Subcommittee on National Plant Health Surveillance

National Surveillance Protocol

For Spongy and Nun Moth (*Lymantria* spp.)

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1 Scope/ rationale

Lymantria spp. and sub-species are potential pests that could cause serious damage to many agricultural production and environmentally important tree species leading to severe economic and social amenity impacts if they were to establish in Australia. This protocol has been developed for early detection, response and pest status surveillance.

2 Background

Exotic *Lymantria* species are a recognised biosecurity threat to Australian agricultural, horticultural and forestry industries, and natural forested areas and urban landscapes, and can also negatively impact human health.

In July 2021, the common name of *Lymantria dispar* (gypsy moth) was discontinued by the Entomological Society of America, and in February 2022, the society voted to adopt spongy moth as the common name for the moth species. This protocol reflects that change.

Spongy moth (*Lymantria dispar*) taxonomy is complex (Pogue & Schaefer 2007). The North American (NASM) and European (ESM) spongy moth sub-species are classified *Lymantria dispar dispar,* and females in these taxa have wings but are flightless. Females of the Asian spongy moth (ASM, *L. dispar asiatica*) and Japanese spongy moth (JSM, *L. dispar japonica*) species are capable of flight. Unless otherwise specified, the information in this protocol refers to all sub-species that may enter Australia. Although currently less of a threat, this protocol also includes surveillance information for *L. monacha*, nun moth, a recognised forest pest throughout Europe and Asia.

Table 1 – Species covered by this protocol.

Scientific name*	Common name	Distribution
Lymantria dispar dispar	Nth American/European spongy moth	Widespread throughout Europe, western Asia and North Africa. Introduced to North America.
Lymantria dispar asiatica	Asian spongy moth	Widespread throughout East Asia. Under eradication in North America.
Lymantria dispar japonica	Japanese spongy moth	Japan
Lymantria monacha	Nun moth	Native through Asia (east to Japan) and Europe (west to the United Kingdom.

*Previous names are described in Appendix one

Spongy moths are not currently established in Australia. They are native throughout Europe and Asia and have been introduced to North America, Russia and northern Africa. They are one of the most destructive taxa of fruit, ornamental, and forestry trees in the northern hemisphere. The feeding behaviour of the caterpillar causes severe defoliation that leads to a reduction in growth, secondary infections and tree death. Eradication programs in the United States have cost an average of $30 million each year in the past twenty years, and the program of deploying pheromone traps across the length of the advancing edge of the moth's invasion front has so far slowed, but not stopped the spread of spongy moth (Sharov *et al.* 2002; Tobin 2008; USDA 2019). Eradication programs, which were initially heavily reliant on insecticides but have now moved to bio-controls, have had limited success (Liebhold & Kean 2019). *Lymantria monacha*, the nun moth, is a significant forest pest throughout Europe, China, Korea and Japan. It is slowly increasing its northward range while increasing in abundance (Fält-Nardmann *et al*. 2018).

In addition to agricultural impacts, the hairs of spongy and nun moth caterpillars may cause allergic reactions in people. The damage caused by feeding can adversely impact the health of recreational and protected forests and swarms of moths are also a nuisance in urban areas (Hajek & Tobin 2009).

Rates of establishment and spread differ between subspecies, but climate models and risk analysis suggest a considerable part of Australia would provide a suitable habitat for spongy moth (Matsuki *et al.* 2001, Paini *et al.* 2018 and reviewed in Bloomfield *et al*. 2018), but less so for nun moth. Given the potential industry and environmental cost, the feasibility of eradication, cost of ongoing management, surveillance and export clearance, surveillance for spongy moth must focus on early detection to support eradication.

3 Glossary

Table 2 - Definitions and abbreviations

Term/abbreviation	Definition
ASM	Asian spongy moth
JSM	Japanese spongy moth
ESM	European spongy moth
NASM	North American spongy moth
NSP	National Surveillance Protocol
USDA	United States Department of Agriculture
DAFF	Department of Agriculture, Fisheries and Forestry
Approved Arrangements	Sites where operators have entered into an agreement with DAFF to manage biosecurity risks and/or perform the documentary assessment of goods in accordance with departmental requirements, using their own sites, facilities, equipment and people, and without constant supervision by the department and with occasional compliance monitoring or auditing.

4 Pest risk profile and pathway analysis

The spongy moth is a proven invader and is likely to occupy all areas of the world where suitable hosts are grown (CABI 2021). ESM and related species have limited dispersal potential as the females do not fly, although both ESM and ASM are aided by their propensity to lay eggs on man-made objects. Spongy moths do not persist in sub-tropical or tropical regions, but both species will find ample host plant and climatic suitability in Australia. Pathway and establishment analyses have been completed by the Commonwealth Department of Agriculture and SNPHS and documented in *Priority Pest Surveillance Requirements Spongy moth*[1].

