Mini Risk Assessment
Pink Gypsy Moth, *Lymantria mathura* Moore
[Lepidoptera: Lymantriidae]

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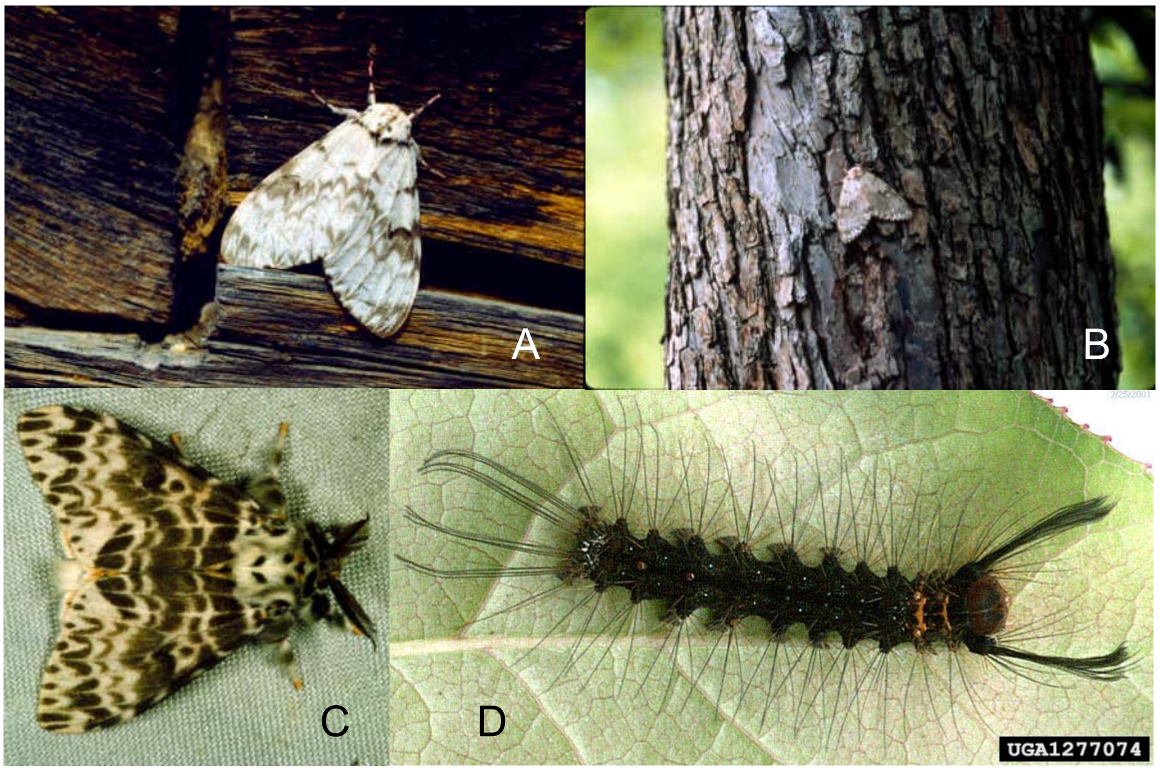

Figure 1. *Lymantria mathura*: (A&B) Adult female with pink hind wings; (C) adult male with yellow hind wings ; (D) larva on foliage of deciduous host. Images not to scale. [Images (A-C) courtesy of W. Wallner, USDA Forest Service, http://www.inspection.gc.ca/english/sci/surv/data/lymmate.shtml (D) David Mohn, www.forestryimages.org]

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Introduction
The pink or rosy gypsy moth, *Lymantria mathura* Moore, is a major defoliator of deciduous trees in the Palearctic, primarily in eastern Asia from India to the Russian Far East (Roonwal 1979b, Baranchikov et al. 1995, CAB 2004, EPPO 2005). Spurred by concerns surrounding *L. mathura*, the US Department of Agriculture-Animal and Plant Health Inspection Service, USDA Forest Service and Russian counterparts have developed an early warning system to alert US pest officials about periods of increased insect activity and prevent the introduction of this insect (Anon. 2001). US officials are also alerted when New Zealand finds a Russian freighter to be infested with this insect (USDA 2001b).

Risks associated with *L. mathura* have been evaluated previously. In the Exotic Forest Pest Information System, *L. mathura* was considered to pose a very high risk to North America forests relative to other forest pests and pathogens, and this assessment was given with a very high degree of certainty (Rosovsky 2001). Gninenko and Gninenko (2002) proposed a scoring system to evaluate the relative propensity of different lymantriids to be moved by international shipping. These authors suggest that *L. mathura* is less likely than *L. dispar* or *L. monacha* to be moved by shipping, but it is more likely to be moved than 26 other species of Lymantriidae. Limited biological information about lymantriids of the Russian Far East, including *L. mathura*, complicates the assessment of risk (Gninenko and Gninenko 2002). The purpose of this mini-pest risk assessment is to further evaluate several factors that contribute to risks posed by *L. mathura* and apply this information to the refinement of sampling and detection programs.

1. **Ecological Suitability. Rating: Medium.** *Lymantria mathura* is present throughout much of Asia. Appendix A provides a detailed list of the reported worldwide distribution of this insect. In general, *L. mathura* occurs in cool, temperate to warm climates with varying amounts of seasonal rainfall, and dry periods. The currently reported distribution of *L. mathura* suggests that the pest may be most closely associated with biomes characterized as: temperate broadleaf and mixed forests; temperate coniferous forests; tropical and subtopical dry broadleaf forests; and tropical and subtropical moist broadleaf forests. Of these biomes, only tropical and subtopical dry broadleaf forests do not occur in the US.

Consequently, we estimate that approximately 38% of the continental US would have a suitable climate for *L. mathura* (Fig. 2). See Appendix A for a more complete description of this analysis.

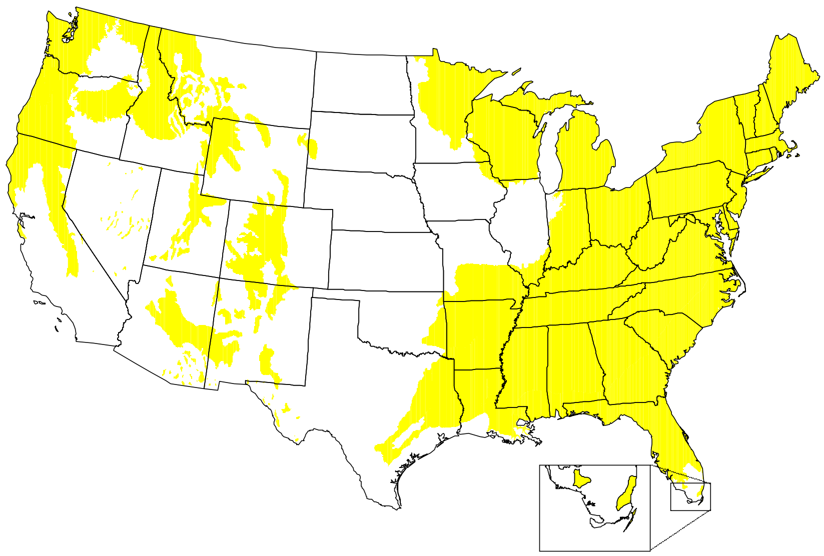

Figure 2. Predicted distribution (yellow) of *Lymantria mathura* in the contiguous US.

Figure 2 illustrates where *L. mathura* 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: Low/High.** *Lymantria mathura* is not host specific; it is a polyphagous pest of taxonomically diverse deciduous trees that are common across the US (Appendix B). *L. mathura* reportedly feeds on more than 45 genera in 24 families. Table 1 summarizes hosts reported in the literature. Numerous accounts of preferential feeding are reported and vary widely [see Table 1 below, and Appendix E for more information on host selection] (Roonwal 1979b, Baranchikov et al. 1995).

