INDUSTRY BIOSECURITY PLAN

FOR THE NURSERY & GARDEN INDUSTRY

Threat Specific Contingency Plan

Gypsy moth

(Asian and European strains)

Lymantria dispar dispar

Plant Health Australia

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Plant Health AUSTRALIA

Nursery & Garden Industry Australia

Disclaimer

Further information

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1 Purpose and background of this contingency plan

This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of the Gypsy moth (*Lymantria dispar*). The taxonomy of the Gypsy moth is complex, with recent developments identifying two subspecies, *L. dispar dispar* and *L. dispar japonica*, of which only *L. dispar dispar* is covered in this plan. Further, within *L. dispar dispar* there are two strains, Asian gypsy moth (AGM) and European gypsy moth (EGM). Unless otherwise stated, the term gypsy moth refers to both AGM and EGM.

This contingency plan provides guidelines and options for steps to be undertaken and considered when developing a Response Plan to this pest. Any Response Plan developed using information in whole or in part from this contingency plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

This contingency plan was developed for the Nursery and Garden Industry Australia (NGIA), and therefore is focussed on production nurseries covered by this association. In the event of an incursion, operations not covered by the NGIA (e.g. retail nurseries) will not be eligible for Owner Reimbursement Costs, as defined in the Emergency Plant Pest Response Deed, if affected by actions carried out under the Response Plan.

The information for this plan has, in part, been obtained and modified from “A response plan and strategy for Gypsy moth, *Lymantria dispar dispar*, in Australia” developed by the Australian Government Department of Agriculture, Fisheries and Forestry, with additional information sourced from CABI Crop Compendium (**www.cabicompendium.org**). Modifications and additions to the plan have been completed to make the information relevant to an incursion of Gypsy moth for the nursery and garden industry.

2 Australian nursery industry

The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than $6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline and in major inland regions servicing urban and production horticulture.

Nursery production adds value to Australia’s primary industry’s sector and in 2008/2009 is forecast to contribute more than $2 billion to the national economy. Nursery production is a highly diverse primary industry servicing the broader $14 billion horticultural sector within Australia (Table 1).

Table 1. *Nursery production supply sectors within Australian horticulture*

Production Nursery	Horticultural markets	Economic value
Container stock[1]	Ornamental/urban horticulture	$2 billion retail value
Foliage plants[1]	Interior-scapes	$87 million industry
Seedling stock[2]	Vegetable growers	$3.3 billion industry
Forestry stock[3]	Plantation timber	$1.7 billion industry
Fruit and nut tree stock[2]	Orchardists (citrus, mango, etc)	$5.2 billion industry
Landscape stock[1]	Domestic & commercial projects	$2 billion industry
Plug and tube stock[4]	Cut flower	$319 million industry
Revegetation stock[1]	Farmers, government, landcare	$109 million industry
Mine revegetation	Mine site rehabilitation	Value unknown
	Total horticultural market value	**$14.5 billion**

3 Eradication or containment determination

The decision to eradicate should be based both on the potential economic impact of host damage resulting from Gypsy moth infestation and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. Two years with no detections of the pests will be necessary to confirm that no Gypsy moth remain before pest free status can be declared.

No specific eradication matrix has been determined for Gypsy moth, however the general decision process as outlined in Figure 1 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

[1] Data sourced from Market Monitor

[2] Data sourced from Horticultural Handbook 2004

[3] Data sourced from ABARE 2005

[4] Data sourced from industry

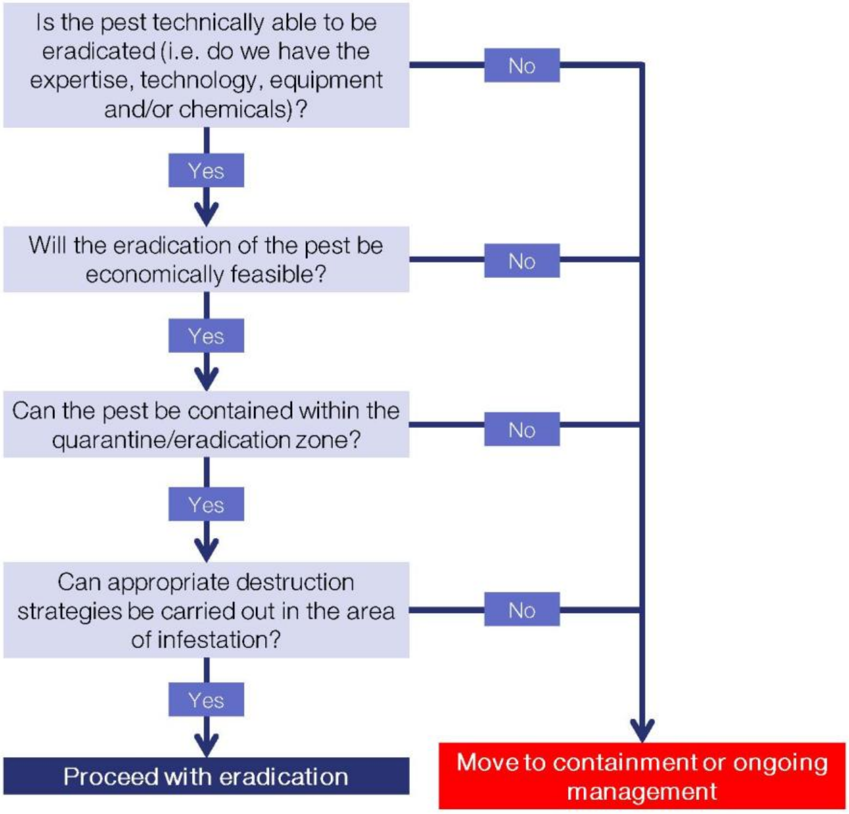

Figure 1. *Decision outline for the response to an exotic pest incursion*

4 Pest information/status

4.1 Pest details

Common names:	Asian gypsy moth, European gypsy moth, gypsy moth
Scientific name:	*Lymantria dispar*
Synonyms:	*Lymantria dispar dispar, Porthetria dispar, Ocneria dispar, Bombyx dispar, Hypogymna dispar, Liparis dispar, Phalaena dispar, Porthesia dispar*
Taxonomic position:	Kingdom, Animalia; Phylum, Arthropoda; Class, Insecta; Order, Lepidoptera; Family, Lymantriidae

4.1.1 Background

The Gypsy moth (*Lymantria dispar*[5]) is an economic important pest species found throughout Asia and Europe. At least two strains of the moth have been identified, named based on their home continents of Asia and Europe. The Asian gypsy moth (AGM) and the European gypsy moth (EGM)

[5] For the purposes of this document, only moths of the subspecies *L. dispar dispar* are considered. The subspecies *L. dispar japonica* is found in Japan and based on its sexual incompatibility with *L. dispar dispar* (Keena and Moore, 1998) it is believed to be a separate species.

are morphologically identical, but the AGM has a broader host range and the female AGM can fly. They are two of the most destructive pests of shade, fruit, ornamental and forestry trees in the northern hemisphere. The caterpillars cause extensive defoliation to host trees through feeding activities, leading to reduced growth and even death of the host tree. The presence of this pest can destroy the aesthetic appeal of forested areas and the hairs of the larvae and egg masses cause allergic reactions in some people.

The Gypsy moth has a single generation per year, with female moths laying eggs in masses during autumn on trees (Figure 2), stones, walls, logs, and a range of outdoor objects. Shipping containers are commonly used by the Gypsy moth for egg deposition (Figure 3), and this can be a major contributor to the spread of the pest. Egg masses are generally covered in yellow or tan fuzz which has been transferred from the abdomen of the female, and contain between 50 and 1000 eggs. Eggs begin to hatch as new leaves are produced in spring.

Figure 2. *Asian gypsy moth egg masses on a European beech tree. Image courtesy of Manfred Mike, USDA Forest Service, Bugwood.org.*

Following hatching, larvae can remain on the egg masses for up to a week (Asian strain usually leaves the egg mass within two days). Larvae move upwards to feed on new buds and leaves. During the first and second instar stages, larvae naturally spread by wind using a strand of silk produced from their head which catches the wind. Most larvae travel about 200 m in this manner in search of new hosts, but some can travel several kilometres.