4.1 Entry pathways

Spongy moth species are not present in any country close enough to Australia to allow natural dispersal. As the females can fly short distances to lay eggs, the likelihood of entry is much higher for ASM, and egg masses are often intercepted at the border on vessels and occasionally on containers. Larvae ballooning off vessels has historically been managed as the major pathway, but container pathways are now considered the major threat due to the concealed locations on containers where egg masses can be laid. The moths and eggs are difficult to target with specific border inspection measures.

Nun moth females will fly and deposit eggs on man-made objects. They are particularly attracted to lights which may increase their presence in port areas. However, nun moths have not been detected on goods or vessels entering Australia.

Notably, spongy moths have not established anywhere in the southern hemisphere. The complexity of embryo development in these species may provide a natural barrier to the establishment as the eggs will often arrive in a port undeveloped (See Section 5.2 – Lifecycle).

4.2 Establishment and spread

Short-range spread of spongy moth occurs through larval ballooning. Ballooning distances are debated (Bell *et al.* 2005), but wind-assisted travel by first instars has been recorded to be several kilometres. Long-range spread of all life stages is generally driven by human-assisted movement, including:

- Eggs on the surface of vehicles, machinery, equipment and shipping containers.
- Larvae attached to travellers and their possessions.
- Eggs, larvae and pupae travelling on plant parts (bark, stems, shoots, trunks and branches), such as nursery stock.

ESM's spread distances across North America have been estimated at over 20km per year, greatly influenced by human movement (Bigsby *et al*. 2011). The establishment of spongy moth species is dependent on the founding population size and the potential distribution of suitable ecological factors. Modelling from Bloomfield *et al*. (2018) suggested that based on a 10% survival rate of 400 eggs in an egg mass, at least two viable eggs masses would be required to establish an ongoing population. Models differ in predicting the suitability of the potential range of spongy moths in Australia but suggest areas inland from Brisbane, and Gladstone ports are cool enough to support the most northern limit of their range.

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[1] Available on request through the *Subcommittee on National Plant Health Surveillance*

Nun moths are trans-palearctic species – occurring within a band between northern latitudes 43 °N and 57 °N. The equivalent latitude in the south would only cover a small area of southern Tasmania, and the risk of establishment of nun moth in Australia is low.

5 Pest biology and ecology

The biology and ecology of the Lymantria are described to assist in surveillance and trapping. In addition, the identification, lifecycle and habits provide insight to surveillance practitioners to support early detection.

5.1 Detection in the field

Species-specific identification in the field is not possible, particularly if trap clearances have hundreds of individual moths.

5.2 Identification

A National Diagnostic Protocol for *Lymantria dispar* is available (Horak *et al.* 2020).

Complete diagnosis and identification to the species level requires an expert in moths of the Lymantriidae family. Taxonomic identification of individual strains should not be based on flight characteristics but determined by molecular methods. As hybridisation is common, mitochondrial DNA should not be used to distinguish strains, but ASM and ESM can be differentiated using randomly amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) markers (Plant Health Australia 2009).

Initial diagnosis of each life stage can be made using the characters described below:

Eggs

Spongy moths are named for their eggs masses which resemble sponges and are covered in light brown-yellowish protective hairs that come from the female's abdomen as she oviposits. Egg masses are commonly about 20 to 40 mm in length and laid in clusters of up to 1000, often in dark crevices or sheltered areas. Common laying areas include the surface of trees and rocks (**Figures 1 and 2**), surfaces of buildings, sea containers and on vehicles.

Nun moth eggs are also laid in a clump but without a covering of hair. Eggs are generally 1 mm in diameter, laid under the bark. Each female may lay up to 300 eggs but deposit them in a range of different places.

Figure 1 – Pale coloured spongy moth egg masses on rock [*Source: John H. Ghent, USDA Forest Service, Bugwood.org*]

Figure 2 – Spongy moth eggs on arrival in Australia [*Source: DAFF, Operational Science Services*]

Caterpillars

Caterpillars of *Lymantria* species vary in colour but are commonly dark. Spongy moths have distinctive dots down their dorsal side; five pairs of blue dots and six pairs of red dots (**Figure 3**). At emergence, the caterpillars are small, 3 mm in length, but after development may reach 50-90 mm, with females almost twice the size of males. Nun moth larvae are often dark until the second instar, where they develop white spots on the third thoracic segment. In later instars, the head turns orange-brown with a mottled brown-black dorsal stripe. The mature larvae are greenish-brown and well camouflaged on their host species.