Table 1. Host plants of *Lymantria mathura*:

Hosts	**References**
alder (*Alnus* sp.)	(Wallner et al. 1995, Yamazaki and Sugiura 2004)
apple (*Malus* sp.)	(Mohn 1993, Pucat and Watler 1997, Zlotina et al. 1998, Gries et al. 1999, CAB 2004, Yamazaki and Sugiura 2004)
apple, Chinese (*Malus prunifolia* (="*M. "pruniflora*"))[1, 2]	(Baranchikov et al. 1995)
arjuna (*Terminalia arjuna*) [3]	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
ash (*Fraxinus* sp.)	(Rosovsky 2001, CAB 2004)
asna (*Terminalia elliptica* (= *Terminalia tomentosa*))	(Roonwal 1979b)
Australian red-cedar (*Toona ciliata* (= *Cedrela toona*))	(Roonwal 1979b)
beech (*Fagus* sp.)	(Mohn 1993, Pucat and Watler 1997, Zlotina et al. 1998, Gries et al. 1999, Rosovsky 2001, CAB 2004)
beech, American (*Fagus grandifolia*)[2]	(Zlotina et al. 1998)
beech, European (*Fagus sylvatica*)[2]	(Zlotina et al. 1998)
beleric (*Terminalia belerica*)	(Roonwal 1979b)
Bengal kino (*Butea monosperma*)	(Roonwal 1979b)
birch (*Betula* sp.)	(Baranchikov et al. 1995, Wallner et al. 1995, Zlotina et al. 1998, Rosovsky 2001, CAB 2004)
blackboard tree (*Alstonia scholaris*)	(Roonwal 1979b)
Buddhas coconut (*Pterygota alata* (=*Sterculia alata*))	(Roonwal 1979b)
"Catania" sp.[1]	(Lee and Lee 1996)
Ceylon tea (*Elaeodendron* (= "*Eeodendron*") *glaucum*)[1]	(Roonwal 1979b)
cherry (*Prunus* sp.)	(Pucat and Watler 1997, Zlotina et al. 1998, CAB 2004)
cherry, wild Himalayan (*Prunus cerasoides* (= *Prunus puddum*))	(Roonwal 1979b)
chestnut (*Castanea* sp.)	(Zhang 1994, Lee and Lee 1996, Rosovsky 2001, CAB 2004)
chestnut, Chinese hairy (*Castanea mollissima*)	(Rosovsky 2001, CAB 2004)
chestnut, European (*Castanea sativa*)	(Roonwal 1979b)
china berry tree (*Melia azedarach*)	(Roonwal 1979b)
cottonwood (*Populus* sp.)	(Baranchikov et al. 1995, Zlotina et al. 1998)

Hosts	References
crabapple, Manchurian (*Malus mandshurica* ([="*mandjurica*"))[1]	(Baranchikov et al. 1995)
dhaoda (*Anogeissus lalifolia*)	(Roonwal 1979b)
Douglas-fir (*Pseudotsuga menziesii*)	(Rosovsky 2001, CAB 2004)
duabanga (*Duabanga grandiflora* (= *Duabanga sonneratioides*))	(Roonwal 1979b)
elm (*Ulmus* sp.)	(Baranchikov et al. 1995, Zlotina et al. 1998)
elm, Japanese (*Ulmus davidiana*)	(Yurchenko and Turova 2002)
fir (*Abies* sp.)	(Rosovsky 2001, CAB 2004)
fir, Manchurian (*Abies nephrolepis* (="*nephroletis*"))[1, 2]	(Zlotina et al. 1998)
Formosan sweetgum (*Liquidambar formosana*)	(Mohn 1993, Zhang 1994, Rosovsky 2001, CAB 2004)
Grewia sapinda	(Roonwal 1979b)
haldu (*Haldina cordifolia* (= *Adina cordifolia*))	(Roonwal 1979b)
hickory (*Carya* sp.)	(Rosovsky 2001, CAB 2004)
hollock (*Terminalia myriocarpa*)[3]	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
Indian banyan (*Ficus benghalensis*)	(Roonwal 1979b)
kadam (*Neolamarckia cadamba* (= *Anthocephalus cadamba*))	(Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
kamala (*Mallotus philipinensis*)	(Roonwal 1979b)
larch (*Larix* sp.)	(Wallner et al. 1995, Rosovsky 2001, CAB 2004)
leechee (*Litchi chinensis*)	(Singh 1954, Roonwal 1979b, Rosovsky 2001, CAB 2004)
linden, Manchurian (*Tilia mandshurica*)	(Zlotina et al. 1998)
longaan (*Dimocarpus longan*)	(Mohn 1993)
Manchurian nut	(Yurchenko and Turova 2002)
mango (*Mangifera indica*)	(Singh 1954, Browne 1968, Roonwal 1979b, Mohn 1993, Pucat and Watler 1997, Zlotina et al. 1998, Rosovsky 2001, CAB 2004)
monkey-jack tree (*Artocarpus lacucha* (= *Artocarpus lakoocha*))	(Roonwal 1979b)
mulberry, white (*Morus alba*)	(Roonwal 1979b)
oak (*Quercus* sp.)	(Odell et al. 1992, Mohn 1993, Wallner et al. 1995, Lee and Lee 1996, Pucat and Watler 1997, Zlotina et al. 1998, Gries et al. 1999, Rosovsky 2001, CAB 2004, Yamazaki and Sugiura 2004)

Hosts	References
oak, banj (*Quercus leucotrichophora* (= *Quercus incana*)) [3]	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
oak, chestnut (*Quercus prinus*) [2]	(Zlotina et al. 1998, Gries et al. 1999)
oak, Chinese cork (*Quercus variabilis*) [2]	(Zlotina et al. 1998)
oak, Daimyo (*Quercus dentata*)	(Wileman 1918)
oak, Japanese evergreen (*Quercus acuta*)	(Wileman 1918)
oak, Konara (*Quercus serrata* (=*Q. glandulifera*)) [3]	(Wileman 1918, Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
oak, Mongolian (*Quercus mongolica*)	(Baranchikov et al. 1995, Zlotina et al. 1998, Rosovsky 2001, Yurchenko and Turova 2002, CAB 2004)
oak, ring-cup (*Quercus glauca*)	(Funakoshi 2004)
oak, white (*Quercus alba*) [2]	(Zlotina et al. 1998)
pear (*Pyrus* sp.)	(Pucat and Watler 1997, Zlotina et al. 1998, CAB 2004)
pine (*Pinus* sp.)	(Lee and Lee 1996, Rosovsky 2001, CAB 2004)
pine, Korean (*Pinus koraiensis*) [2]	(Zlotina et al. 1998)
pink-cedar (*Acrocarpus fraxinifolius*)	(Roonwal et al. 1962, Roonwal 1979b)
plum, Java (*Syzigium cumini* (=*Eugenia jambolana*)) [3]	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
pongame oil tree (*Millettia pinnata* (=*Pongamia glabra*))	(Roonwal 1979b)
Prunus sp.	(Mohn 1993, Yamazaki and Sugiura 2004)
rayana (*Aphanamixis polystachya* = *Amoora* (="*Ammora*") *rohituka*) [1]	(Roonwal 1979b)
rose, Japanese (*Rosa rugosa*) [2]	(Baranchikov et al. 1995)
sal tree (*Shorea robusta*) [3]	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Browne 1968, Roonwal 1979a, b, Pucat and Watler 1997, Rosovsky 2001, CAB 2004)
sea buckthorn (*Hippophae rhamnoides*)[2]	(Baranchikov et al. 1995)
sumac (*Rhus* sp.)	(Gries et al. 1999)
Terminalia pyrifolia	(Roonwal 1979b)
walnut (*Juglans* sp.)	(Rosovsky 2001, CAB 2004)
walnut, Manchurian (*Juglans mandshurica*)	(Baranchikov et al. 1995, Zlotina et al. 1998)
waxtree, Japanese (*Toxicodendron succedaneum* (=*Rhus succedanea*))	(Wileman 1918)

Hosts	References
willow (*Salix* sp.)	(Zlotina et al. 1998, Rosovsky 2001, CAB 2004)
willow, crack (*Salix fragilis*) [2]	(Baranchikov et al. 1995)
zelkowa (*Zelkowa* sp.)	(Gries et al. 1999)
zelkowa, Japanese (*Zelkowa acuminata*)	(Wileman 1918)

1. Likely mispelling in literature, or unrecognized name.
2. Experimental hosts (Baranchikov et al. 1995, Zlotina et al. 1998)
3. In 1954, following an outbreak in the New Forest Area (Western Sub-Himalayas), 185 tree species were observed with egg masses, 22 of these species were defoloiated, and 6 species (noted in the table) were heavily defoliated. *L. mathura* has historically demonstrated food preferences; depending on host availability some hosts may be chosen or avoided in the presence of more preferred species (Roonwal 1979b).