The larvae are voracious feeders, consuming a total of about 1 m^2 of foliage over their life span. Feeding occurs mainly during the day for the first three instars, and at night for the later 2-3 instars. The later instars are by far the most voracious feeders, and at outbreak density, larval feeding continues through the day. Males usually have five instars and females have six. The larvae range from 3 mm in length during the first instar through to 50-65 mm for the 5^{th} or 6^{th} instar. At maturity these hairy caterpillars range in colour from black through to yellow, but typically have two rows of spots on their back – five pairs of blue spots followed by six pairs of red spots.

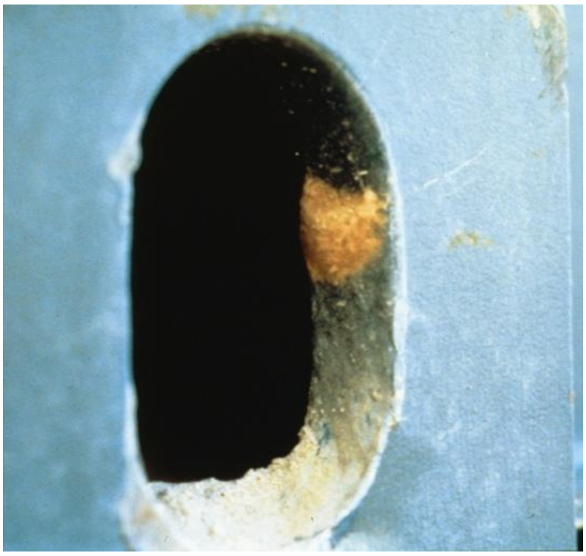

Figure 3. *Gypsy moths will lay eggs on hard surfaces, including shipping containers as shown here. Image courtesy of Manfred Mielke, USDA Forest Service, Bugwood.org.*

Larval stages last about 6-8 weeks in total, after which they find a resting site, usually on a trunk, rock or in leaf litter, and then pupate within a silken nest. Pupal development is completed within three weeks, with males emerging 1-2 days before females. Males of both AGM and EGM are good flyers, but only the females of the Asian strain are capable of flight, although females of the European strain do have fully formed wings. In both strains, adult moths are large and show sexual dimorphism. Males have a wingspan of 30-40 mm compared to the 40-70 mm wingspan of females and wing colouration ranges from greyish-brown (males) to white with black stripes (females). All adults are short-lived, surviving for only one week and they do not feed.

4.1.2 Life cycle

Gypsy moths complete one generation per year, maturing through four life stages: egg, larvae (5-6 instars), pupae and moth. The specific timing of each stage of the life cycle is dependent on environmental conditions, with the pest overwintering as eggs laid on trees, stones, walls, logs, furniture and other outdoor objects. Eggs are laid in masses of 50-1000 which are generally covered with yellowish or tan fuzz (Figure 4) that has been transferred from the females' abdomen while laying. Egg masses are generally 2-3 cm by 1-2 cm in size.

Eggs commonly hatch to coincide with the budding of most hardwood trees in the spring, as these provide the food source for many of the newly hatched larvae. Each larvae will go through five (male) to six (females) instar stages before maturity (Figure 5) and complete this life cycle stage in about 6-8 weeks from hatching. Emerging caterpillars stay with the egg mass (Figure 6) for 2 (AGM) to 7 (EGM) days before moving upwards to the tops of trees. These first or second instar caterpillars can then disperse on wind currents by spinning a thread of silk from their heads which catches the wind. Through this mechanism, the young larvae can move a few hundred metres to several kilometres in search of new host plants.

Figure 4. *Female gypsy moth depositing eggs onto a tree trunk. Note the tan, fuzzy appearance of the egg mass. Image courtesy of Hannes Lemme, Bugwood.org.*

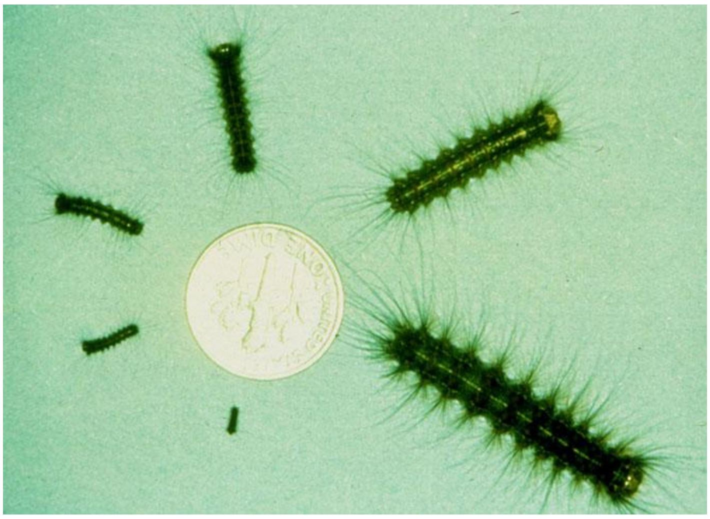

Figure 5. *The five instar stages of gypsy moth larvae development, with an American dime (18 mm in diameter) for size comparison. Image courtesy of USDA Forest Service – Rocky Mountain Region Archive, Bugwood.org.*

Figure 6. *First instar larvae remaining with the egg masses. Image courtesy of John Ghent, USDA Forest Service, Bugwood.org.*

First instar larvae are black with long hairs (Figure 7) and are about 3 mm in length. Second instar larvae have shorter hairs, are brown in colour and are slightly longer at 5 mm. Both the first and second instars (only first instars of EGM) are capable of ballooning (spreading by wind). Feeding activity in the first three instars only occurs during daylight hours, but from the fourth instar onwards feeding occurs at night. These older larvae descend to the leaf litter or rest in the bark of the tree during the day. However, during outbreaks, when populations are at a high density, feeding continues during the day.

Figure 7. *Early instar Gypsy moth larvae. Image courtesy of John Ghent, USDA Forest Service, Bugwood.org.*

Larvae of instars four to six look similar to each other and may be light to dark grey in colour with flecks of yellow and long hairs that may be dark or golden in colour. These late instar larvae all have a very recognisable double row of tubercles along the back, usually five pairs of blue followed by six pairs of red (Figure 8). These final instar larvae are by far the most voracious feeders, on average consuming about 1 m^2 of green foliage.

Figure 8. *Mature Gypsy moth larvae, showing the distinctive red and blue tubercles. Image courtesy of John Ghent, USDA Forest Service, Bugwood.org.*

Gypsy moths undergo pupation in early summer, lasting about 2 weeks, on the trunk of the host tree, on rocks or on walls. The larvae surround themselves with a silken cocoon, which is about 1.5 cm (males) or 3 cm (females) in length (Figure 9). Both sexes are fully mature at emergence, with males emerging 1-2 days before females. Males of all strains are good flyers, but only females of the AGM strain are capable of flight. In both strains, adult moths are large and show a sexual dimorphism (Figure 10). Males have a wingspan of 30-40 mm compared to the 40-70 mm wingspan of females and wing colouration ranges from greyish-brown (males) to white with black stripes (females).

Figure 9. *Gypsy moth pupae on a tree trunk. Image courtesy of Jim Occi, BugPics, Bugwood.org.*

Figure 10. *Comparison between male (left) and female (right) adult Gypsy moths. Image courtesy of USDA APHIS PPQ Archive, Bugwood.org.*

Following emergence, females will move to an elevated position and start releasing a pheromone to attract males. Females will only mate once and will lay only a single egg mass. All adults are short-lived, surviving for only one week and they do not feed.

4.1.3 Dispersal

Natural dispersal of Gypsy moth occurs at either the first instar larvae stage or as an adult moth (in the case of the AGM):

- First instar larvae readily spread several hundred metres by ballooning (Figure 11) on the wind, and can move as much as several kilometres. To achieve this, they move to an elevated position and spin silk from their head, which catches the wind.
- Adult female EGM have fully formed wings but do not fly. However, the female AGM will readily fly and can travel up to 40 km before mating.

Introduction of this pest into new locations not adjacent to current populations will most likely occur through human aided dispersal. Eggs are the most likely form to be transported on vehicles and commodities, but larvae are also known to attach to travellers and their possessions. The most likely human aided dispersal pathways include:

- Movement on plant parts:
    - Bark – eggs, borne externally.
    - Stems, shoots, trunks and branches – eggs, larvae and pupae, all borne externally.
    - Wood – eggs, borne externally.
- Movement on nursery stock.
- Movement on machinery and equipment, such as shipping containers, trucks, hulls and rigging of ships.