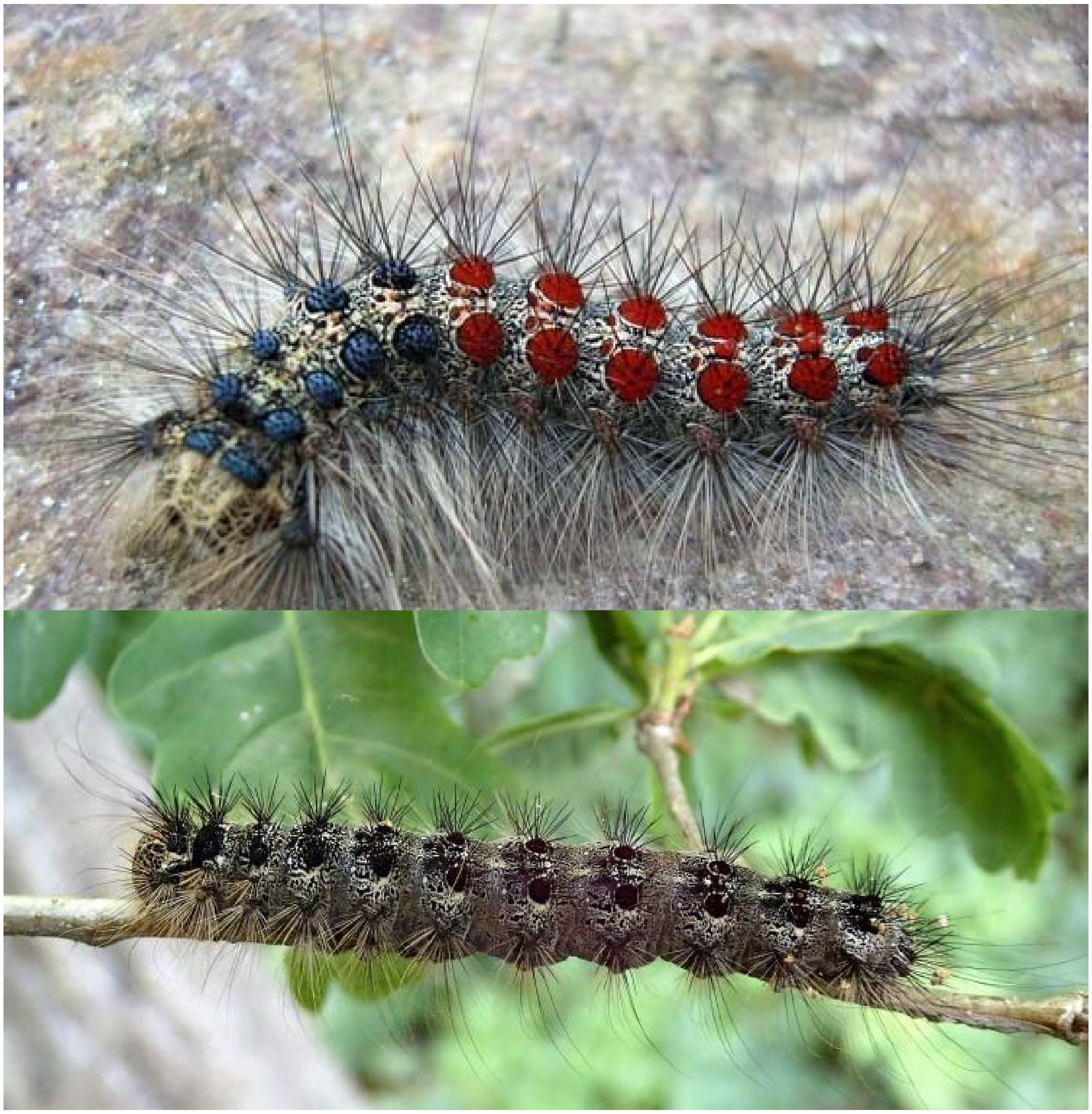

Figure 3 – (top) Spongy moth caterpillar [*Source: creative commons*] (bottom) Late instar of nun moth caterpillar [*Source: Tomáš Vrána, biolib.cz*].

Pupae

All pupae are reddish-brown with red hairs, usually found on bark. Females are around 20-30 mm long, and males are shorter.

Adults

Adult spongy moth females are pale yellow/white with dark brown bands across the forewing. All species show sexual dimorphism. Females are larger than males at 40-70 mm. Males reach a size of 30-40 mm and are dark grey-brown with darker bands across the wings (**Figure 4**). Adult nun moths are commonly white but maybe brown to dark grey, with black wavy lines across each wing. Males have distinctive bipectinate antennae - giving a distinctive comb-like appearance.

Figure 4 – (top) Asian spongy moths, lighter, larger female at the top, darker, smaller male on the bottom [*Source: NSW DPI*] (bottom) Colour variation across females (top row) and males (bottom row) of adult nun moths.