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

3. **Survey Methodology. Rating: High.** Several tools are available to assist with surveys for *L. mathura*. Pheromone-baited traps are particularly useful for regional surveys while visual inspections are necessary for conveyances that may be bringing *L. mathura* into an area. Inspectors should look for egg masses on any products originating from infested areas. Egg masses may be deposited on logs, nursery stock, forest products, or sea containers (Pucat and Watler 1997). Females prefer to deposit eggs on a rough surface (Roonwal 1979b).

Sex pheromones for *L. mathura* have been identified and can be used for detection surveys. Early research (reviewed in Gries et al. 1999) indicated that males of *L. mathura* were attracted to *cis*-7,8-epoxy-2-methyloctadecane and 2-methyl-*Z*7-octadecene (Odell et al 1992). Males also demonstrated elctrophysiological responses to (*Z*3,*Z*6,*Z*9)-nonadecatriene and (9*S*,10*R*)-9,10-epoxy-*Z*3,*Z*6-nonadecadiene in extracts from abdominal tips of *L. mathura* females (Oliver et al. 1999). Subsequent research revealed that major sex pheromone components include a blend of (9*R*,10*S*)-*cis*-9,10-epoxy-*Z*3,*Z*6-nonadecadiene (named (+)-mathuralure) and (9*S*,10*R*)-*cis*-9,10-epoxy-*Z*3,*Z*6-nonadecadiene (named (-)-mathuralure) in a 1:4 ratio (Gries et al. 1999). Neither component is attractive alone (Gries et al. 1999). Khrimian et al. (2004) explain that the enantiomer (-)-mathuralure is equivalent to the compound identified by Oliver et al. (1999) and provide a detailed protocol for the synthesis of (+)-

Figure 3. Delta trap used for detecting lymantriids. [Image from USDA APHIS PPQ Archives, www.forestpests.org]

mathuralure and (-)-mathuralure in a 4:1 ratio. The pheromone is most effectively deployed using PVC-coated string dispensers with 64 µg pheromone per cm (Khrimian et al. 2004). Traps baited with (+)-disparlure will also attract male *L. mathura* (Odell et al. 1992).

Pheromone lures have been used with Delta sticky traps (Fig. 3, Gries et al. 1999) or 3.8-L milk carton traps (Odell et al. 1992). Traps are generally hung 1.5-2 m [ca. 5-6.5 ft] above ground (Odell et al. 1992, Gries et al. 1999). To improve diffusion of the pheromone, traps have been suspended 0.6 m [2 ft] from the trunk of a tree on wooden stakes nailed to the tree (Odell et al. 1992). For research purposes, traps were placed 20-25 m apart (Gries et al. 1999), but standard protocols for detection of gypsy moth in uninfested states should be appropriate.

Wallner et al. (1995) evaluated several light sources (e.g., diffuse coated sodium lamps; phosphor-coated, high-pressure mercury lamps, and blacklight lamps) and found that *L. mathura* were most attracted to blacklight. However, light traps are generally considered ineffective and impractical for regional monitoring of this insect (CAB 2004).

4. **Taxonomic Recognition. Rating: High.** *Lymantria mathura* is not likely to be confused with other lymantrrids, particularly if a specimen is an adult or late instar larva (EPPO 2005). Eggs or neonates are incredibly difficult to distinguish, and molecular tools are being developed to aid with identification (Armstrong et al. 2003). *Lymantria mathura* might be confused with *L. monacha* (also exotic, not known to occur in the US) or *L. dispar*. See Appendix C for a more complete description of the morphology of *L. mathura*.

5. **Entry Potential. Rating: Low.** Officers with USDA-APHIS and Department of Homeland Security did not report an interception of *L. mathura* at US ports of entry from 1985-2004 (USDA 2005). Two specimens, one *L. dispar* and one "*Lymantria* sp.," were noted from infested sea containers in Wilmington, NC and Seattle, WA, respectively (USDA 2005). The container infested with *L. dispar* may have come from Germany, although the record questions this origin, while the container with *Lymantria* sp. came from the Russian Federation. These records may not reflect the true potential for entry of *L. mathura*. Lymantriids can be extremely difficult to identify, particularly as eggs and larvae. Interceptions of "Lymantriidae; species of" were reported much more frequently. Unidentified lymantriids were intercepted at least 112 times between 1985-2004 (incomplete records complicate teh accuracy of this count) (USDA 2005); on average, 5.6 (±0.7 standard error of the mean) interceptions were reported annually. Most interceptions were associated with permit cargo (38%), international airline baggage (38%), and general cargo (17%) and were most commonly reported within the continental US from Los Angeles, CA (31%), JFK International airport, NY (25%), Dallas, TX (4%), Miami, FL (4%), and Long Beach, CA (4%). 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.

Remarkably, a substantial number of unspecified lymantriid interceptions (USDA 2005) were associated with cut flowers, for example *Oncidium* sp. (24%), Orchidaceae (7%), *Dendrobium* sp. (5%), and *Astilbe* sp. (2%). These plants are not known hosts for *L. mathura*, and it is possible that insects were strictly hitchhikers. However, only ~16% of the infested items came from a country known to have *L. mathura*. Thus, it seems unlikely that all or even most of the interceptions would have been of *L. mathura*.

Even if all unidentified specimens of Lymantriidae had been *L. mathura*, this insect would still have an apparent low potential for entry, relative to other exotic insects. Although we assign a low rating to the potential for entry, 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 the rating.

6. **Destination of Infested Material. Rating: Medium.** When an actionable pest is intercepted, officers ask for the intended final destination of the conveyance. The shipments intercepted with *L. dispar* and "*Lymantria* sp." were destined for North Carolina and Oregon, respectively (USDA 2005) Materials infested with "Lymantriidae" were destined for 17 of the contiguous United States. The most commonly reported destinations were California (38%), New York (24%), Texas (6%), Florida (6%), Georgia (3%), Illinois (3%), and Massachusetts (3%) (USDA 2005). Some portion of each state identified as the intended final destination has a climate and hosts that would be suitable for establishment by *L. mathura*, yet probably very few of these interceptions involved *L. mathura*. Consequently, available data do not permit a confident evaluation of this element.

7. **Potential Economic Impact. Rating: High.** *Lymantria mathura* larvae are gregarious defoliators, able to consume whole leaves and sometimes avoid tough veins in older foliage growth. Larvae may also feed on flowers and tender young shoots (Browne 1968, Roonwal 1979b). Damage of this nature can result in decline in overall growth and development, a reduction in yield or total crop loss (fruit crops), or even tree death (Singh 1954, Roonwal 1979b).

