Sweden	(Smith 1978)
Switzerland	(Smith 1978)
Ukraine	(Smith 1978)

1. Intercepted; not established (Chrystal 1928, Smith 1978).

Table A1. Reported geographic distribution of *Urocerus gigas taiganus*:

Locations	References
Asia (north coniferous belt)	(Benson 1951)
China (Liaoning, Heilongjiang, Sichuan, Gansu, Qinghai, Xinjiang)	(Anon. 1996)
England	(Smith 1978)
Europe (north coniferous belt)	(Benson 1951)
Finland	(Benson 1943, Maa 1949, Smith 1978)
Japan	(Benson 1943, Smith 1978)

Locations	References
Lapland	(Benson 1943)
Norway	(Benson 1943, Smith 1978)
Poland	(Smith 1978)
Russia (Altay)	(Smith 1978)
Russia (Amur)	(Smith 1978)
Russia (Buryat)	(Smith 1978)
Russia (Chita)	(Smith 1978)
Russia (Irkutsk)	(Smith 1978)
Russia (Kamchatka)	(Smith 1978)
Russia (Kemerovo)	(Smith 1978)
Russia (Khabarovsk)	(Smith 1978)
Russia (Krasnoyarsk)	(Smith 1978)
Russia (Kurile Islands)	(Smith 1978)
Russia (north)	(Benson 1943, Maa 1949)
Russia (Novosibirsk)	(Smith 1978)
Russia (Primorski Krai)	(Smith 1978)
Russia (Sakhalin)	(Smith 1978)
Russia (Siberia)	(Benson 1943)
Russia (Siberia – southwest)	(Maa 1949)
Russia (Tomsk)	(Smith 1978)
Russia (Tuvian)	(Smith 1978)
Russia (Tyumen)	(Smith 1978)
Russia (Yakutsk)	(Smith 1978)
Scotland	(Smith 1978)
Scotland (Aberdeen)	(Benson 1943)
Scotland (East Lothian – Whittingham)	(Benson 1943)

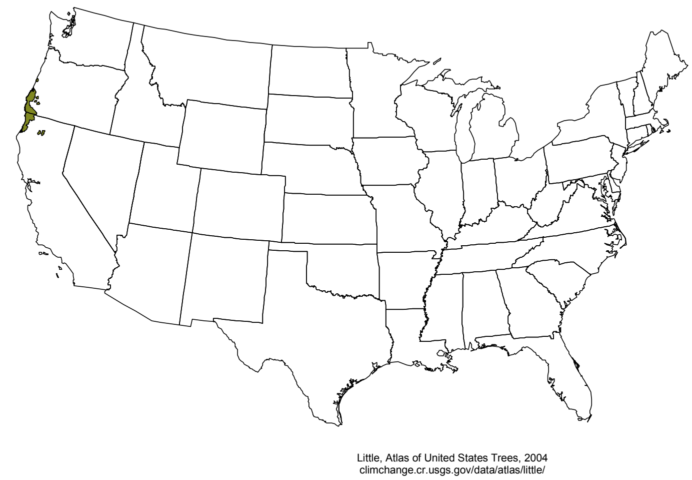
Table A1. Reported geographic distribution of *Urocerus gigas orientalis*:

Locations	References
China	(Savela 2000, Ciesla 2003)
China (Shantung)	(Maa 1949, Smith 1978)
Japan	(Maa 1949, Smith 1978, Savela 2000, Ciesla 2003)
Korea	(Smith 1978, Savela 2000, Ciesla 2003)
Russia (Eastern Siberia)	(Savela 2000)
Russia (Far East)	(Ciesla 2003)
Russia (Kamchatka)	(Maa 1949, Smith 1978, Savela 2000, Ciesla 2003)
Russia (Sakhalin)	(Maa 1949, Smith 1978, Savela 2000, Ciesla 2003)
Russia (Tschita or Chita)	(Maa 1949, Smith 1978)