5.3 Lifecycle

Spongy moths produce one generation per year and mature through four main life stages. After oviposition, eggs develop and then enter diapause until emergence in the early spring/beginning of summer (Doane & McManus 1981). Eggs can survive extreme temperature variations (Clatterbuck *et al.* 2017), but embryos must go through three temperature-dependent phases to complete development:

- A temperature of around 25°C degrees allows embryos to develop in the eggs in approximately 16 days, and development is slowed in cooler weather.
- Diapause then begins and usually lasts for several months until a sufficient amount of time at a cooler temperature terminates this phase.
- The last phase of development is again responsive to warm temperatures, and exposure to 25°C degrees will allow eggs to hatch in 11–18 days (Gray *et al.* 2001). This obligate and temperature-dependent diapause period is a natural barrier to development in eggs that travel on ships across the open ocean.

After hatching, caterpillars begin feeding immediately or disperse via ballooning to a nearby tree. Once on a tree, they feed on new leaves first, in daylight hours, particularly in the morning, although this is switched to night-time feeding by the third or fourth instar (Doane & McManus 1981). Caterpillars rest on the underside of leaves attached by a silk thread.

Each instar stage takes approximately a week; five to six instars are common, but development is plastic, and up to nine instars have been recorded. The larvae pupate in sheltered locations such as tree bark crevices or leaf litter and take approximately two weeks to emerge with adults reproductively ready to mate and oviposit within hours (Doane & McManus 1981). Moths live for approximately a week and do not feed during this time.

Lifecycles for nun-moths are extremely similar, though only 6-7 instars have been recorded. Females mate and lay from July through September in the northern hemisphere.

5.4 Habitat

Spongy moths are particularly sensitive to climate, temperature, moisture and light, although they often take advantage of microclimates found in crevices and sheltered areas of forests and orchards (Doane & McManus 1981). Sub-zero temperatures are lethal for prolonged periods but would have little restrictive effect in Australia's temperate climate. Significantly for Australia, daytime temperatures of up to 32°C accelerate growth and development and have been associated with large outbreaks in the United States (Doane & McManus 1981).

The outbreak zone of nun moth in the northern latitudes is generally bounded by the July isotherm of 16°C and September isotherm of 10.5°C, and outbreaks are more common in areas of low precipitation (400–700mm annually) (Bejer 1988).

6 Host range and part of host affected

Spongy moth caterpillars feed on new buds and leaves of trees in great numbers and can cause extreme defoliation during an outbreak. Damage usually begins on new leaves towards the top of the canopy. Severe and prolonged feeding is marked by damaged, chlorotic leaves, which are often smaller than normal, and these symptoms eventually lead to dieback or severe secondary infections (Clatterback *et al.* 2017). Each caterpillar is able to eat up to 1 m^2 of foliage in its lifetime, adult moths do not feed.

The host range is expansive and extends to many commercially and environmentally sensitive trees in Australia. Successful development and pupation on *Eucalyptus* spp. is variable, but many species tested were able to support complete larval development (Matsuki *et al.* 2001). Preferred hosts include species that are dominant street trees in temperate cities, including oak, alder broadleaf trees, Douglas fir and western hemlock needle trees. Outbreaks commonly begin on these preferred hosts and move to other species as the spongy moth density increases.

Nun moths prefer *Picea abies* (Norway spruce) and *Pinus sylvestris* (Scots pine) in its European range. In cooler parts of Australia, trees grown as street and residential trees would be the preferred species. A New Zealand study found nun moths were able to complete their lifecycle on pine species (including *Pinus radiata*), oak and spruce that are found abundantly in Australia (Withers & Keena 2001).

Appendix two contains a list of known primary spongy moth and nun moth hosts.

7 Pest damage

Caterpillar feeding and defoliation, as described above, are the most obvious visual symptoms on host trees (**Figure 5**). These sightings will often be accompanied by caterpillar silk strands and droppings and, depending on the season, egg masses and dead adults which may help with identification in the field. In its native range, outbreaks are localised and infrequent, but major outbreaks in North America occur every 5-10 years, lasting 2-3 years, which, when combined with other stressors such as drought, results in high tree mortality (Doane & McManus 1981).

Figure 5 – (top) Caterpillars and feeding damage [*Source: Tim Tigner, Virginia Department of Forestry, Bugwood.org*] (bottom) Visible feeding damage on street trees [*Source: Karla Salp, Washington State Department of Agriculture, Bugwood.org*]

8 Surveillance methodology

To maximise the likelihood of surveillance efforts, the deployment of traps should consider survey location and surveillance methods, e.g. trap type and lure, along with timing and frequency. In addition, sample handling of *Lymantria* species needs to be considered to maintain the sample's integrity and improve diagnostic outcomes.