   In India, *L. mathura* is an economically important forest pest, which defoliates *Shorea robusta*, and several other deciduous forest and fruit tree species [see 'Host Specificity']. Roonwal (1953, 1962, 1979b) states that outbreaks are periodic, and prior to the worst epidemic of this pest on record in India during 1953, *L. mathura* was considered unimportant. In India, this severe outbreak occurred in Uttar Pradesh in the New Forest area of Dehra Dun (approximately 610 m in altitude, in the western sub-Himalayas). The outbreak extended from the western sub-Himalayas to West Bengal, encompassing several adjacent forest divisions. In the Russian Far East, there has been only one reported outbreak in the Primorie region, where losses amounted to hundreds of hectares of deciduous forests (Baranchikov et al. 1995). Damage to chestnut resulted from an outbreak of *L. mathura* in areas of Kyonggi province, Korea (Lee and Lee 1996).

Establishment of *L. mathura* in the US could also adversely impact trade. This insect has been proposed as an A2 quarantine pest in Europe, a status reflecting its limited presence (EPPO 2005). Potentially infested products within the US could become the focus of domestic or international quarantines.

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

   Because *L. mathura* is known to adversely impact forest productivity and cause tree mortality with repeated outbreaks, this insect has the potential to directly and indirectly alter the structure and function of forests. *Lymantria mathura* has the potential to directly affect forest composition because it has a broad host range and feeds on foliage of primarily deciduous tree species [see 'Host Specificity']. Indirect effects stem from the arrival and establishment of secondary organisms/pathogens, such as opportunistic fungi.

   Synthetic insecticides are an option, but in many natural settings, complex terrain limits the feasibility of this option, especially over large areas. However, as has been observed with *L. dispar*, formulations of endotoxin from *Bacillus thuringiensis* (e.g, *Bt-k*) may be applied aerially to localized populations (Myers and Hosking 2002). *Bt* is generally considered host specific (Lacey and Siegel 2000), but some exceptions have been noted especially after repeated applications (Lacey and Siegel 2000, Boulton 2004). Biological control is a much more likely option (Rosovsky 2001). Previous experience with gypsy moth demonstrates that predators, parasitoids, and pathogens might be introduced. In previous years, generalist agents (e.g., *Compsilura concinata*) were introduced, often with significant impacts on non-target species (reviewed in Syrett 2002). Current protocols for the screening of agents limit the likelihood of these severe impacts to non-target species (reviewed in Hoddle and Syrett 2002).

   Lymantria mathura may also jeopardize threatened or endangered plants. Appendix D summarizes state and federally listed threatened or endangered plant species (USDA 2001a) found within plant genera known to be hosts (or potential hosts) for *L. mathura*. Plants listed in Appendix D might be suitable hosts for *L. mathura*, and thus, could be adversely affected by this insect.

9. **Establishment Potential. Rating: Medium.** Large areas of the United States are predicted to have a suitable climate for establishment of *L. mathura*, but this area is only moderate compared with the entire area of the country. The host

status of many plants is largely inferred from the genera of plants attacked in Asia. Additional research is needed to confirm the susceptibility of US species. If host associations at the genus level continue to hold, several plants in the US would be threatened. Many of these hosts naturally occur over broad geographic areas and in relatively high densities. Thus, the potential for establishment seems high, but our confidence in this assessment is, at best, moderate.

See Appendix E for a more detailed description of the biology of *L. mathura*.

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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 *Lymantria mathura*:

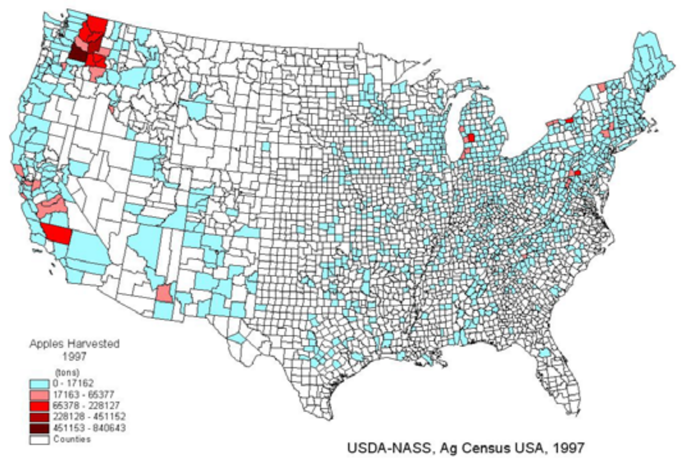
Locations	**References**
Asia (southeast)	(Roonwal 1979b, Baranchikov et al. 1995)
Bangladesh	(Rosovsky 2001, CAB 2004)
China	(Wileman 1918, Zhang 1994, Pucat and Watler 1997, Gries et al. 1999, Rosovsky 2001, Khrimian et al. 2004)
China (Beijing)	(Lewis et al. 1984)
China (Dunhua)	(Lewis et al. 1984, Odell et al. 1992)
China (Heilogjiang Province)	(CAB 2004)
China (Heilongjiang Province - Menjiagang)	(Lewis et al. 1984, Odell et al. 1992)
China (Hong Kong)	(Mohn 1993, Rosovsky 2001, CAB 2004)
China (Jiaohe)	(Lewis et al. 1984)
China (Jingpo Hu)	(Lewis et al. 1984)
China (Manchuria)	(Wileman 1918, Pucat and Watler 1997)
China (north)	(Zlotina et al. 1998)
China (northeast)	(Wallner et al. 1995, Rosovsky 2001)
China (Yabuli)	(Lewis et al. 1984)
China (Yunnan)	(Schintlmeister 2004)
India	(Wileman 1918, Browne 1968, Zhang 1994, Pucat and Watler 1997, Zlotina et al. 1998, Gries et al. 1999, Rosovsky 2001, CAB 2004, Khrimian et al. 2004)
India (Assam)	(Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Roonwal 1979a, b)
India (Bengal - northeast)	(Schintlmeister 2004)
India (Darjeeling District - Tukdah)	(Sevastopulo 1947)
India (Darjeeling District)	(Schintlmeister 2004)
India (north)	(Wileman 1918, Beeson 1941, Roonwal 1953, Roonwal et al. 1962, Schintlmeister 2004)

Locations	References
India (northwest)	(Baranchikov et al. 1995)
India (Uttar Pradesh)	(Roonwal et al. 1962, Roonwal 1979a, b)
India (Uttaranchal - Dehra Dun)	(Roonwal 1953, Singh 1954, Roonwal 1979b)
India (Uttaranchal - Doon Valley)	(Roonwal 1979b)
India (West Bengal - Buxa Forest Division)	(Roonwal 1979b)
Japan	(Wileman 1918, Zhang 1994, Pucat and Watler 1997, Zlotina et al. 1998, Gries et al. 1999, Rosovsky 2001, Khrimian et al. 2004, Schintlmeister 2004)
Japan (central)	(Funakoshi 2004)
Japan (Higo Province - Kosadake-machi)	(Wileman 1918)
Japan (Hokkaido Prefecture - Bibai)	(Gries et al. 1999)
Japan (Hokkaido Prefecture - Jozankei)	(Wileman 1918)
Japan (Honshu)	(Schintlmeister 2004)
Japan (Iwate Prefecture - Morioka)	(Gries et al. 1999)
Japan (Iyo Province - Ohoki)	(Wileman 1918)
Japan (Kishu Province - Koyasan)	(Wileman 1918)
Japan (Kyushu)	(Wileman 1918)
Japan (Musashi Province - Kawai, Dzushi)	(Wileman 1918)
Japan (Musashi Province - Tokyo)	(Wileman 1918)
Japan (Nagahama)	(Schintlmeister 2004)
Japan (Osaka Prefecture - Sakai City)	(Yamazaki and Sugiura 2004)
Japan (Ryukyu Islands)	(Wileman 1918)
Japan (Settsu Province - Kobe)	(Wileman 1918)
Japan (Shinano Province - Karuizawa)	(Wileman 1918)
Japan (Yokohama)	(Wileman 1918)
Kashmir	(Wileman 1918)
Korea	(Wileman 1918, Rosovsky 2001)
Korea (Kyonggi Province - Jinjung-Ri)	(Lee and Lee 1996)
Korea (Kyonggi Province - Songchon-Ri)	(Lee and Lee 1996)
Korea, Republic of	(CAB 2004)
Kurile Islands	(Wileman 1918)
Myanmar (formerly Burma)	(Roonwal 1979b)
Pakistan	(Browne 1968, Pucat and Watler 1997, Rosovsky 2001)
Russia	(Khrimian et al. 2004)
Russia (Amur)	(Zolotarenko and Dubatolov 1998)
Russia (eastern Siberia)	(Wileman 1918)
Russia (eastern)	(Gries et al. 1999)
Russia (Far East - Yakolevka)	(Pfeifer et al. 1995)
Russia (Far East)	(Baranchikov et al. 1995, Wallner et al. 1995, Zlotina et al. 1998, Anon. 2001, Rosovsky 2001, CAB 2004)
Russia (Nakhodka)	(Anon. 2001)
Russia (Primorsky Krai - Kavalerovo)	(Zlotina et al. 1998, Zlotina et al. 1999)
Russia (Primorsky Krai - Mineralni)	(Wallner et al. 1995)
Russia (Primorye Region - Barabash)	(Oliver et al. 1999)