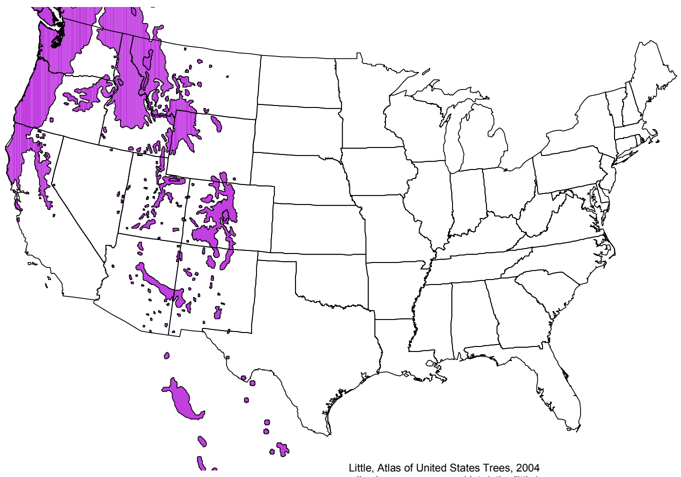
Table A1. Reported geographic distribution of *Urocerus gigas tibetanus*:

Locations	References
China (Tibet)	(Benson 1943, Smith 1978, Savela 2000, Ciesla 2003)
China (Tibet - southeast)	(Maa 1949)

Appendix B. Host distribution (potential) for *Urocerus gigas* in the contiguous US. Not all potential hosts are shown.



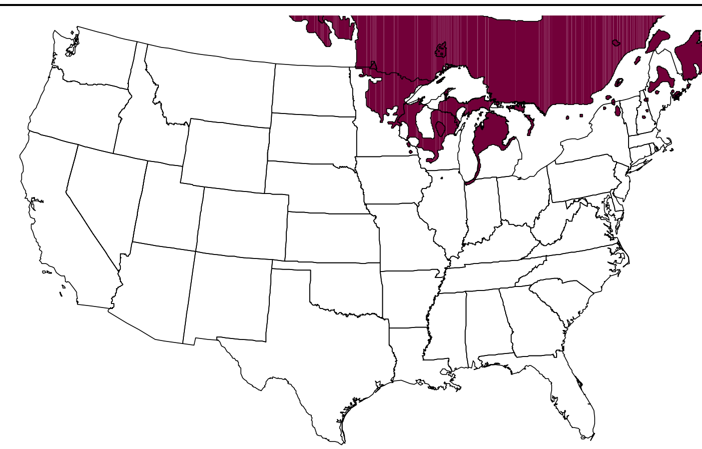
Map 1. Port-Orford cedar (*Chamaecyparis lawsoniana*)



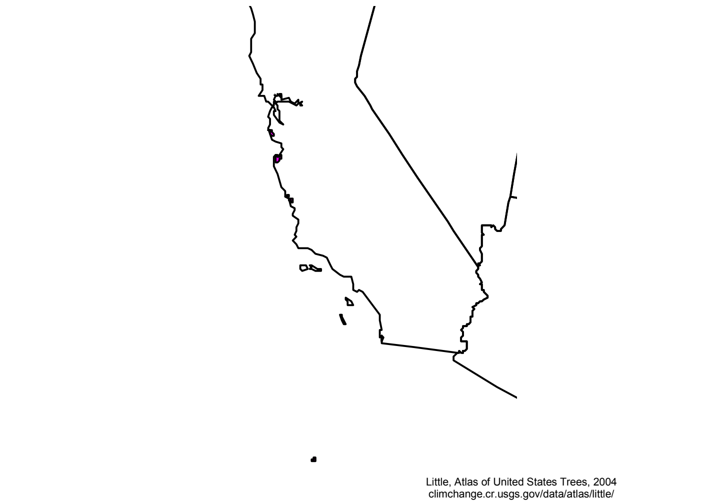
Map 2. Douglas fir (*Pseudotsuga menziesii*)

Map 3. Grand fir (*Abies grandis*)