8.1 Survey locations

Climate matching by Matsuki *et al.* (2001) suggested that all ports from Brisbane south, across to Perth and including Tasmania would support the full development of the lifecycle of spongy moths. This is in contrast to the CLIMEX model of Paini *et al.* (2018), which suggests the establishment will not occur in Brisbane. Further modelling by Bloomfield et al. (2018) also found Brisbane unsuitable, although marginally suitable for establishment when moving further inland.

Surveillance should occur in the vicinity of high-risk ports targeting the pathways from caterpillars ballooning from vessels. Surveillance should target areas with hosts that are favourable for population build-up, as close as possible to the major berths.

Surveillance to target eggs on the container pathway should identify sites close to where containers and goods may sit for extended periods. Visual surveillance locations for eggs should be focussed within seaports, container storage parks, Approved Arrangements, freight hubs and other commercial and industrial areas, and include high-risk oviposition sites such as containers, machinery and vehicles.

8.2 Surveillance methods

Pheromone baited traps are the primary detection method for spongy moths.

Trapping surveys (adults)

<u>Lures</u>
Traps should be baited with Disparlure – a commercially synthesised sex pheromone of spongy moth. As this lure attracts adult males, it will be effective for both ASM and ESM as males of both species can fly. The Disparlure should be changed every six weeks across the trapping season.

Disparlure has been shown to be an effective lure for nun moth males. However, a species-specific lure (Flex lure) has been developed and has shown a positive response in field trials in China (Wang *et al*. 2017). This lure has been shown to be more effective as an attractant for nun moths than Disparlure, and as the female nun moth pheromone repels spongy moth males, the synthetic lure reduces by-catch of spongy moths. This lure has not been tested in low population or early detection studies, and it is unclear how widely available it is commercially.

Similarly, the lure Lymowit (witasek®) has been shown to be effective in large population studies, where it is useful for monitoring. Effectiveness at low population levels remains unknown.

<u>Traps</u>

Agrisense delta traps are a triangular-shaped trap, with a sticky base. Delta traps catch significantly higher males than other trap types, such as bucket traps (Cardé *et al.* 2017) and are consistently recommended by the USDA (2019) for detection surveys. The traps have a sticky base and do not require insecticide. Sticky traps need to be checked fortnightly for integrity and replaced when necessary. Trap placement should consider other traps nearby, each trap must be placed at a minimum of 200 metres from any other traps containing Disparlure lures and at least 3 metres from any other traps.

Trap studies of nun moths have shown they can be caught in the sticky traps, but Unitraps (funnel with lid) have a higher catch rate (Morewood *et al*. 2000). Unitraps also catch more by-catch (David Smith pers. comm.).

In large trapping events in Finland, it has been shown that nun moths lose their typical black and white wing colouring when densely packed in traps (Melin *et al*. 2020).

Figure 6 – (left) Agrisense delta moth trap (right) plain black stripe. The manufacturer claims a 15% increase in catch from the black stripe trap. [*Source: https://www.entosol.com.au/prodpc_mdelta.htm*]

<u>Trap placements</u>

Male spongy moths usually follow the edge of host plants and do not gather in areas with no trees or plants. Therefore, if possible, the periphery of host plant areas in survey locations is the best site for trap placement, on the windward side so the pheromone scent is carried into the trees. Traps for all moth species should be placed preferentially in shady areas against a flat surface such as the trunk, approximately 1.5m off the ground.

Visual surveys of adults, larvae and pupae on host plants

Host trees and any areas of defoliation in survey locations should be targeted for visual surveillance. Caterpillars are often found on the periphery of the tree branches, on the top of the canopy, or resting underneath leaves attached by a silk thread. Late season instars feed at night and may be concealed during the day. Pupae are often attached to the trunk of the tree. Caterpillars should be handled with care as they can induce an allergic reaction.

Eggs on oviposition sites

Inspection of non-hosts is not recommended for early detection surveys but may be undertaken in response to a detection or areas of heightened threat. Eggs, larvae and pupae can be found on host plants or other hard surfaces, including walls, rocks, vehicles and outdoor furniture. All visual surveys in survey locations for eggs should concentrate on surfaces that are relatively concealed and do not receive direct sunlight.

8.3 Survey timing and frequency

Trapping should be placed from spring to autumn in high-risk areas to coincide with peaks in flight periods for adult male moths. Host-plant surveys using visual surveillance, sweep netting and beating trays can target all life stages during spring and summer. Temperature has strong impacts on the timing of larval emergence, as such latitude will be a large predictor of behaviour and Bloomfield *et al*. (2018) suggests timing of surveillance could be specifically aligned with male flight behaviour in each Australian port.