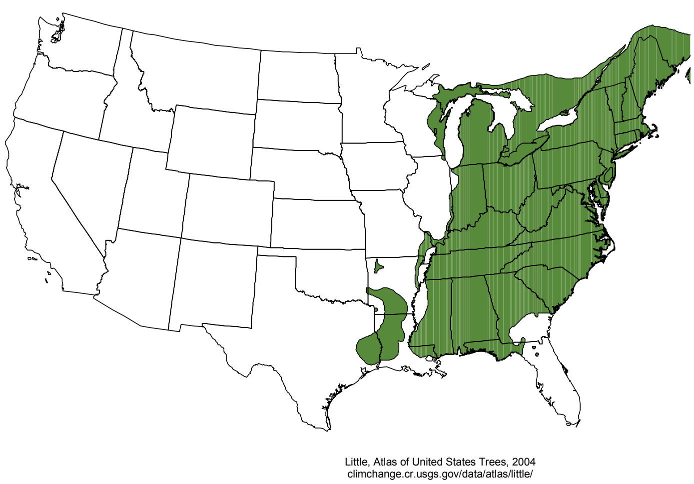
Locations	**References**
Russia (Primorye Region)	(Baranchikov et al. 1995, Zolotarenko and Dubatolov 1998)
Russia (Siberia)	(CAB 2004)
Russia (Vladivostok)	(Oliver et al. 1999, Anon. 2001, Rosovsky 2001)
Russia (Vostochny)	(Anon. 2001)
Taiwan	(Zhang 1994, Pucat and Watler 1997, Gries et al. 1999, Rosovsky 2001, CAB 2004, Schintlmeister 2004)
Taiwan (Puli-Wushe)	(Schintlmeister 2004)
temperate broadleaf and mixed forest[2]	(Schintlmeister 2004)
temperate coniferous forest[2]	(Schintlmeister 2004)
tropical and subtropical dry broadleaf forest[2]	(Schintlmeister 2004)
tropical and subtropical moist broadleaf forest[2]	(Schintlmeister 2004)
United States of America[1] (N. America; west coast ports)	(Baranchikov et al. 1995, CAB 2004)

1. Intercepted but not established (Baranchikov et al. 1995, CAB 2004).
2. Refer to map by Schintlmeister for general locations; no scale provided (Schintlmeister 2004).

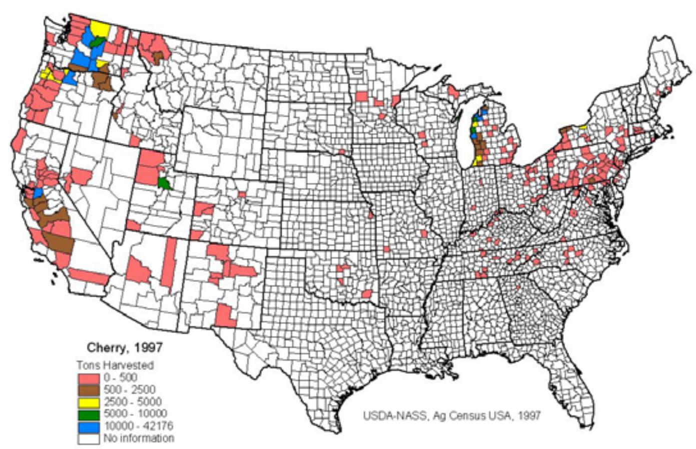
Appendix B. Host distribution (partial) for *Lymantria mathura*. The host status of all <u>species</u> has not necessarily been confirmed.



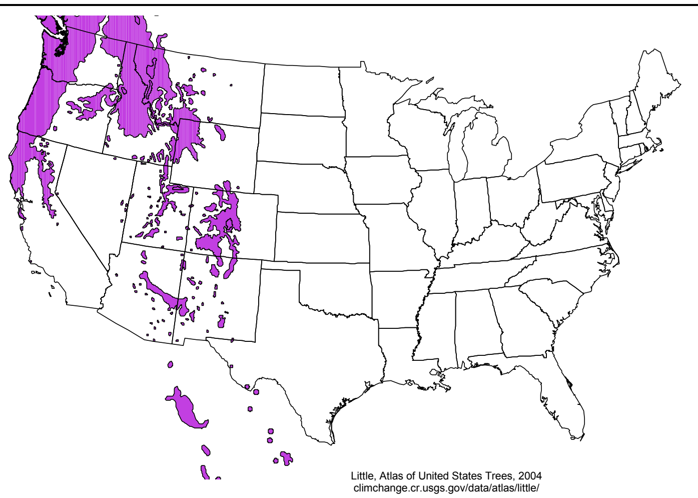
Map 1. Apple (*Malus domestica*)



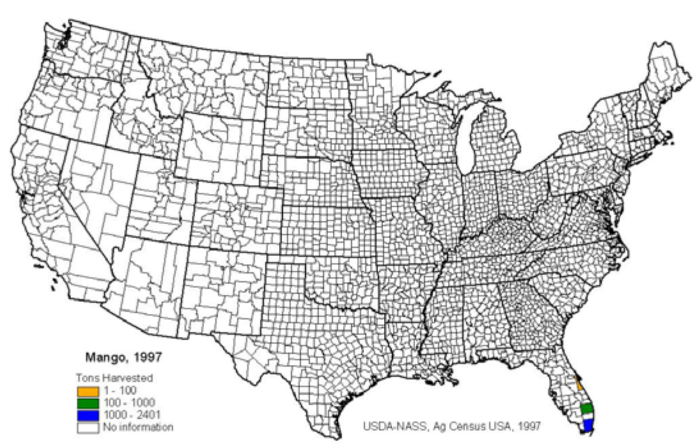
Map 2. American beech (*Fagus grandifolia*)



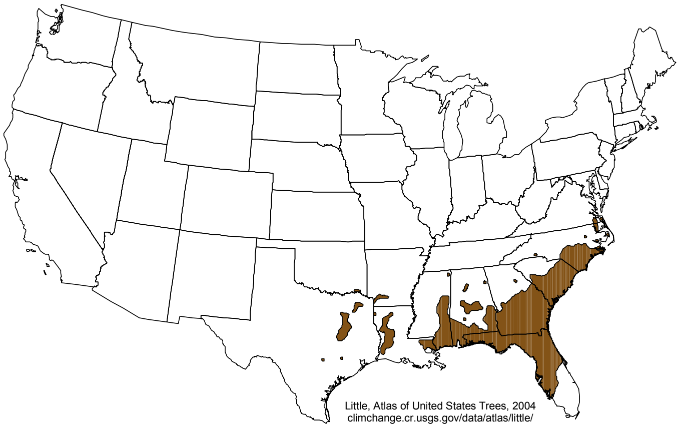
Map 3. Cherry (*Prunus avium*)