Figure 11. *First instar larvae ballooning by spinning a strand of silk from their head and allowing it to catch the wind. Image courtesy of Steven Munson, USDA Forest Service, Bugwood.org.*

4.2 Affected hosts

4.2.1 Host range

Gypsy moths have an extremely wide host range, being able to complete their life cycle on over 650 plant species worldwide. While relatively few Australian species have been tested for susceptibility to Gypsy moth attack, at least 55 Australian host species are known (Matsuki *et al.*, 2001, and list reproduced in Section 9.1 (page 41). Their preferred hosts include oak, alder broadleaf trees, Douglas fir and western hemlock needle trees. Outbreaks usually begin on these preferred hosts and move to other species as the Gypsy moth density increases.

Host lists for Gypsy moth have been compiled previously (Forbush and Fernald, 1896; Kurir, 1953; Liebhold *et al.,* 1995; Schaefer *et al.,* 1986), although these lists are not exhaustive. The list of known host genera (Table 2) and limited host list reproduced from the CAB Compendium (Table 3; CAB International, 2007) are shown below.

Table 2. *List of known host genera for Gypsy moths*

Acacia, Acer, Alnus, Betula, Callistemon, Carpinus, Carya, Castanea, Corylus, Corymbia, Diospyrus, Eucalyptus, Eugenia, Fagus, Fraxinus, Glycine, Hamamelis, Larix, Leptospermum, Liquidambar, Litchi, Lithocarpus, Malus, Nothofagus, Ostrya, Picea, Pinus, Pistacea, Platanus, Populus, Prunus, Pseudotsuga, Pyrus, Quercus, Robinia, Salix, Taxodium, Tilia, Ulmus, Vaccinium, Zea

Table 3. *Gypsy moth host list (not complete) as listed on the CAB Compendium (CAB International, 2007)*

Major hosts	*Acer saccharum* (sugar maple), *Betula papyrifera* (paper birch), *Quercus alba* (white oak), *Quercus coccinea* (scarlet oak), *Quercus ellipsoidalis* (Northern pin oak), *Quercus garryana* (Garry oak), *Quercus ilex* (holm oak), *Quercus lobata* (California white oak), *Quercus montana* (basket oak), *Quercus muehlenbergii* (Chinquapin oak), *Quercus palustris* (pin oak), *Quercus petraea* (durmast oak), *Quercus robur* (common oak), *Quercus rubra* (northern red oak), *Quercus suber* (cork oak), *Quercus velutina* (black oak), *Salix fragilis* (crack willow)
Minor hosts	*Acer* (maples), *Acer negundo* (box elder), *Acer platanoides* (Norway maple), *Acer rubrum* (red maple), *Acer saccharinum* (soft maple), *Alnus* (alders), *Alnus rhombifolia* (white alder), *Betula* (birches), *Betula alleghaniensis* (yellow birch), *Betula lenta* (sweet birch), *Betula populifolia* (gray birch), *Carpinus* (hornbeams), *Carya* (hickories), *Castanea sativa* (chestnut), *Corylus*, *Eucalyptus camaldulensis* (red gum), *Fagus* (beeches), *Fagus grandifolia* (American beech), *Fagus sylvatica* (common beech), *Fraxinus americana* (white ash), *Fraxinus pennsylvanica* (downy ash), *Glycine max* (soyabean), *Hamamelis virginiana* (Virginian witch-hazel), *Larix* (larches), *Larix kaempferi* (Japanese larch), *Larix occidentalis* (western larch), *Liquidambar styraciflua* (Sweet gum), *Litchi chinensis* (lichi), *Lithocarpus edulis*, *Malus* (ornamental species apple), *Malus domestica* (apple), *Ostrya virginiana* (American hophornbeam), *Picea abies* (common spruce), *Picea jezoensis* (Yeddo spruce), *Pinus* (pines), *Pinus contorta* (lodgepole pine), *Pinus echinata* (shortleaf pine), *Pinus resinosa* (red pine), *Pinus rigida* (pitch pine), *Pinus strobus* (eastern white pine), *Pinus sylvestris* (Scots pine), *Pinus taeda* (loblolly pine), *Pistacia vera* (pistachio), *Platanus acerifolia* (London planetree), *Populus* (poplars), *Populus grandidentata* (Bigtooth aspen), *Populus nigra* (black poplar), *Populus tremuloides* (trembling aspen), *Prunus* (stone fruit), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), *Prunus salicina* (Japanese plum), *Prunus serotina* (black cherry), *Prunus serrulata* (Japanese flowering cherry), *Pseudotsuga menziesii* (Douglas-fir), *Pyrus* (pears), *Quercus ilicifolia* (bear oak), *Robinia* (locust), *Robinia pseudoacacia* (black locust), *Salix* (willows), *Salix babylonica* (weeping willow), *Taxodium distichum* (bald cypress), *Tilia americana* (basswood), *Tilia cordata* (small-leaf lime), *Vaccinium* (blueberries), *Zea mays* (maize)

4.2.2 Current geographic distribution

Gypsy moth is widespread, particularly in the northern hemisphere. AGM is found throughout Asia, while the EGM is found both in Europe and in North America. Current distribution of the Gypsy moth species (both AGM and EGM) is shown in Table 4 (CAB International, 2007).

Table 4. *Current worldwide distribution of the Gypsy moth*

Continent	Countries
Africa	Algeria, Morocco, Tunisia
Asia	Afghanistan, Azerbaijan, China, India, Iran, Iraq, Israel, Japan, Kazakhstan, Korea, Kyrgyzstan, Lebanon, Syria, Tajikistan, Turkey, Turkmenistan, Uzbekistan
Europe	Austria, Belarus, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Macedonia, Moldova, Netherlands, Poland, Portugal, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Spain, Sweden, Switzerland, Ukraine, United Kingdom
North America	Canada, USA

4.2.2.1 POTENTIAL DISTRIBUTION IN AUSTRALIA

Based on climatic conditions, the Gypsy moth has the potential to establish in Australia along the east coast, throughout Victoria and Tasmania, and in limited regions along the coast lines of South Australia and Western Australia (Matsuki *et al.,* 2001, and see CLIMEX model in Figure 12).

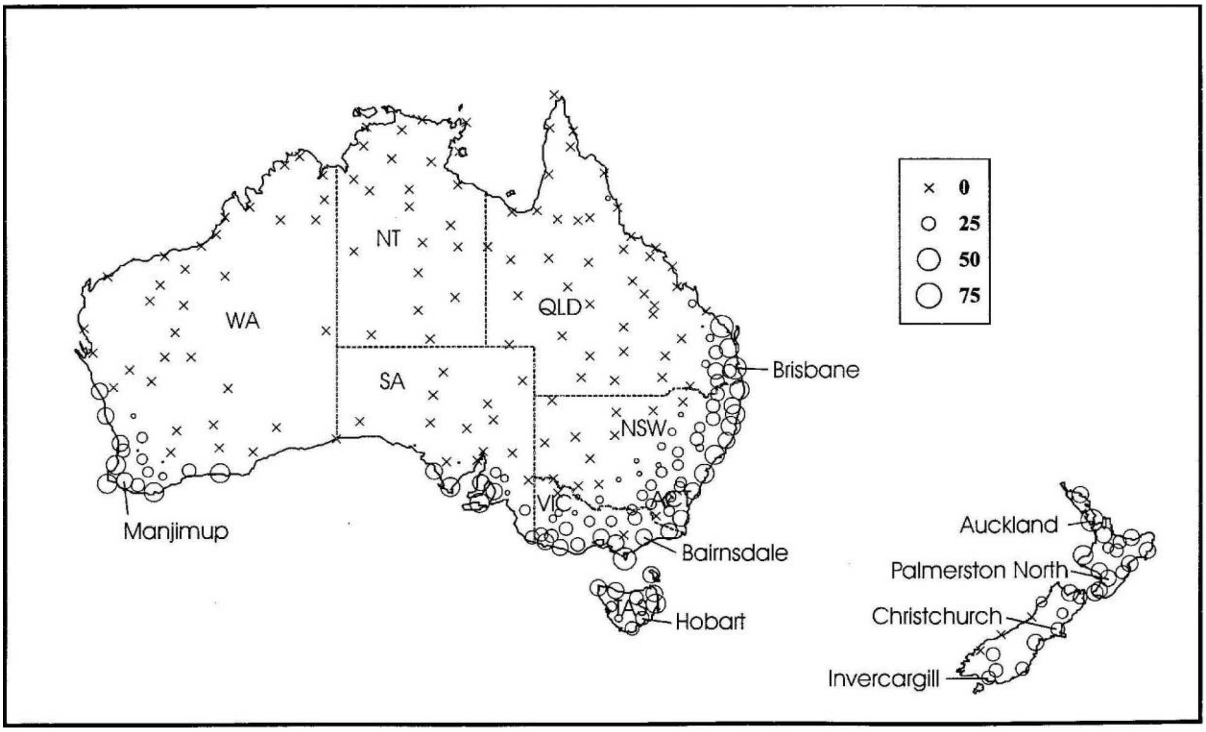

Figure 12. *Predicted distribution of the Gypsy moth in Australia and New Zealand based on climatic data. The size of the circle indicated the degree of suitability of the climate, and crosses indicate where the moth is predicted not to survive. Figure copied from Matsuki et al. (2001).*