Response or pest status surveillance will need to consider the spongy moth's lifecycle in relation to seasonal influences in Australia and adjust surveillance timing and methods if the introduced population begins to align its behaviour with local conditions.

Table 3 – Generalised phenology of spongy moth in northern ports of origin and early detection surveillance timing in Australia.

Month	Northern hemisphere behaviour	Surveillance in Australia
May	Larvae emerge, feed and pupate.	No trapping
Jun	Adults mate and females oviposit, potentially on vessels or machinery at port.	
Jul		
Aug		
Sep		
Oct	Pre diapause	
Nov	Eggs enter diapause	Trapping
Dec		
Jan		
Feb		
Mar	Post diapause	
Apr		

8.4 Sample handling

By law everyone must comply with biosecurity legislation when moving any suspect exotic plant pest sample, including when sending samples for identification.

In developing a surveillance program, all participants must be clear about their obligations regarding what to do if suspect samples need to be moved.

If movement obligations are not understood, contact the Emergency Plant Pest hotline on 1800 084 881, to obtain instructions to collect and move samples safely.

General diagnostic laboratory contact, preparation and sample submission information is provided below in **Table 4**.

All laboratories should be contacted before sample submission to determine if they have suitable diagnostic capability for the pest (including the life stage being sampled) and have appropriate accreditation to receive biosecurity material. In some cases, specimens may need to be collected as live samples for diagnostic reasons and the laboratory must meet jurisdictional requirements to handle live specimens.

Table 4 – State and territory diagnostic contacts for submission of suspect plant pest samples.

Jurisdiction	Contact details
Queensland	13 25 23 Submitters will be advised what to do with samples through this service.
Western Australia	08 9368 3080 Photos of samples can also be submitted through MyPestGuide app or website Preparation and submission: https://www.agric.wa.gov.au/livestock-biosecurity/sending-specimens-identification
South Australia	(08) 8429 2249 Preparation: https://pir.sa.gov.au/__data/assets/pdf_file/0020/236234/Packaging_Brochure_low.pdf Submission: https://pir.sa.gov.au/research/services/crop_diagnostics/insect_diagnostic_service
New South Wales	1800 680 244 biosecurity@dpi.nsw.gov.au Preparation and submission: https://www.dpi.nsw.gov.au/about-us/services/laboratory-services/plant-health/collecting-and-submitting-plant-or-insect-samples
Northern Territory	(08) 8999 2118 Submission: https://nt.gov.au/industry/agriculture/food-crops-plants-and-quarantine/plant-diseases-and-pests/plant-pathology-and-entomology-contacts
Victoria	(03) 9032 7515 Submission: https://agriculture.vic.gov.au/support-and-resources/services/diagnostic-services
Tasmania	(03) 6165 3777 plantdiagnosticservices@nre.tas.gov.au Preparation and submission: https://nre.tas.gov.au/biosecurity-tasmania/plant-biosecurity/plant-diagnostic-services

If suspect moths are detected in a sticky trap, the entire trap should be collected, and insects should not be removed from the trap as they may be damaged and unable to be identified. Spongy moths share similarities with native Lymantriidae, and expert entomological identification is required.

Adults collected via sweep net should be carefully placed in a killing jar with cotton wool to prevent damage. If long transport times are expected, consult with the identifying entomologist to confirm other options.

Pupae, larvae and eggs may be collected for rearing or molecular analysis.

Molecular collections

Caterpillars and pupae collected should be placed in 90% ethanol for preservation to undergo molecular diagnostics.

Live collections

Eggs, caterpillars and pupae collected during visual inspection can be reared for identification. Host plant material should be noted, collected and refreshed when housing the insect, and a damp paper towel should be included for moisture. The long life cycle of spongy moths means adults are the best life stage to be collected for efficient identification, but all life stages are recommended if available.

9 Record keeping

Surveillance data captured for use in the plant health surveillance system in Australia should be collected using the Pest Record Specification. This biosecurity specific data standard is endorsed for use by the Sub-committee on National Plant Health Surveillance and Plant Health Committee and is maintained by the Commonwealth. Surveillance planning should include the development of a program data standard, based on the Pest Record Specification, and utilising any relevant pest-specific data protocols. Information on using the Pest Record Specification and Data Protocols is available on the Plant Surveillance Network Australasia-Pacific (PSNAP) website.

A pest specific data protocol for Spongy and Nun moth has been developed and is available on the PSNAP website.

When undertaking surveillance, the data fields to be collected must be considered for individual pests and surveillance methods and the data protocol describes the mandatory, required and optional data fields. A number of data fields have specific controlled vocabulary from which they must be filled. Controlled vocabulary lists are included in the data protocol and tabled below, based on the methods and technology described in this protocol.