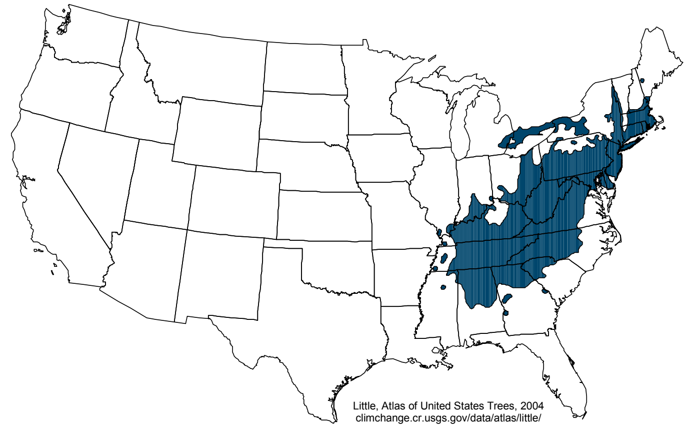
Map 4. Douglas fir (*Pseudotsuga menziesii*)



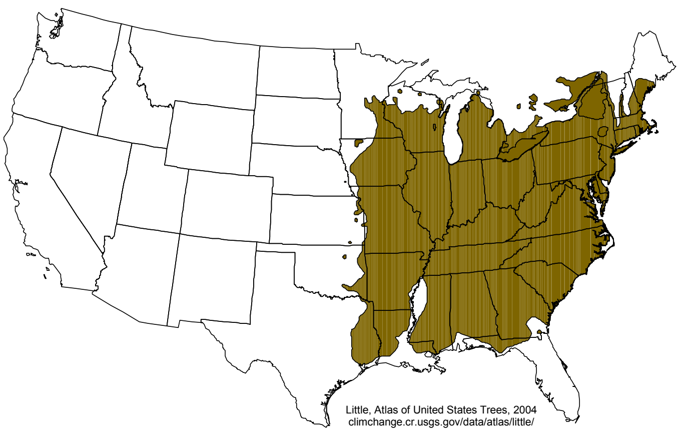
Map 5. Mango (*Mangifera indica*)



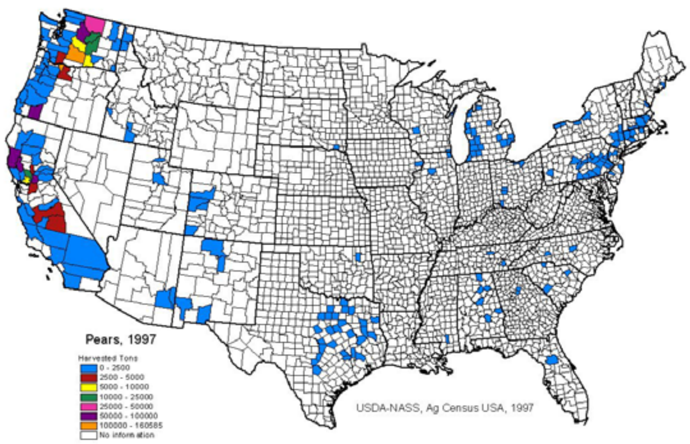
Map 6. Banj oak (*Quercus leucotrichophora*)



Map 7. Chestnut oak (*Quercus prinus*)



Map 8. White oak (*Quercus alba*)



Map 9. Pear (*Pyrus communis*)

Appendix C. Taxonomy and morphology of *Lymantria mathura*

Synonyms

Portheria mathura (Moore)
Ocneria mathura (Moore)
Lymantria aurora Butler
Lymantria fusca Leech
Lymantria mathura aurora Butler

Diagnostic features

For complete accuracy, the following morphological descriptions of *L. mathura* are quoted from Moore (1865) and Roonwal (1979b).

Lymantria mathura

"*Lymantria mathura* Moore (Lepidoptera : Lymantriidae) is a moderate sized moth... There is marked sexual dimorphism in size and colour. The male is smaller (wing expanse male: 35-50mm; female: 75-95mm), with the forewings brown and hindwings yellow. In females the forewings are white with dark markings, and the hindwings pink..."(Roonwal 1979b).

Male

"Upperside-fore wing greyish white, markings brown, with pale-brown interspaces; with two or three black and yellow spots at the base; two transverse subbasal irregular lines, between which is a broad band; a round spot within the cell and a blackish curved streak at its end; three transverse discal lunulated bands, the first broad, the others narrow; a marginal row of spots: hind wing dull yellow, with a blackish discal spot, narrow submarginal maculated band, and a marginal row of small spots. Underside dull yellow, suffused with pale brown between the veins, with darker-brown discal and marginal spots. Thorax white, with yellow and black spots. Abdomen yellow, tuft white, with dorsal, lateral, and a row beneath of black spots. Head at the sides, palpi in front, and legs yellow; palpi above and at the sides, and spots on the legs, black. Antennae brown. Expanse 2¼ inches" (Moore 1865).

"Egg-masses and covering hairs"

Egg masses are laid from ground-level up to about 18 m (60 ft.) of the trunk, but are most dense between the levels of 0.5 to 5 m. They are flat, of an ovoid-elongate or other shape, with irregular edges, and vary in extent from about 0.5 x 1 cm to 6 x 15 cm. From a distance the egg masses are visible as characteristic white, fluffy patches against the dark-coloured bark. Each egg-mass contains about 50 to 1,200 or more eggs which are laid 2 to 4 layers deep directly on the bark. An egg-mass is covered over with a nearly one-millimetre, white thick felt-like covering composed of long, white, silken hairs. (... these hairs are shed by the female from the anal tuft. ...) The hairs are about 800-1200 μ long and 3.1-6.2 μ in diameter; one end is knob-like, the other pointed; a few such hairs are also mixed with the eggs. Freshly laid eggs are rounded, have a flat base, the maximum and minimum diameters varying from 1 .13-1.19 mm and 0.86-0.92 mm respectively ” (Roonwal 1979b).

“Egg-mass after hatching”
After the majority of eggs have hatched, an egg mass presents a changed appearance. Firstly, the hair-covering which has hitherto (for several months in the case of the overwintering eggs) remained pure white, now becomes dull-coloured, a dirty cream, and, in a few cases, with irregular patches of pale buff. Secondly, the hair covering is pierced by numerous rounded holes of varying diameters (c. 0.5-3 mm) through which the newly hatched larvae have escaped. Beneath the thin, hole-pierced, hairy covering, there is a flat, hollow space containing the remnants of eggshells and a few remaining eggs which have not yet hatched” (Roonwal 1979b).

Larvae
“Three main colour forms are found in mature caterpillars, the following proportions being noticed in 1,613 caterpillars examined: grey-white 66 %, intermediate 11 %, and blackish brown 23 %. The details of colour are described below briefly.

Form I (Grey-white) : Ground colour dirty white tinged with grey. Dorsal : Head white with numerous black or brown spots; frons with a longitudinal median black streak; rest of body grey-white, with numerous fine dots forming paired patches. A transverse yellow-brown streak present between pro- and mesothorax, and another in middle of metathorax: abdominal warts blackish; paired lateral papules on abdomen white, with tufts of long white and brown hairs. Long pencil-like plumes of hairs on head and on, end of abdomen black. Ventral: Brownish pink; legs and prolegs brown, the latter with a black patch externally.

Form II (Intermediate): Dorsal: Ground colour pale brown, with a median white patch on abdominal terga 4 and 5. Ventral: As in Form I.

Form III (Blackish brown): Dorsal: Ground-colour dark brown to almost black; numerous black spots visible in brown larvae but merged with ground-colour in darker ones; several small white dots present on abdominal terga 4 to the last, and large white patches on terga 4-6. Ventral: Ashy, suffused with a little pink in the median parts; rest as in Form I.