4.2.3 Symptoms

The larvae are voracious feeders with each larvae consuming about 1 m^2 of green leaves in its life time. At low levels, the Gypsy moth caterpillars do not impact on the general health of trees, but at outbreak levels they can completely defoliate trees (Figure 13). The physiological stress associated with the feeding activities of the caterpillar can result in reductions in tree growth, crown dieback and tree mortality. Tree mortality is often associated with other insects and pathogens that attack the stressed trees. Caterpillar feeding on the leaves (Figure 14) is the most obvious symptom of Gypsy moth attack.

Adults do not feed and will cause no adverse impacts on host species. However, caterpillar silk strands, droppings, destroyed leaves, egg masses and dead moths would be evident.

Figure 13. *Defoliation of mature trees caused by outbreak populations of Gypsy moth. Images courtesy of William M. Ciesla, Forest Health Management International, Bugwood.org (top) and Tim Tigner, Virginia Department of Forestry, Bugwood.org (bottom).*

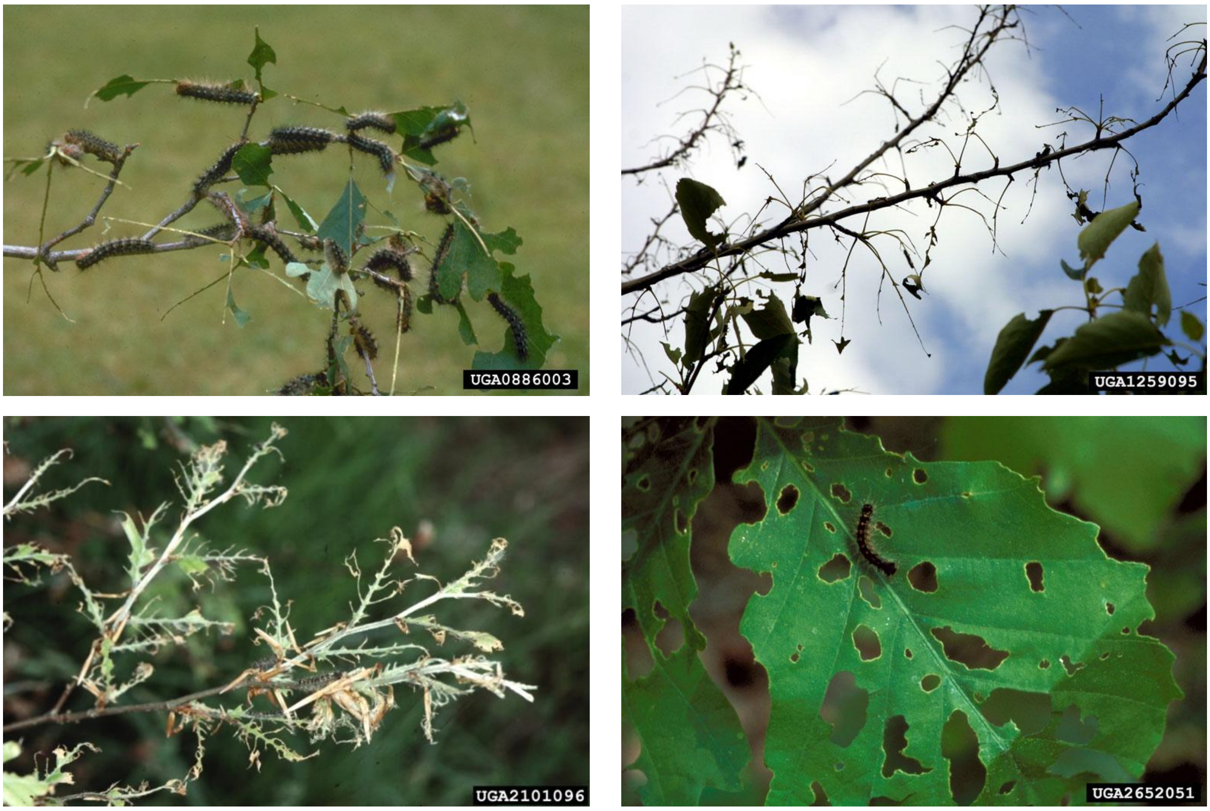

Figure 14. *Leaf feeding damage caused by Gypsy moth caterpillars. Images courtesy of Tim Tigner, Virginia Department of Forestry, Bugwood.org (top left), Landesforstpräsidium Sachsen Archive, Bugwood.org (top right), Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org (bottom left) and USDA APHIS PPQ Archive, Bugwood.org (bottom right).*

4.3 Diagnostic information

There are a large number of endemic and exotic moth species within the Lymantriidae family, many of which are economically important pests of trees and shrubs. Initial diagnosis can be made based on the morphological characteristics described previously in Sections 4.1.1 and 4.1.2, including the following key points:

- Egg masses – generally covered with yellowish or tan fuzz (Figure 4) 2-3 cm by 1-2 cm in size.
- Larvae – range in size from 3 mm to 65 mm throughout development. Mature larvae have a very recognisable double row of tubercles along the back, usually five pairs of blue followed by six pairs of red (Figure 8).
- Adults – show a sexual dimorphism (Figure 10). Males have a wingspan of 30-40 mm compared to the 40-70 mm wingspan of females and wing colouration ranges from greyish-brown (males) to white with black stripes (females).

Full diagnosis and identification to the species level requires an expert in moths of the Lymantriidae family. A diagnostic protocol for Gypsy moths is currently under development through the Subcommittee on Plant Health Diagnostic Standards (**www.daff.gov.au/sphds**). This protocol will be released following finalisation and endorsement, but should be made available if required under an Approved Response Plan following the incursion of Gypsy moth into Australia. Distinguishing between

AGM and EGM can be achieved through the application of randomly amplified polymorphic DNA-polymerase chain reaction (RAPD-PCR) markers (Garner and Slavicek, 1996; Schreiber *et al.*, 1997).

The State Chief Plant Health Manager will select the diagnostic faculties to be used during a response to a Gypsy moth incursion. Contact details for a number of diagnostic facilities can be found in Section 9.2 (page 42).

4.4 Pest risk ratings and potential impacts

A pest risk analysis has been carried out on this pest, taking into account the entry, establishment and spread potentials, together with the economic and environmental impact of establishment. A summary of these ratings are shown in Table 5. Based on this information, Gypsy moth is considered a **medium-high** overall risk to Australia.

Table 5. *Pest risk ratings for Gypsy moth as determined in the Nursery and Garden IBP (Plant Health Australia, 2009)*

Potential or impact	Rating
Entry potential	Medium-High
Establishment potential	Medium
Spread potential	High
Economic impact	High
Overall risk	**Medium-High**

4.4.1 Phytosanitary risk

Expansion of invading Gypsy moth populations range is primarily by human assisted movement, although natural dispersal by the first instar larvae ballooning and flight of the adults (only in the Asian strain) does occur over shorter distances. The accidental introduction of Gypsy moth is a risk to all temperate countries where it is not present, including Australia. The USA and Canada have extensive programs to prevent establishment of new populations outside the current range. In 2003, a male AGM was detected in New Zealand, presumably after hatching from an egg mass introduced on an imported used car. Eradication of AGM from New Zealand was achieved using aerial application of *Bacillus thuringiensis*.