Table 5 – Controlled vocabulary lists for spongy moth.

scientificName	inspectionMethod	hostMaterial	non-hostMaterial	lureType	trapType	protocolID
Lymantria dispar dispar	Trapping	Plantae	Container	Disparlure	Delta trap	Spongy (formerly gypsy) moths
Lymantria dispar asiatica	Visual surveillance	Host lists provided in Appendix two	Machinery	Lymowit	Bucket trap	
Lymantria dispar japonica			Vehicle			
			Premises			

Table 6 – Controlled vocabulary lists for nun moth.

scientificName	inspectionMethod	hostMaterial	non-hostMaterial	lureType	trapType	protocolID
Lymantria monacha	Trapping	Plantae	Container	Disparlure	Delta trap	NSP_Spongy and Nun Moth
	Visual surveillance	Host lists provided in Appendix two	Machinery	Flex lure	Bucket trap	
			Vehicle	Lymowit	Unitrap	
			Premises			

10 Research and development

Knowledge of the spongy moths' larvae's ability to complete its lifecycle on native species would improve our understanding of impacts and the management of its spread in Australia.

Understanding the pathways for entry, potential habitat, and host range of nun moths is also important to assess impacts and determine whether trapping networks targeting this species are necessary.

For both species, defoliation of host trees is likely to be noticed and potentially reported by the general public. However, the likelihood varies based on tree resistance, visibility and other additional stressors making damage more obvious (Bloomfield *et al*. 2018). Citizen science reporting and engagement should be investigated to improve response time during early detection before infestation rates are too high to eradicate.

10.1 Triggers for protocol document review

- If an outbreak occurs and surveillance priorities change from detection to delimiting.
- If establishment occurs in export ports of the southern hemisphere

11 Contacts and further information

Plant Health Australia 2009

Threat Specific Contingency Plan Gypsy moth Asian and European strains *Lymantria dispar dispar*. Plant Health Australia Canberra ACT. Available from: http://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Gypsy-moth-CP-2009.pdf

Mark Stanaway

Plant Health Policy, Department of Agriculture, Fisheries and Forestry

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13 Appendices

13.1 Appendix one Previous names for spongy and nun moth

Accepted scientific name	Previous names
Lymantria dispar	*Bombyx dispar* Linnaeus
	Hypogymna dispar Linnaeus
	Liparis dispar Linnaeus
	Ocneria dispar Linnaeus
	Phalaena dispar Linnaeus
	Porthesia dispar Linnaeus
	Porthetria dispar Linnaeus
Lymantria monacha	*Bombyx eremita* Hübner, 1808
	Bombyx nigra Freyer, 1833
	Liparis monacha Linnaeus
	Liparis monacha var. *oethiops* De Selys-Longchamps, 1857
	Lymantria brunnea Stipan, 1933
	Lymantria fasciata Hannemann, 1916
	Lymantria kusnezovi Kulossow, 1928
	Lymantria monacha chosenibia Bryk
	Lymantria monacha eremita
	Lymantria monacha flaviventer Kruilikovsky
	Lymantria monacha gracilis Kruilikovsky
	Lymantria monacha idae Bryk
	Lymantria monacha lateralis Bryk
	Lymantria monacha matuta Bryk
	Lymantria monacha nigra
	Lymantria transiens Lambillion, 1909
	Noctua heteroclita Müller, 1764
	Ocneria monacha Linnaeus
	Phalaena Bombyx monacha Linnaeus, 1758
	Phalaena monacha Linnaeus
	Porthetria monacha Linnaeus
	Psilura monacha Linnaeus
	Psilura transiens Thierry Mieg, 1886

13.2 Appendix two Known host plants of spongy and nun moth

Table 7 - Known primary and secondary plant hosts of spongy moth (CABI 2021)