In the masses of caterpillars on tree trunks the various colour types are mixed on individual trees; this fact has a protective value by making detection by enemies difficult” (Roonwal 1979b).

“The size ... characteristics of the six larval stages are given below briefly...

Stage I. Length 3 mm; head-width 0.5 mm. Generally black dorsally; meso- and metathorax and segment 5 of abdomen brown; legs black; prolegs pale brown with a black patch externally.

Stage II. Length 5 mm; head-width 0.7 mm. Generally black dorsally; meso- and metathorax greyish; last abdominal segment pale brown with blackish tinge; rest as in Stage I.

Stage III. Length 13 mm; head-width 1.5 mm. Head brown; body black above, paler below; thoracic terga with yellow-brown spots; legs black, prolegs brown with a black external patch.

Stage IV. Length 20 mm; head-width 2.5 mm. Head above either black (brown distally) or pale green with black dots; sides brown; body black with white warts; meso- and metathorax with brown stripes anteriorly; legs and prolegs as in Stage III.

Stage V. Length 30-40 mm; head-width 3.5 mm. Head above brown to grey, speckled with black; body black with many minute white spots; pro- and mesothorax with a transverse brown streak at the distal edge; ninth abdominal segment with a pair of prominent dorsal white spots; legs and prolegs reddish brown, the latter with a large black patch externally.

Stage VI. Length 60-85 mm; head-width 5-6 mm. With sexual dimorphism, females being longer (males: 60-65 mm, females: 70-85 mm). Colour pattern similar to Stage V, but in ground-pattern three types recognizable, viz., grey-white, blackish-brown and intermediate (vide infra). Older larvae well "camouflaged" against tree trunks" (Roonwal 1979b).

The pupa

"The pupa is of the 'obtect adecticus type,' and the appendages are firmly soldered to the body. It is buff to dark brown, about 20-36 mm long, and shows sexual dimorphism; the female pupa is paler, larger and heavier than the male, as follows:

> Female: Buff to pale brown. Length (including hair tufts) 30-36 mm; maximum width 10-14 mm. Weight 0.88 gm (average of 18 pupae).
> Male: Very dark chocolate brown, Length (including hair tufts) 15-25 mm; maximum width 6-8 mm. Weight 0.14 gm (average of 53 pupae)" (Roonwal 1979b).

Appendix D. Threatened or endangered plants potentially affected by *Lymantria mathura*.

Lymantria mathura has the potential to adversely affect threatened and endangered plant species. Because *L. mathura* 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, *L. mathura* is known to feed on species within the following families: Anacardiaceae, Apocynaceae, Betulaceae, Celastraceae, Combretaceae, Dipterocarpaceae, Elaeagnaceae, Euphorbiaceae, Fabaceae, Fagaceae, Hamamelidaceae, Juglandaceae, Lythraceae, Malvaceae, Meliaceae, Moraceae, Myrtaceae, Oleaceae, Pinaceae, Roseaceae, Rubiaceae, Salicaceae, Sapindaceae, Tiliaceae, and Ulmaceae. 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) (USDA NRCS 2004). 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 *Lymantria mathura*.

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Abies sp., *A. nephrolepis*	*Abies balsamea*	balsam fir		CT (E)
	A. fraseri	Fraser fir		TN (T)
Alnus sp.	*Alnus incana* ssp. *rugosa*	speckled alder		IL (E)
	A. viridis ssp. *crispa*	mountain alder		MA (T) PA (E)
Betula sp.	*Betula alleghaniensis*	yellow birch		IL (E)
	B. minor	dwarf white birch		ME (E) NY (E)
	B. nana [= *B. glandulosa*]	dwarf birch		ME (E) NH (T) NY (E)
	B. nigra	river birch		NH (T)
	B. papyrifera var. *cordifolia*	mountain paper birch		TN (E)
	B. populifolia	gray birch		IL (E)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	**Common Name**	**Federal**	**State**
	B. pumila	bog birch		IA (T) MA (E) NH (E) NY (T) OH (T)
	B. pumila var. *glandulifera*	bog birch		VT (E)
	B. uber	Virginia roundleaf birch	T	VA (E)
Carya sp.	*Carya aquatica*	water hickory		KY (T)
	C. cordiformis	bitternut hickory		ME (E)
	C. laciniosa	shellbark hickory		MD (E) NY (T)
	C. myristiciformis	nutmeg hickory		NC (T)
	C. pallida	sand hickory		AR (T) IL (E) IN (T)
	C. texana	black hickory		IN (E)
Castanea sp., *C. mollissima, C. sativa*	*Castanea dentata*	American chestnut		KY (E) MI (E)
	C. pumila	chinkapin		KY (T) NJ (E)
Fraxinus sp.	*Fraxinus profunda*	pumpkin ash		MI (T) NJ (E) PA (E)
	F. quadrangulata	blue ash		IA (T) WI (T)
Juglans sp., *J. mandshurica*	*Juglans cinerea*	butternut		TN (T)
Larix sp.	*Larix laricina*	tamarack		IL (T) MD (E)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
Malus sp., *M. mandshurica*, *M. prunifolia*	*Malus angustifolia*	southern crabapple		FL (T) IL (E)
	M. glaucescens	Dunbar crabapple		NY (E)
Morus alba	*Morus rubra*	red mulberry		CT (E) MA (E) MI (T) VT (T)
Pinus sp., P. koraiensis	*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)
Populus sp.	*Populus balsamifera*	balsam poplar		IL (E) OH (E) PA (E)
	P. heterophylla	swamp cottonwood		CT (E) MA (E) MI (E) NY (T)
Prunus sp., *P. cerasoides*	*Prunus alleghaniensis*	Allegheny plum		MD (T) NJ (E) PA (T)
	P. americana	American plum		NH (T) VT (T)
	P. angustifolia	Chickasaw plum		NJ (E)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Prunus geniculata	scrub plum	E	FL (E)
	P. maritima	beach plum		MD (E) ME (E) PA (E)
	P. maritima var. *gravesii*	Grave's plum		CT (E)
	P. nigra	Canadian plum		IA (E)
	P. pumila	sandcherry		AR (T) TN (T)
	P. pumila var. *depressa*	eastern sandcherry		NY (T)
	P. pumila var. *pumila*	Great Lakes sandcherry		NY (E)
	P. pumila var. *susquehanae* [= *P. pumilla var. cuneata*]	Sesquehana sandcherry		OH (T)
Quercus sp., *Q. acuta, Q. alba, Q. dentata, Q. glauca, Q. leucotrichophora, Q. mongolica, Q. prinus, Q. serrata, Q. variabilis*	*Quercus acerifolia*	mapleleaf oak		AR (T)
	Q. bicolor	swamp white oak		ME (T)
	Q. coccinea	scarlet oak		ME (E)
	Q. falcata	southern red oak		OH (T) PA (E)
	Q. hinckleyi	Hinckley oak	T	TX (T)
	Q. ilicifolia	bear oak		VT (E)
	Q. imbricaria	shingle oak		NJ (E)
	Q. lyrata	overcup oak		NJ (E)
	Quercus macrocarpa	bur oak		CT (E)
	Q. muehlenbergii [= *Q. prinoides*]	chinkapin oak		IN (E)
	Q. nigra	water oak		NJ (E)
	Q. oglethorpensis	Oglethorpe oak		GA (T)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Quercus phellos	willow oak		IL (T) NY (E) PA (E)
	Q. prinus [= *Q. montana*]	chestnut oak		IL (T) ME (T)
	Q. shumardii	Shumard's oak		MD (T) PA (E)
	Q. sinuata var. *sinuata* [= *Q. durandii*]	bastard oak		AR (T)
	Q. texana [= *Q. nuttallii*]	Texas red oak		IL (E)
Rosa rugosa	*Rosa acicularis*	prickly rose		IA (E) IL (E) MA (E) NH (E) VT (E)
	R. acicularis ssp. *sayi*	prickly rose		NY (E)
	R. blanda	smooth rose		MD (E) OH (T)
	R. minutifolia	Baja rose		CA (E)
	R. nitida	shining rose		NY (E)
Rhus sp.	*Rhus aromatica var. arenaria*	fragrant sumac		IN (T)
	R. michauxii	false poison sumac	E	FL (E) GA (E) NC (E)
Salix sp., *S. fragilis*	*Salix arctophila*	northern willow		ME (E)
	S. argyrocarpa	Labrador willow		ME (E) NH (T)
	S. bebbiana	Bebb willow		MD (E)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Salix candida	sageleaf willow		ME (T) OH (T) PA (E)
	S. caroliniana	costal plain willow		OH (T) PA (E)
	S. cordata [= *S. syrticola*]	heartleaf willow		IL (E) NY (E) WI (E)
	S. eriocephala [= *S. cordata*]	Missouri River willow		FL (E) IN (T)
	S. exigua	narrowleaf willow		CT (T) MD (E)
	S. floridana	Florida willow		FL (E) GA (E)
	S. herbacea	snowbed willow		ME (T) NH (T) NY (E)
	S. interior	sandbar willow		ME (E)
	S. lucida	shining willow		IA (T) MD (E)
	S. myricoides	bayberry willow		ME (E)
	S. pedicellaris	bog willow		CT (E) IA (T) NJ (E) OH (E) PA (E)
	S. pellita	satiny willow		NH (T) WI (E)