4.4.2 Entry potential

Rating: MEDIUM-HIGH

While the Gypsy moth is widely distributed through Asia and Europe, it is currently not found in southern Asian countries neighbouring Australia. Therefore, it is extremely unlikely that it would enter Australia through natural dispersal. However, egg masses are regularly attached to equipment, machinery, vehicles and products that are transported long-distance, and larvae and pupae can be transported with plant products. Introduction into New Zealand was believed to have occurred through an egg mass attached to an imported used car, and egg masses are regularly found on shipping containers leaving countries where Gypsy moth infestation occurs. While the egg masses are coloured and can be seen with the naked eye, the volume of trade from countries infested with Gypsy moth and the hidden location of where egg mass deposition can occur result in a medium to high potential of entry. Due to the medium-high risk of entry through human aided transport into ports, the Australian Government Department of Agriculture, Fisheries and Forestry currently fund a *Lymantria* moth trapping program around Australian ports. This program provides an early warning system for any Gypsy moth incursions that occur through these ports.

4.4.3 Establishment potential

Rating: HIGH

Australian climatic conditions along the east coast, Victoria, Tasmania and regions of South Australia and Western Australia are highly suitable for Gypsy moth establishment (Figure 12). The extremely wide host range, including at least 55 Australian plant species (see Section 9.1) adds to the ability of the pest to establish in Australia if it entered.

4.4.4 Spread potential

Rating: HIGH

Following establishment, movement and spread of Gypsy moth can be via natural and human-aided means. Short range movement by the first instar larvae using wind currents can occur over distances greater than one kilometre. However, greater movement potential comes from the flight of adult females, which can cover over 40 kilometres. EGM females are unable to fly, and as such, limiting the spread of this strain has been more successful than limiting the spread of AGM.

A greater potential for spread occurs through the movement of vehicles, equipment and produce with egg masses, larvae or pupae attached. Eggs are laid on a variety of hard surfaces, and can survive for long periods of time and are resistant to extremes of temperature. In addition, larvae and pupae are occasionally found on host material that has been transported. As such, movement of nursery stock could provide a pathway for potential spread of the pest if it were to become established.

4.4.5 Economic impact

Rating: HIGH

When at outbreak densities, Gypsy moth larvae completely defoliate trees and shrubs and in some cases this leads to host death. As a consequence of the extremely wide host range of Gypsy moth, including many plant species grown in commercial nurseries in Australia, together with the severe impact on host plants, the potential economic impact of this pest on the nursery and garden industry is high. In addition, undetected populations of Gypsy moth in commercial nurseries have the potential to spread to retail nurseries and consumers with nursery stock. As a result, trade restrictions on the nursery and garden industry may be imposed following the detection of this pest due to the potential distribution pathway it provides.

4.4.6 Environmental, amenity and human health impact

Gypsy moths are capable of partial or total defoliation of trees and forests reducing rates of tree growth and causing loss of production. Where pest outbreaks occur over several years there can be significant tree mortality (Montgomery and Wallner, 1988). There can be significant reduction in the aesthetic values of defoliated trees and forests. Suppressed and understorey trees have a greater probability of being defoliated and dying than overstorey trees (Davidson *et al.,* 2001). Silvicultural manipulations such as thinning do not appear to be useful in reducing frequency or intensity of Gypsy moth outbreaks (Muzika *et al.,* 1998).

They also impact on human recreation through nuisance value, allergic reactions to the hairs on the caterpillar, dead tree hazard and loss of shade. A recent New Zealand study estimated a potential economic impact of AGM in that country of up to $100 million annually (Harris Consulting, 2003, 2004).

A number of potential impacts of Gypsy moth establishment should be considered (Table 6).

Table 6. *Potential impacts of Gypsy moth establishment*

Location/activity	Impact
Urban household	Residential impacts occur with tree defoliation and potential death, droppings and nuisance value from the hairs and larvae. They can be a significant proportion of the damage caused by this insect, and in a study conducted in south-western USA comprised 83% of the total impacts.
Schools and golf courses	These are situations where potential health impacts from contact with the larvae and loss of amenity from defoliation are less likely to be tolerated and control costs may be higher than for other businesses and households.
Other urban land	Public land in urban areas is likely to be affected by increased mortality and increased requirement for spraying if Gypsy moth becomes established as susceptible trees are likely to be a significant proportion of amenity plantings. In the USA there is an estimate of 30%-60% mortality per decade.
Horticultural	Gypsy moth is a reported pest of a wide range of horticultural crops. Existing spray programs in many of these crops are likely to cope with the pest in terms of yield losses. Some crops and organic properties without spray programs will be affected.
Forestry	*Pinus, Eucalyptus, Corymbia, Acacia* and *Pseudotsuga* are all host genera for Gypsy moth. The exact risk to commercial plantations is unknown but it must be assumed that there will be some growth impact losses. If an incursion in a commercial plantation region is not detected early there is a significant risk that spread of Gypsy moth will be rapid and widespread, making containment or eradication difficult.
Shelter, riparian and soil conservation plantings	Some species used for these purposes are known hosts of Gypsy moth. Tree mortality is of concern for reasons of increased erosion potential and loss of shelter. Spraying in the proximity of waterways is not common.
Human health	Gypsy moth has been associated with a variety of health impacts associated with allergic reactions to the urticating hairs of the caterpillar. Larvae contaminate water with their frass.
Natural heritage value and indigenous flora	*Acacia, Callistemon, Corymbia, Diospyrus, Eucalyptus, Eugenia, Leptospermum*, and *Nothofagus* are host genera for Gypsy moth. It is likely that many more genera/species, as yet untested, may be susceptible. A significant risk therefore exists for the health of native forests in Australia should the pest become established.
Trade impacts	Gypsy moth is capable of laying eggs on the outside of many products currently exported from Australia. There will be significant costs associated with disinfestation prior to export to meet other countries' standards for freedom of risk from Gypsy moth. Vessels and cargo may need to be inspected/ disinfected.

5 Pest management

5.1 Response checklist

The following checklist (Table 7) provides a summary of generic requirements to be identified and implemented within a Response Plan.

Table 7. *Checklist of requirements to be identified in a Response Plan*

Checklist item	Further information
Destruction methods for plant material, soil and disposable items	Sections 6.1.1 and 6.1.2
Disposal procedures	Section 6.1.5
Quarantine restrictions and movement controls	Section 6.3
Decontamination and property cleanup procedures	Section 6.5
Diagnostic protocols and laboratories	Sections 4.3 and 9.2
Trace back and trace forward procedures	Section 6.6
Protocols for delimiting, intensive and ongoing surveillance	Section 5.2
Zoning	Section 6.4
Reporting and communication strategy	See PLANTPLAN

A range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia, 2009). Additional information is provided by Merriman and McKirdy (2005)[6] in the Technical Guidelines for Development of Pest Specific Response Plans.

5.2 Surveys and epidemiology studies

Information provided in Section 5.2.1 to 5.2.3 provides a framework for the development of early detection and delimiting surveys for Gypsy moth in Australia.

Where Gypsy moth is found in a production nursery that is in close proximity to potential host trees and shrubs, periodically inspect nearby hosts for signs of Gypsy moth infestation. Infested sources within the nursery may provide an opportunity for Gypsy moth to spread to trees and shrubs outside the nursery.

Agricultural inspectors and other nursery visitors should avoid moving infested plant material between nurseries. Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be infested, including disposable overboots that may be used and disposed of on-site.

[6] Available on the PHA website (**www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information**)

5.2.1 Technical information for planning surveys

When developing surveys for Gypsy moth presence and/or distribution, the following characteristics of the pest provide the basic biological knowledge that impact on the survey strategy:

- The exotic Gypsy moth shares a number of similarities with a range of endemic and other exotic moths from the Lymantriidae family. While many of these species are pests, none are as destructive as the Gypsy moth.
- Endemic host species in Australia are likely to be numerous and widely dispersed.
- The risk of pest movement on machinery, equipment and personal effects is high.
- Significant proportions of Australia have favourable climatic conditions for Gypsy moth spread and establishment.
- Eggs, larvae and pupae can be found away from host plants on other hard surfaces including, walls, rocks, vehicles and outdoor furniture. Surveys should also include non-host material.
- Larvae can spread up to several kilometres by ballooning.
- Male adult moths of both strains can spread by flight, and adult females of the AGM can fly up to 40 km. EGM females do not fly.
- Fourth to sixth instar larvae will descend from host trees during the day to rest in the leaf litter, unless the population is at outbreak density.