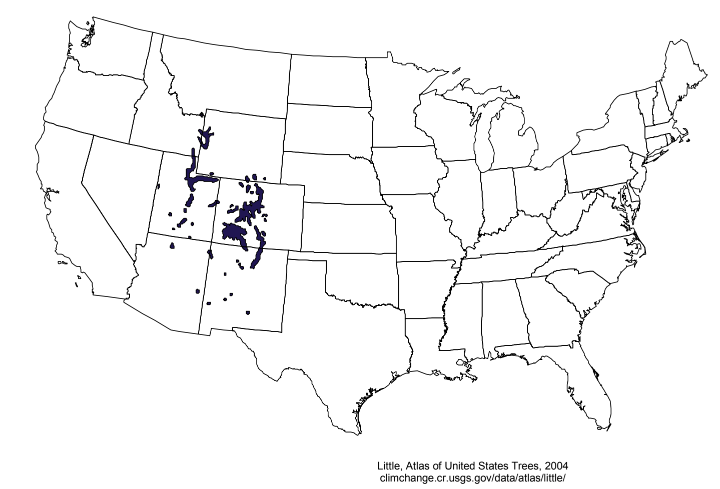
Map 4. Noble fir (*Abies procera*)



Map 5. Jack pine (*Pinus banksiana*)



Map 6. Monterrey pine (*Pinus radiata*)



Map 7. Blue spruce (*Pices pungens*)

Map 8. Sitka spruce (*Picea sitchensis*)

Little, Atlas of United States Trees, 2004
climchange.cr.usgs.gov/data/atlas/little/

Little, Atlas of United States Trees, 2004
climchange.cr.usgs.gov/data/atlas/little/

Appendix C. Taxonomy and morphology of *Urocerus gigas*

Synonyms
The following is a list of currently recognized names (**bold**) and synonyms (Benson 1943, Maa 1949, Smith 1978, Krombein et al. 1979, Viitasaari 1984, Smith and Schiff 2002).

Urocerus gigas gigas (=*Ichneumon gigas* Linnaeus, 1758; *Sirex gigas* Linnaeus, 1761; *Urocerus gigas*, Geoffroy, 1785; *Urocerus gigas taiganus* Benson, 1943);

Urocerus gigas flavicornis (Fabricius) (=*Sirex flavicornis* Fabricius, 1781; *Sirex bizonatus* Stephens, 1835; *Sirex latifasciatus* Westwood, 1874; *Urocerus riparius* MacGillivray, 1893);

Urocerus gigas orientalis Maa, 1949 (=*U. gigas taiganus* Benson, 1943; *Urocerus taiganus* Kapuscinski, 1962)

Urocerus gigas tibetanus Benson, 1943

Diagnostic features
For complete accuracy, the following morphological descriptions are quoted from Maa (1949) and Smith and Schiff (2002). Note that *U. gigas taiganus* was initially placed in synonymy with *U. gigas orientalis*, but following a subsequent revision, was placed in synonymy with *U. gigas gigas.*, as noted above. The description of *U. gigas taiganus* is not included in this report.

Guide to genus
"Use of the white spot behind each eye to separate *Urocerus* and *Sirex* is commonly used in keys but is not infallible" [character is variable in some species]. ..."Examination of the shape of the female cornus and the male hind tarsus should be checked for determination" (Smith and Schiff 2002).

Guide to species
U. gigas flavicornis
"[Males] Males are more difficult to separate than females. Use caution in the keys to males since color variation may be more extensive than we have observed. ... Head largely black, with a broad black band separating yellow spots on each side of head. Abdominal segments 1 and 2 or 1 to 3, and 7 to apex black, segments 2 or 3 to 7 red to orange: wings hyaline. Hindbasitarsus 4.0-5.5 X longer than broad" (Smith and Schiff 2002).

"[Females] Yellow on head separated into a spot on each side by a black band usually as broad as distance between eyes; thorax black Wings yellow, only apical margins may be slightly blackish: antenna yellow, scape and pedicel may be black" (Smith and Schiff 2002).