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

Documented/Reported Hosts	Threatened and/or Endangered Plant		Protected Status[1]	
	Scientific Name	Common Name	Federal	State
	Salix petiolaris	meadow willow		OH (T) PA (E)
	S. planifolia	diamondleaf willow		ME (T) MI (T) NH (T) VT (T) WI (T)
	S. pyrifolia	balsam willow		NY (T)
	S. sericea	silky willow		AR (E)
	S. serissima	autumn willow		IL (E) IN (T) PA (T)
	S. sessilifolia	northwest sandbar willow		WA (T)
	S. uva-ursi	bearberry willow		ME (T) NY (T) VT (E)
Tilia mandshurica	*Tilia americana* var. *heterophylla* [= *T. heterophylla*]	American basswood		IL (E)
Toxicodendron succedaneum	*Toxicodendron rydbergii*	western poison ivy		OH (E)
	T. vernix	poison sumac		KY (E)
Ulmus sp., U. davidiana	*Ulmus thomasii*	rock elm		IL (E) NY (T) OH (T)

1. E= Endangered; T=Threatened.

Appendix E. Biology of *Lymantria mathura*

Population phenology

Lymantria mathura is bivoltine (Beeson 1941, Browne 1968, Roonwal 1979b, Baranchikov et al. 1995, Lee and Lee 1996). Roonwal (1953, 1962, 1979b) provides a thorough review of the phenology and behavior of *L. mathura* following the most damaging outbreak on record for this pest in 1953 in Uttar Pradesh, India. The first generation occurs between April and October. Eggs are laid between mid-April and mid-June and hatch in 3-4 weeks. Larvae and pupae occur from early June to late September, and from late July to late October, respectively. In the second or overwintering generation, eggs are laid between early September to mid-October, and embryos are developed within 6 weeks. This generation overwinters as developed embryos, and eggs hatch in the spring between February and early April, depending on temperature. Incubation requires160-178 days, or a shorter duration in warmer temperatures. Of 426 field-collected pupae in the overwintering generation in the New Forest area, 58% were male. The pupal stage occurs within 10-11 days for this generation.

In outbreak years, *L. mathura* tends to lay eggs on many tree species, including non-hosts. *Lymantria mathura* eggs were laid on 185 different host species, and of these, 22 tree species were later defoliated by feeding larvae, and 6 species were heavily defoliated [see 'Host Specificity']. *Lymantria mathura* has historically demonstrated food preferences, but these preferences depend on which hosts are available (Roonwal 1979b, Baranchikov et al. 1995). The selection of a location for egg deposition may also depend on the presence or density of other egg masses, host preference, and the extent of feeding that has already occurred on a host (Roonwal 1979b).

Stage specific biology

Several papers discuss periods of development for *L. mathura* and related species, however there are no known temperature developmental thresholds for *L. mathura* in published literature obtained to date (Anon. 2001).

Adult

Flight has been observed between 1-3 a.m. in far east Russia. Flight activity is not well known for this species, but is thought to coincide with peak flight activity of two closely related species, *L. dispar* and *L. monacha* (Anon. 2001). Males are scarcely seen and die about a week before females. Females congregate in groups of 6 or more near the egg masses and become inactive after laying eggs. They do not fly or feed before dying (Roonwal 1979b).

Egg

Between 50-1,200 eggs are laid in white, distinctive silky hair-covered masses on trunks and large branches of deciduous hosts (Browne 1968, Roonwal 1979b). Eggs are laid from the base of a tree trunk to a height of about 18 m (60 ft.), and most egg masses tend to occur at a height between 0.5 to 5 m (Roonwal 1979b).

During an outbreak in the New Forest area of the western sub-Himalayas in 1953-54, between 1-223 egg masses were reported on 405 trees over an area of 10 km^2. After eggs hatch, the egg mass becomes darker in color. The group of newly hatched larvae remain near the hair-covered mass for 2-3 weeks. It is not known whether the larvae recieve some nutritive benefit from the mass prior to feeding on foliage (Roonwal 1979b).

Larva

There are 6 larval stages or instars and 5 molts. Larvae are gregarious defoliators, devouring entire leaves, sometimes avoiding tough veins in older growth. Larvae may also feed on flowers and tender young shoots (Browne 1968, Roonwal 1979b). Early stages of larvae move about more freely than later instars (Roonwal 1979b). Late instar larvae have demonstrated regular periods of daily dispersal activity (Roonwal 1979b, Zlotina et al. 1999). Roonwal (1979b) observed that caterpillars remained still and at rest for much of the day and migrated to the tree crown to feed at night. Prior to dusk, caterpillars exhibited a characteristic twisting body movement, then crawled to the tree crown at a rate of approximately 65.5 cm/min. Feeding occurs from dusk to near dawn, followed by a rapid descent to the trunk. Larval densities may approach can average was 1,338 / tree (1,140-1,671), or an average of 629 larvae (510-836) per square meter (Roonwal 1979b). Density on the host trunk reached a maximum at 5 PM, just prior to the evening migration to the crown. Early instar *L. mathura* larvae are thought to possess the ability to disperse in a similar manner as other related species, by dropping on a trailing silk thread and utilizing air and wind currents to "balloon" to other locations (Zlotina et al. 1999).

Zlotina et al. (1999) studied dispersal rates, settling velocities and diel dispersal activity of *L. mathura* and *L. dispar* larvae. *Lymantria mathura* larvae showed a higher dispersal tendency than *L. dispar*. Unlike *L. dispar*, larval dispersal tendency was inversely related to larval weight, with lighter individuals having a greater propensity to disperse (Zlotina et al. 1999). Settling velocity of *L. dispar* larvae was significantly higher compared to that of *L. mathura*. This result suggests that larvae of *L. mathura* may disperse farther via wind than *L. dispar*. Dispersal activity was influenced by time of day. Activity of *L. mathura* larvae began to increase after 11AM and peaked at 5 PM , while *L. dispar* activity began to increase after noon , and peaked at 4 PM (Zlotina et al. 1999). This result indicates that *L. mathura* has a greater window of activity than *L. dispar*. Collectively, these results imply that ballooning of neonate larvae from infested ships could be an important means for the arrival.

When population density is high, parasitism by Hymenoptera and polyhedral viral disease may result in high mortality of larvae and pupae (Roonwal 1979b).

Pupa

Pupation often occurs in groups of 40-50 in protected areas of branches, in leaf litter at the base of trees, or on the back or underside of signs or other objects (Browne 1968, Roonwal 1979b).