5.2.2 Surveys for early detection of an incursion in a nursery

Effective ways to monitor Gypsy moth in commercial nurseries are:

- Moths are large and easily seen.
- Larvae on foliage are easily distinguishable from other defoliators. Leaf feeding damage also aids in the detection of larvae.
- Sweep nets should be used to collect adults.
- Pheromone baited traps (for example, Agrisense® Delta sticky trap) are the primary method for detecting new gypsy moth populations in previously uninfested areas. Pheromone traps are a very sensitive tool that can be used to detect very low density populations that could not be detected using any other method.
    - The Gypsy moth male prefers to land on vertical surfaces, such as tree trunks and walls. The trap should be attached firmly in a horizontal position, about chest height, onto the trunk of a tree or wall. Ensure the side of the trap rests against the vertical surface.
    - Traps should be put in place from mid-spring through to late autumn.
    - Traps should be checked fortnightly and the lure will need to be changed every six weeks.
    - Traps can be placed at a density of one per kilometre.

Targeted surveillance should be focussed on high-risk areas. These include commercial propagators and production nurseries involved with the import and export of cut flowers and other nursery produce. Other import locations are also high risk due to Gypsy moth eggs commonly being attached to solid structures such as shipping containers.

If an incursion of Gypsy moth is to be eradicated in a nursery, it must be detected early, before the insect has had the opportunity to disperse to a large extent. It is therefore necessary to consider pathways and plan surveys accordingly. Important points to consider when developing early detection surveys are:

- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators).
- The greatest entry risk currently comes from importations of host plants or other goods. Therefore surveys at importing nurseries and ports are required.
- Systematic and careful inspection of nursery crops and propagative plant material is essential to prevent introduction of Gypsy moth and limit its spread within and from infested nurseries. Early detection of the pest, while at very low levels, will provide the best chance of eradication.
- An inspector must be trained to recognize the basic identification of all stages of Gypsy moth, including egg masses, larvae, pupae and adults as well as other endemic moths of the Lymantriidae family for comparison (see Section 4.3). A nursery layout map that includes approximate locations of known host species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop the most efficient survey strategy each time the nursery is inspected.
- Begin the inspection with an overview of the area from the crop perimeter or with a quick walk-through. If suspicious symptoms or stages of Gypsy moth are apparent, immediately examine them more closely and collect samples if required. If no symptoms are apparent from the overview inspection, start the complete inspection by walking a systematic path through the crop. A common survey technique is to move relatively quickly down a walkway and scan both sides of adjacent production beds, back and forth. If suspicious symptoms are seen, inspect plants more closely. If plants are found with suspicious symptoms or stages of Gypsy moth are apparent, a sample should be taken and the plant marked with plastic tape or a flag with the location noted on the survey map. Also, a few plants can be selected at random to closely inspect for Gypsy moth. Surveys can be prioritised to highest risk stock.
- New stock or cuttings of hosts should be monitored closely. Note outside sourced plants on survey maps for weekly examination.

5.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, information from delimiting surveys will be used in the decision-making process.
- The size of the survey area will depend on the size of the known infested area and the insect population size, as well as prevailing winds and movement of plant material during the period prior to detection.
- Initial high density surveys should be carried out in a 1.5 km radius of the initial detection. However, delimiting surveys will also need to be carried out in a 40 km radius of the initial detection if it is the Asian strain due to the flight distance of the female moths.
    - The survey area should be extended to centre around each new detection.

- All potential host species (refer to Section 4.2 and 9.1) should be surveyed, with particular attention paid to the species in which the pest was initially detected.
- Depending on the time of year, as well as the crop area within the survey radius, rocks, vehicles, equipment and other solid structures should be sampled for the presence of eggs, larvae and pupae. Leaf litter should also be included as the mature larvae will descend during the day. More than 20 infestation sites in a specific geographic area (40 km radius), indicates a serious infestation.
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may assist.

5.2.4 Collection and treatment of samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia, 2009). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia, 2009). Containers should be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (preferably with a GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

5.2.4.1 COLLECTION OF SPECIMENS

Sampling procedures

Samples can be collected by hand, using pheromone traps or swept from foliage with a hand net. Life stages are not all confined to the host plant material. Eggs, larvae and adults are regularly found on other structures, such as walls, outdoor furniture, rocks and buildings. While adults are the best life stage for identification, collection of eggs, larvae, and pupae by hand is easier, and these can be reared in the laboratory. However, the long life cycle delays the identification process, so the collection of adults with sweep nets or pheromone traps is the preferred method as it speeds up the diagnostic process.

Pheromone traps

Sex pheromone baited traps (for example, Agrisense® Delta sticky trap) placed on walls, tree trunks and other vertical surfaces, will attract male adult moths (and hence be effective for both AGM and EGM as males of both species can fly). When moths are caught in these traps, send the entire trap with the moth undisturbed to the diagnostic lab for identification. Attempts at removing the moth from the trap damage the moth and inhibit the identification process.

- Traps should be put in place from mid-spring through to late autumn.
- Traps should be checked fortnightly and the lure will need to be changed every six weeks.

- Traps should be placed with a one kilometre distance between them

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Number of specimens to be collected

Where possible, collect multiple specimens representative of all life stages of the population available. If possible, at least one of the samples should be an adult moth, as the adult life stage is the easiest with which to confirm identification.

Record the identity of the host plant where the fly was collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

How to preserve insects

Authors recommend varying concentrations of ethanol for preserving Lepidopteran specimens, ranging from 70-95%, but sometimes concentrations as high as 100% are recommended. While ethanol is useful as a preservative where morphological characteristics of an adult moth will be used for specific determination, it is not ideal as a preservative where DNA analysis of specimens is to be undertaken.

Acetone has been recommended (Mandrioli *et al.,* 2006) as a possible alternative to ethanol if the Lepidopteran specimen is to be used for DNA analysis. Acetone has the additional advantage of being effective at preserving morphological features of Lepidopteran specimens at room temperature.

Where taxonomic expertise is readily available and identification can be carried out quickly it may be practical to keep adult moths alive or kill and relax the insect immediately prior to transport.

How to transport insects

Vials containing the samples in a preservative should be sealed to avoid leakage and packed in a manner to minimise shock to the vials (i.e. with cushioning material in a strong box). It is important to ensure that vials are filled with preservative so as to remove excess air which, through movement of the vial, will allow agitation of the preservative and quickly degrade the specimen.

Live insects should be packaged in a strong, sealed container.

A word of caution on both methods:

- Where a quarantine situation occurs, special authority will be needed to remove live exotic insects from the quarantine area.
- Transport/airline regulations may preclude the transportation of ethanol or acetone. Contact the relevant transport authority or company for advice.

How to collect and send plant samples with eggs, larvae or pupae

Adults are the preferred stage for identification. However, if an adult Gypsy moth is not available for collection, other life stages (eggs, larvae and pupae) can be collected and sent for identification. Where these life stages are attached to plant material, it may be appropriate to send the plant part with the insect attached to avoid damaging the sample. In this case, plant samples should be packed between sheets of dry newspaper (for stem, bark, etc.) or moist paper (for leaves) and sealed in a plastic bag. Each sealed bag should be placed in a second bag along with additional paper to absorb excess moisture. Bagged samples should then be placed in a non-crushable container with paper, bubble or foam to fill the remaining space and protect samples during transit.

Precaution

Overheating or desiccation of samples prior to despatch should be prevented. Samples may be stored in a fridge (4-10°C) for a few days if necessary.

Receipt

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia, 2009).