U. gigas gigas
"[Males] Antennae usually entirely yellow, occasionally darkened, or basally and apically contrastly colored, never black at both ends and whitish at the middle. Body color much

paler. ...Antennae uniformly pale colored or nearly so, at most gradually darkened toward the base, never sharply contrasted in basal and apical halves. ... Body more or less darker, at least with dull markings on frons, thorax and abdominal apex; head more or less strongly sculptured; vertex usually medially with a pretty deep furrow. ... Head posterior to the supra-orbital line extensively black; wings not uniformly clear hyaline, at least with a broad, light brownish, transverse band at the middle or along the apical margin; vertex coarsely punctate; abdomen not so pale colored. ... Basal and apical abdominal tergites dull brown to black (usually black), the intermediate ones paler; median furrow of vertex deep, narrow. ... Antennae yellow or brownish yellow, only the scape blackish, the segment III rather shorter than the IV; vertex, especially anteriorly, densely puncate. ... Abdominal tergite VIII with greenish metallic lustre; M 1 2 in the forewing apically very weak and indistinct, cell 3r incompletely closed. 15-30 mm." (Maa 1949)

[Females] Cornus relatively slenderer and longer (the post-cercal length at least thrice as long as the maximum breadth), acuminate or slenderly lanceolate, the lateral margins in dorsal aspect at most only slightly dilated preapically; dorso-lateral margins of terebra apically with a series of strong spines. ... Antennae almost uniformly yellowish red, at most the scape and pedicel black, never whitish at the middle and black or brownish black at both extremities. ... Body much paler, more richly pale-marked. ... Abdomen more or less more richly dull marked; preapical tooth of the tarsal claw subperpendicular to the main axis, moderately long; vein 1A in the hind wing well developed. ... Vertex entirely black, or medially with a very broad, transversely rectangular or trapezoidal, black band, of which the median breadth at least as broad as POL + POL; median vertical furrow never deep and distinct; abdominal tergites I-II and VII-VIII (excluding anterior margin of the I and sometimes also posterior margin of the II or of the VIII) uniformly yellow, while the III-VI uniformly black. ... Hairs on head and thorax of usual length, those lying between antennal insertions, for instance, are scarcely longer than a-half the scape; abdominal tergite II entirely yellow. ... Terebra brownish or yellowish, subequal in length to the forewing or nearly so (ca. 0.98-1.17); abdominal tergite 9 dominantly yellow, at least with the precornal basin entirely yellow, and at most, black only on the anterior margin; the VIII entirely yellow; wings basally and costally rather rich in amber color. ... Terebra distinctly shorter than the forewing (ca. 1.06:1.17); cornus in profile weakly but distinctly dentate at a point of about basal one-fourth of the inferior margin; tibiae uniformly yellow. 12-40 mm." (Maa 1949)

U. gigas orientalis

"[Females] Cornus relatively slenderer and longer (the post-cercal length at least thrice as long as the maximum breadth), acuminate or slenderly lanceolate, the lateral margins in dorsal aspect at most only slightly dilated preapically; dorso-lateral margins of terebra apically with a series of strong spines. ... Antennae almost uniformly yellowish red, at most the scape and pedicel black, never whitish at the middle and black or brownish black at both extremities. ... Body much paler, more richly pale-marked. ... Abdomen more or less more richly dull marked; preapical tooth of the tarsal claw subperpendicular to the main axis, moderately long; vein 1A in the hind wing well developed. ... Vertex entirely black, or medially with a very broad, transversely rectangular or trapezoidal, black band, of which the median breadth at least as broad as POL + POL; median vertical furrow never deep and distinct; abdominal tergites I-II and VII-VIII (excluding anterior margin of the I and sometimes also posterior margin of the II or of the VIII) uniformly yellow, while the III-VI uniformly black. ... Hairs on head and thorax of usual length, those lying between antennal insertions, for instance, are scarcely longer than a-half the scape; abdominal tergite II entirely yellow. ... Terebra black or piceous, distinctly shorter than the forewing (ca 1.14-1.37); abdominal tergite IX (excluding cornus) entirely black or nearly so, at least with the precornal basin entirely black, at most yellowish brown on anterio-lateral areas in dorsal aspect and discal areas in lateral aspect; the VIII usually posteriorly black; wings almost clear hyaline, basally and costally not rich amber in color. ... Abdominal tergite VIII posteriorly more or less darkened, the IX in lateral aspect almost entirely black. ... Abdominal tergite VIII posteriorly only narrowly black on the median portion, exterior surface of the tibia III with the apical fourth distinctly darkened. 13-27 mm" (Maa 1949)