Scientific name	Common name	Family	Host type
Alnus	Alders	Betulaceae	Primary
Alnus incana	Grey alder	Betulaceae	Primary
Alnus maritima		Betulaceae	Primary
Alnus oblongifolia		Betulaceae	Primary
Alnus rubra	Red alder	Betulaceae	Primary
Betula	Birches	Betulaceae	Primary
Betula nigra	River birch	Betulaceae	Primary
Betula papyrifera	Paper birch	Betulaceae	Primary
Betula pendula	Common silver birch	Betulaceae	Primary
Betula populifolia	Gray birch	Betulaceae	Primary
Betula pumila	Low birch	Betulaceae	Primary
Corylus		Betulaceae	Primary
Corylus americana	American hazel	Betulaceae	Primary
Corylus avellana	Hazel	Betulaceae	Primary
Cotinus coggygria	Fustet	Anacardiaceae	Primary
Cotinus obovatus		Anacardiaceae	Primary
Crataegus	Hawthorns	Rosaceae	Primary
Hamamelis virginiana	Virginian witch-hazel	Hamamelidaceae	Primary
Larix	Larches	Pinaceae	Primary
Larix decidua	Common larch	Pinaceae	Primary
Larix kaempferi	Japanese larch	Pinaceae	Primary
Larix laricina	American larch	Pinaceae	Primary
Larix lyallii	Subalpine larch	Pinaceae	Primary
Larix occidentalis	Western larch	Pinaceae	Primary
Liquidambar styraciflua	Sweet gum	Hamamelidaceae	Primary
Malus	Ornamental species apple	Rosaceae	Primary
Malus angustifolia		Rosaceae	Primary
Malus coronaria	Sweet crab-apple	Rosaceae	Primary
Malus fusca		Rosaceae	Primary
Malus ioensis	Prairie crab-apple	Rosaceae	Primary
Ostrya virginiana	American hophornbeam	Betulaceae	Primary
Pistacia vera	Pistachio	Anacardiaceae	Primary
Populus	Poplars	Salicaceae	Primary
Populus angustifolia	Narrow-leaved poplar	Salicaceae	Primary
Populus balsamifera	Balm of Gilead	Salicaceae	Primary
Populus grandidentata	Bigtooth aspen	Salicaceae	Primary
Populus heterophylla	Swamp cottonwood	Salicaceae	Primary
Populus nigra	Black poplar	Salicaceae	Primary
Populus tremuloides	Trembling aspen	Salicaceae	Primary

Quercus	Oaks	Fagaceae	Primary
Quercus alba	White oak	Fagaceae	Primary
Quercus austrina		Fagaceae	Primary
Quercus bicolor	Swamp white oak	Fagaceae	Primary
Quercus coccinea	Scarlet oak	Fagaceae	Primary
Quercus ellipsoidalis	Northern pin oak	Fagaceae	Primary
Quercus garryana	Garry oak	Fagaceae	Primary
Quercus ilex	Holm oak	Fagaceae	Primary
Quercus ilicifolia	Bear oak	Fagaceae	Primary
Quercus lobata	California white oak	Fagaceae	Primary
Quercus montana	Basket oak	Fagaceae	Primary
Quercus muehlenbergii	Chinquapin oak	Fagaceae	Primary
Quercus palustris	Pin oak	Fagaceae	Primary
Quercus petraea	Durmast oak	Fagaceae	Primary
Quercus robur	Common oak	Fagaceae	Primary
Quercus rubra	Northern red oak	Fagaceae	Primary
Quercus suber	Cork oak	Fagaceae	Primary
Quercus velutina	Black oak	Fagaceae	Primary
Rhus copallina	Shining sumac	Anacardiaceae	Primary
Rhus glabra	Smooth sumac	Anacardiaceae	Primary
Rhus typhina	Staghorn sumac	Anacardiaceae	Primary
Salix	Willows	Salicaceae	Primary
Salix alba	White willow	Salicaceae	Primary
Salix babylonica	Weeping willow	Salicaceae	Primary
Salix discolor		Salicaceae	Primary
Salix fragilis	Crack willow	Salicaceae	Primary
Salix nigra	Black willow	Salicaceae	Primary
Sorbus americana	American mountainash	Rosaceae	Primary
Sorbus aucuparia	Mountain ash	Rosaceae	Primary
Tilia americana	Basswood	Tiliaceae	Primary
Tilia cordata	Small-leaf lime	Tiliaceae	Primary

Table 8 - Known primary and secondary plant hosts of spongy moth (CABI 2020)

Scientific name	Common name	Family	Host type
Abies firma	Momi fir	Pinaceae	Primary
Betula ermanii	Erman's birch	Betulaceae	Primary
Betula pendula	Common silver birch	Betulaceae	Primary
Fagus sylvatica	Common beech	Fagaceae	Primary
Larix decidua	Common larch	Pinaceae	Primary
Larix gmelinii	Dahurian larch	Pinaceae	Primary
Larix kaempferi	Japanese larch	Pinaceae	Primary
Picea abies	Common spruce	Pinaceae	Primary
Picea jezoensis	Yeddo spruce	Pinaceae	Primary

Picea sitchensis	Sitka spruce	Pinaceae	Primary
Pinus contorta	Lodgepole pine	Pinaceae	Primary
Pinus koraiensis	Fruit pine	Pinaceae	Primary
Pinus sylvestris	Scots pine	Pinaceae	Primary
Quercus petraea	Durmast oak	Fagaceae	Primary
Quercus robur	Common oak	Fagaceae	Primary