5.2.5 Epidemiological study

The extent of infestation in a nursery, on a property or within a region will depend on the initial population size and whether conditions have been favourable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the nursery or on the property with the initial detection and those on neighbouring properties.
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source.
- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material from other regions should also be considered.
- The source of any nursery stock propagation material.
- If any other crops have been propagated from the same source and/or distributed from the affected nurseries.
- Gypsy moths have one generation per year under most environmental conditions.
- Gypsy moth is capable of surviving cold weather through diapauses at the egg life cycle stage.
- Larvae can spread over a kilometre through ballooning and adults (particularly AGM) can spread larger distances (up to 40 km) by flight, although this is generally below one kilometre (Liebhold *et al.,* 2008)

5.2.6 Models of spread potential

The movement of Gypsy moth (European strain) from 1900 to 1990 in North America has been tracked (Liebhold *et al.,* 1992) and can provide guidance on potential movement in Australia should it become established. Average movement rates between 2.8 and 20.9 km a year were recorded for this Gypsy moth incursion. Spread can be attributed to the movement of first instar larvae together with accidental movement by humans.

Spread of the Asian strain may occur at a higher rate due to the adult female moths' ability to fly. Although no models of spread have been developed for this species, adults can fly up to 40 km, but are more likely to travel less than one kilometre before oviposition (Liebhold *et al.,* 2008). However, it is important to note that the 20.8 km per year spread of the EGM (Liebhold *et al.,* 1992) exceeds the natural dispersal distance for this species, and therefore this strain relies on human-aided dispersal. Rates of AGM movement may be similar as it may utilise the same mechanisms of spread with minor increases due to the females' flight ability.

5.2.7 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC, 1998a, 1999).

General points to consider are:

- Design of a statistical delimiting field survey for the presence of the insect on host plants (see Section 5.2 for points to consider in the design).
- Surveys should be completed as described in the BioSecure HACCP manual (Nursery and Garden Industry Australia, 2008), including monitoring processes (summarised in Table 8 and Table 9), indicator plants and weed monitoring.
- Surveys should also consider alternative hosts (see Sections 4.2.1 and 9.1) and not be limited to the primary infested host.
- Information (including absence of the pest) should be recorded.

Table 8. *Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines*

Wear protective clothing when handling suspect samples
Walk at random through the area in a zigzag pattern
Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m^2 of production area
Inspect the tops and bottoms or leaves, looking for any direct evidence of insects
Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually
Inspect the length of all stems and branches for insects and symptoms
During individual plant inspection, strike the foliage over a white sheet of paper or a paper plate to dislodge small insects for easier viewing
If any plants show suspect symptoms or evidence of eggs or nymphs (refer to Section 4.2.3) take a sample (refer to Section 5.2.4) to be formally diagnosed (refer to Section 4.3)
Check for a problem that have occurred regularly in the past, until you are certain it is not present
Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest
Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of PFAs as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

Table 9. *Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines*

Wear protective clothing when handling suspect samples
Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres
Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection
Vary the entrance point in the sampling area (1m to 3m) for each subsequent sampling so that the same plants are not inspected each time
Walk at random through the area in a zigzag pattern
The scout should follow the same general pattern at each sampling
Make an effort to select those plants that appear less healthy for visual inspection
Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m^2 of production area
Inspect the tops and bottoms or leaves, looking for any direct evidence of insects
Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually
Inspect the length of all stems and branches for insects and symptoms
During individual plant inspection, strike the foliage over a white sheet of paper or a paper plate to dislodge small insects for easier viewing
If any plants show suspect symptoms or evidence of eggs or nymphs (refer to Section 4.2.3) take a sample (refer to Section 5.2.4) to be formally diagnosed (refer to Section 4.3)
Check for a problem that have occurred regularly in the past, until you are certain it is not present
Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest
Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed

5.3 Availability of control methods

5.3.1 General procedures for control

- Keep traffic out of affected areas and minimize movement in adjacent areas.
- Adopt best-practice property hygiene procedures to retard the spread of the pest.
- After surveys are completed, destruction of the infested plant material is an effective control.
- On-going surveillance of infested areas to ensure the pest is eradicated.
- Do not use any material from infested plants for propagation.

5.3.2 Chemical control

Gypsy moth can be controlled through broad spectrum insecticides, usually applied from aircraft to control outbreaks. Diflubenzuron, carbaryl and tebufenozide are commonly used synthetic insecticides that are effective against Gypsy moth. Recently these synthetic broad spectrum insecticides have been replaced by applications of *Bacillus thuringiensis* (*Bt*). This naturally occurring bacteria produces a caterpillar-specific toxin. When sprayed on tree leaves, *Bt* will disrupt the digestive system of caterpillars that ingest the leaves. This suppresses their appetites, slows their movement and results in death within 7-10 days.

Any chemicals used for the eradication or control of Gypsy moth in Australia must be registered for use through the Australian Pesticides and Veterinary Medicines Authority (APVMA). For information regarding this process visit the APVMA website (**www.apvma.gov.au**).

5.3.3 Biological control

The most common method of Gypsy moth eradication and control is the application of *Bt* bacteria (see above, Section 5.3.2). Other biological controls currently used or under investigation for Gypsy moth control include:

- *Ooencyrtus kuvanae* – an egg parasite.
- A nuclear polyhedrosis virus from Europe (Fravel and Villemant, 1995).
- Other parasitoids, including *Ceranthia samaensis.*

5.3.4 Physical and cultural control

Silvicultural practices have been proposed as a method of reducing Gypsy moth population numbers, but the wide host range and the economic value of the primary hosts makes this approach nonviable. However, the removal of low vigour trees (Gottschalk, 1993) could lower stand vulnerability. However, these methods are not applicable in an eradication campaign.

5.4 Market access impacts

Within the AQIS PHYTO database (**www.aqis.gov.au/phyto**), export of *Prunus* spp. fruit to India requires an addition phytosanitary statement declaring Gypsy moth is not known to occur in Australia (as at November 2009). Should Gypsy moth be detected or become established in Australia, additional countries may require a specific declaration or supplementary measures upon export. Latest information can be found within PHYTO, using an Advanced search “Search all text” for *Lymantria dispar.*

6 Course of action

Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a PFA) or a measure to eliminate an established pest (establish a PFA). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

6.1 Destruction strategy

6.1.1 Destruction protocols

- General protocols:
  - Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial.
  - Any equipment removed from the site for disposal should be double-bagged.
  - Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser.
- Gypsy moth destruction strategy:
  - Knock down populations with a surface insecticide or *Bt* bacteria.
  - Infested plants can then be destroyed by enclosed incineration or deep burial.
  - Methyl bromide is effective at killing eggs, larvae and pupae.
  - Planting media should be sterilised by autoclaving or methyl bromide, or disposed of through deep burial.

6.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation.
- Readily accessible with clear signage.
- Access to fresh water and power.
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting).
- Gently sloped to drain effluent away.
- Effluent must not enter water courses or water bodies.
- Allow adequate space to move larger vehicles.
- Away from hazards such as power lines.
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Plant Health Australia, 2009]).

- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning.
- Skin and hair in contact with infested plant material or growing media/soil should be washed.

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure *HACCP* Guidelines, however, in the event of a Gypsy moth incursion, procedures outlined in the BioSecure *HACCP* Guidelines may not be effective for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

6.1.3 Priorities

- Confirm the presence of the pest.
- Prevent movement of vehicles and equipment through affected areas.
- Stop the movement of any plant material that may be infested with the pest.
- Determine the strategy for the eradication/decontamination of the pest and infested host material.
- Determine the extent of infestation through survey and plant material trace back.

6.1.4 Plants, by-products and waste processing

- Any growing media/soil or infested plant material removed from the site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial.
- As the pest can be mechanically transmitted, plant debris from the destruction zone must be carefully handled and transported for destruction.
- Infested areas or nursery yards should remain free of susceptible host plants until the area has been shown to be free from the pest.

6.1.5 Disposal issues

- Particular care must be taken to minimize the transfer of infested plant material or insects from the area.
- Host material, including leaf litter, should be collected and incinerated or double bagged and deep buried in an approved site.

6.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice (see Section 3, page 6).

6.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia, 2009) for administrative details and procedures.

6.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions

6.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for translocation of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following, however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones.
- Fenced, barricaded or locked entry to quarantine areas.
- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease.
- Where no dwellings are located within these areas, strong movement controls should be enforced.
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced.
- If a production nursery is situated within the Restricted Area, all nursery trading must cease and no material may be removed without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material.
- Residents should be advised on measures to minimise the inadvertent transport of Gypsy moth from the infested area to unaffected areas.
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned.
- Plant material or plant products must not be removed from the site.
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 6.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found treatment with insecticide may be required.