U. gigas tibetanus
"[Females] Cornus relatively slenderer and longer (the post-cercal length at least thrice as long as the maximum breadth), acuminate or slenderly lanceolate, the lateral margins in dorsal aspect at most only slightly dilated preapically; dorso-lateral margins of terebra apically with a series of strong spines. ...Antennae almost uniformly yellowish red, at most the scape and pedicel black, never whitish at the middle and black or brownish black at both extremities. ... Body much paler, more richly pale-marked. ... Abdomen more or less more richly dull marked; preapical tooth of the tarsal claw subperpendicular to the main axis, moderately long; vein 1A in the hind wing well developed. ... Vertex entirely black, or medially with a very broad, transversely rectangular or trapezoidal, black band, of which the median breadth at least as broad as POL + POL; median vertical furrow never deep and distinct; abdominal tergites I-II and VII-VIII (excluding anterior margin of the I and sometimes also posterior margin of the II or of the VIII) uniformly yellow, while the III-VI uniformly black. ... Hairs on head and thorax exceptionally long, for instance, those lying between antennal insertions are even longer than the scape; abdominal tergite II posteriorly mostly black, the VIII entirely yellow, the IX mostly yellow, at least the precornal basin entirely so; terebra black or piceous, and shorter than the forewing (ca. 10:13)" (Maa 1949)

Appendix D. Threatened or endangered plants potentially affected by *Urocerus gigas*.

Urocerus gigas (exotic forms) have the potential to adversely affect threatened and endangered plant species. However, because *U. gigas* 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. Because the indiginous species is considered a secondary pest, it is unknown whether the introduction of exotic subspecies of *U. gigas* would further impact threatened and endangered hosts in the US. From available host records, *U. gigas* is known to develop only on hosts belonging to the family Pinaceae [see 'Host Specificity']. 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 U.S. that are potential hosts for *Urocerus gigas*.

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Abies sp., *A. alba, A. fabri*, *A. grandis*, *A. nephrolepis*, *A. procera*	*Abies balsamea*	balsam fir		CT (E)
	A. fraseri	Fraser fir		TN (T)
Larix sp., *L. decidua*, *L. gmelinii*	*Larix laricina*	tamarack		IL (T) MD (E)
Picea sp., *P.abies*, *P. asperata*, *P. koraiensis*, *P. sitchensis*	*Picea rubens*	red spruce		NJ (E)
Pinus sp., *P. nigra*, *P. radiata*, *P. sylvestris*	*Pinus banksiana*	jack pine		IL (E) NH (T) VT (T)
	P. echinata	shortleaf pine		IL (E)
	P. pungens	Table Mountain pine		NJ (E)
	P. resinosa	red pine		CT (E) IL (E) NJ (E)
	P. virginiana	Virginia pine		NY (E)

1. E= Endangered; T=Threatened

Appendix E. Biology of *Urocerus gigas*

Population phenology

Urocerus gigas is closely associated with a basidiomycetous wood decay fungus, *Amylostereum chuilletii* (Morgan 1968, Talbot 1977, Vasiliauskas et al. 1998, Slippers et al. 2002, Smith and Schiff 2002). In this symbiotic relationship, the fungus is carried to new tree hosts in specialized mycangia of the adult female, and then is deposited under the bark or cambial layer when the female bores into the tree to lay eggs. Conifers susceptible to attack by this fungus tend to have wood with certain lipids, low oleoresin pressure and relatively low moisture, all of which are favorable for the growth of *Amylostereum* (Morgan 1968). The fungus is propagated and breaks down cellulose in the tree host with digestive enzymes, which provides a source of nutrition for the developing larvae. Whether the developing siricids actually feed on the digested wood products or solely on the fungus is not well undertood (Morgan 1968, Smith and Schiff 2002). Female larvae are thought to have a specialized organ that play a role in scraping fungal hyphae into the mycangia (Morgan 1968, Smith and Schiff 2002).