The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

6.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia, 2009). These zones are outlined below and in Figure 15.

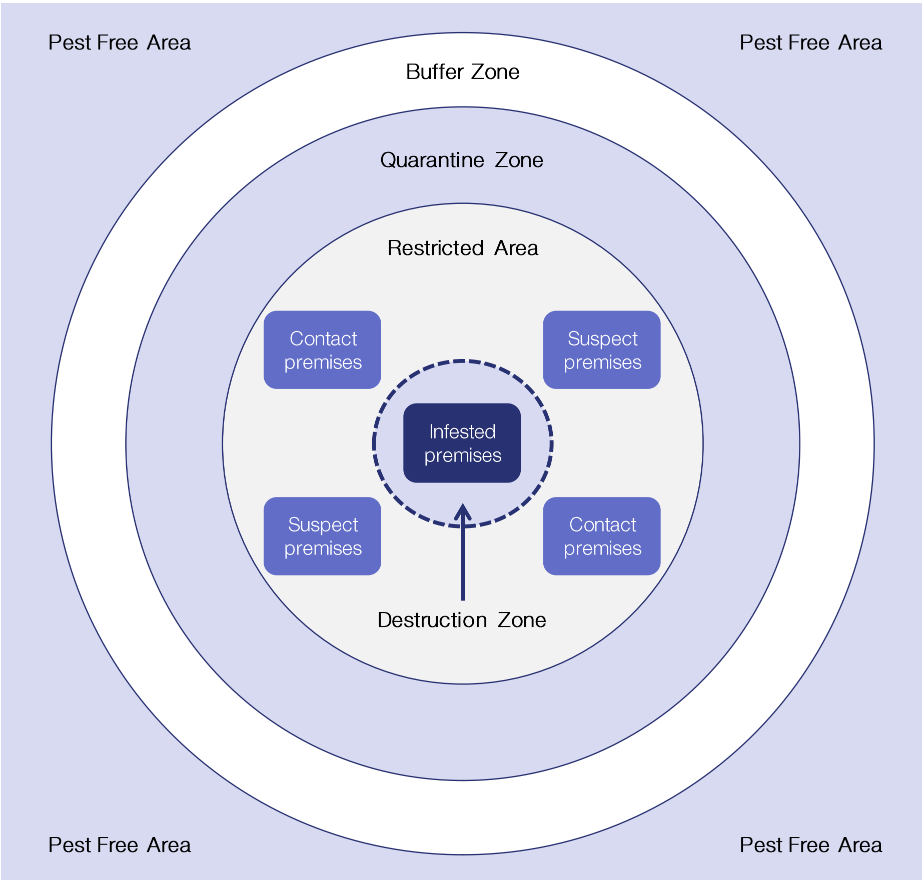

Figure 15. *Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)*

6.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire nursery, property or forest area if spread could have occurred prior to the infection being identified).

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

6.4.2 Restricted Area

The Restricted Area is defined as the zone immediately around the infested premises and suspected infested premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

6.4.3 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infested property.

6.4.4 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

6.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infested premises and all suspected infested premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

6.5 Decontamination and property clean up

Decontaminant practices are aimed at eliminating the pest thus preventing its spread to other areas.

6.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia, 2009) for further information.
- Keep traffic out of affected area and minimize it in adjacent areas.
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties.
- Machinery, equipment, vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 6.1.2.
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label.
- Infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial.

6.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

6.6 Surveillance and tracing

6.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area.
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk.
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to Gypsy moth.
- Surveying production nurseries selling at risk host plants.
- Surveying other host growing properties and backyards.

6.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 6.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for Gypsy moth have been outlined elsewhere in this plan (refer to Section 5.2).

Steps outlined in Table 10 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

Table 10. *Phases to be covered in a survey plan*

Phase 1	• Identify properties that fall within the buffer zone around the infested premise • Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)
Phase 2	Preliminary survey of host crops in properties in buffer zone establishing points of pest detection
Phase 3	Surveillance of an intensive nature, to support control and containment activities around points of pest detection
Phase 4	Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or the pest. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the pest. Pathways to be considered are: • Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment • The producer and retailer of infested material if this is suspected to be the source of the outbreak • Labour and other personnel that have moved from infested, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers) • Movement of plant material and growing media/soil from controlled and restricted areas
Phase 5	Surveillance of production and retail nurseries, gardens and public land where plants known to be hosts of the pest are being grown
Phase 6	Agreed area freedom maintenance, post control and containment

6.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including cropping conditions, the previous level of infestation, the control measures applied and the pest biology.

Specific methods to confirm eradication of Gypsy moth may include:

- Monitoring of sentinel plants that have been grown at the affected sites. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms or other indications of Gypsy moth presence.
- If symptoms or suspect insects are detected, samples are to be collected and stored and plants destroyed.
- Targeted surveys for Gypsy moth should be undertaken within the Quarantine Zone to demonstrate pest absence.
- Alternate non-host crops should be grown on the site and any self-sown plants sprayed out with a selective herbicide

7 Technical debrief and analysis for stand down

Refer to PLANTPLAN (Plant Health Australia, 2009) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group
- Eradication has been deemed impractical and procedures for long-term management of the pest risk have been implemented

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

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8.1 Related Websites

Australian Pesticide and Veterinary Medicine Authority (**www.apvma.gov.au**)

Center of Invasive Species and Ecosystem Health – Bugwood Network (**www.bugwood.org**)

CAB Compendium (**www.cabicompendium.org**)

Pest and Disease Image Library (**www.padil.gov.au**)

9 Appendices

9.1 Appendix 1: Known Australian host species

Table 11. *Known Australian plant species on which the gypsy moth can complete its lifecycle. Table modified from Matsuki et al (2001).*

Quercus pubescens	*E. laevopinea*	*E. viminalis*
Q. robur	*E. macarthurii*	*Callistemon brachyandrus*
Corymbia maculata	*E. melliodora*	*Callistemon citrinus*
Eucalyptus acaciiformis	*E. neglecta*	*Callistemon macropunctatus*
E. aggregata	*E. nicholii*	*Callistemon viminalis*
E. amygdalina	*E. nitens*	*Melaleuca squamea*
E. archeri	*E. nitida*	*Grevillea juniperina*
E. camaldulensis	*E. obliqua*	*Acacia melanoxylon*
E. cinerea	*E. ovata*	*Acacia dealbata*
E. coccifera	*E. pauciflora*	*Hakea laurina*
E. cordata	*E. perriniana*	*Nothofagus cunninghamii*
E. dalrympleana	*E. polyanthemos*	*N. fusca*
E. delegatensis	*E. pulchella*	*N. menziesii*
E. glaucescens	*E. radiata*	*N. moorei*
E. globulus globules	*E. regnans*	*N. solandri*
E. globulus maidenii	*E. risdonii*	*N. solandri cliffortioides*
E. globulus pseudoglobulus	*E. rubida*	*N. truncata*
E. grandis	*E. sieberi*	*Podocarpus halli*
E. gunnii	*E. sideroxylon*	*Podocarpus totara*
E. gunnii X *E. dalrympleana*	*E. stellulata*	*Pinus contorta*
E. kartzoffiana	*E. urnigera*	*Pinus radiata*

9.2 Appendix 2: Resources and facilities

Table 12 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

Table 12. *Diagnostic service facilities in Australia*

Facility	State	Details
DPI Victoria – Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9222; Fax: (03) 9800 3521
DPI Victoria – Horsham Centre	Vic	Natimuk Rd Horsham VIC 3400 Ph: (03) 5362 2111; Fax: (03) 5362 2187
Industry and Investment New South Wales – Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: (02) 4640 6327; Fax: (02) 4640 6428
I&I New South Wales – Tamworth Agricultural Institute	NSW	4 Marsden Park Road Calala NSW 2340 Ph: (02) 6763 1100; Fax: (02) 6763 1222
I&I New South Wales – Wagga Wagga Agricultural Institute	NSW	PMB Wagga Wagga NSW 2650 Ph: (02) 6938 1999; Fax: (02) 6938 1809
SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: (08) 8303 9400; Fax: (08) 8303 9403
Grow Help Australia	QLD	Entomology Building 80 Meiers Road Indooroopilly QLD 4068 Ph: (07) 3896 9668; Fax: (07) 3896 9446
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: (08) 9368 3721; Fax: (08) 9474 2658