One generation (egg to adult) occurs every 2-3 years under favorable conditions, and up to 5-6 years when the climate is unfavorable. Siricid activity is greatest during warm and sunny conditions with low relative humidity, and decreases during unfavorable conditions (Hanson 1939, Morgan 1968, Kolk and Starzyk 1996). According to Chrystal (Chrystal 1928), *U. gigas* has the ability to bore into and deposit eggs into large, more mature trees, due to the length of its ovipositor. In Poland, adult flight occurs in sunny conditions between late June – early August, reaching a peak in July. In Great Britain, the flight period was observed between June and September – early October (Chrystal 1928).

Pest attack and fluctuations in population density have been strongly correlated to destruction of forested areas following natural distasters, including forest fires or other severe weather events (Mihalciuc et al. 2001). In the Western US, females are attracted to fire scarred trees following forest fires (Smith and Schiff 2002).

Stage specific biology

Adult

Adults emerge within a period of 3-4 weeks in spring and summer (Chrystal 1928, Morgan 1968). Females typically lay eggs singly with tube-like ovipositor in tunnels or chambers constructed in the mid to lower portions of trunks (below 3 meters) of weakened or dying conifers (Chrystal 1928, Wang et al. 2001, Smith and Schiff 2002). With a saw-like motion of toothed setae, females construct one or more oviposition tunnels sequentially, with each tunnel completed within 8-9 minutes (Chrystal 1928). If the site is unfavorable, eggs may not be deposited (Chrystal 1928). Females have been observed ovipositing in conifer logs and sawn timber (Chrystal 1928, Hanson 1939). Males have been observed occasionally in small groups in tree tops, but are otherwise seldom seen (Smith and Schiff 2002). According to Smith and Schiff, males are commonly reared for study (Smith and Schiff 2002).

Similar to other woodboring insects, *U. gigas* has a symbiotic relationship with a wood decay fungi. *Urocerus* is associated with two of only a few known species belonging to the genus *Amylostereum*, *A. chailletii* and *A. laevigatum* which occur in the US. *A. areolatum*, which is associated with *Sirex* spp., is not currently known to occur in the US (Farr et al. 1989, Smith and Schiff 2002) (note: the *Sirex noctilio*- *A. areolatum* complex was introduced to the southern hemisphere and is presumed the causal agent in white rot fungus which is considered pathogenic in some conifers). *Amylostereum chailletii* has been isolated from several North American and European *Urocerus* spp, including *U. gigas flavicornis*, and from decaying coniferous hosts but is not considered anything other than a secondary pest complex (Talbot 1977, Vasiliauskas et al. 1998, Slippers et al. 2002, Smith and Schiff 2002). Culturing fungi and examining spore types may help to differentiate *Urocerus* species, as arthrospores are produced by *A. aerolatum* and not by *A. chailletii* (Talbot 1977). However, a fungal species may be associated with more than one siricid species (Slippers et al. 2002).

Egg
In Poland, a female lays between 2-8 eggs singly into wood of the conifer host, producing a maximum of up to 350 eggs (Kolk and Starzyk 1996).

Larva
Eggs hatch within 2-4 weeks and larvae proceed to bore further into the softwood of the host (Chrystal 1928, Kolk and Starzyk 1996). At first, boring occurs at a right angle to the egg tunnel, followed by deep penetration into the conifer trunk. Larvae produce sawdust and frass packed tunnels up to 40 cm in length and 0.7 cm wide (Kolk and Starzyk 1996). Larvae return to pupate within approximately 1 cm of the surface, and build pupal chambers measuring approximately 7-10 x 12-30 mm (Kolk and Starzyk 1996) Between one to three years or more are required for development prior to pupation (Morgan 1968, Kolk and Starzyk 1996, Smith and Schiff 2002). Near the end of their development, larvae overwinter in pupal chambers (Hanson 1939, Kolk and Starzyk 1996).

Pupa
Pupation occurs between late spring and summer, followed by emergence of new adults. Exit holes measure between 4-7mm in diameter (Morgan 1968, Kolk and Starzyk 1996).