Pest risk analysis for six moth species: lessons for the biosecurity system on managing hitchhiker organisms

1. Executive summary

1.1. BACKGROUND
There has been concern about the number of recent arrivals and incursion responses for moth species over the last decade and there is a perception that such arrivals have increased. This risk analysis considers six high-profile moth incursions from the last decade. The purpose of this risk analysis is twofold; firstly, to consider whether the species that have been eradicated are likely to arrive again and if so, what measures are necessary to prevent reinvasion and secondly, to use some of the recently arrived species as examples to investigate a range of different arrival pathways and better understand moth invasions. This work uses pest risk analysis methodology to understanding potential entry pathways and management. It uses a broad approach to arrival pathways, considering host plant and non-host (inanimate) pathways, including a wide range of imported goods (including items such as passenger baggage and military transport) as well as the associated packaging, containers, ships and aircraft. Natural invasion has also been considered.

This risk analysis has investigated the risks associated with five recently arrived species in detail, including pathways for the entry and establishment, and impacts overseas and in New Zealand. These species are Asian gypsy moth\(^1\), fall webworm\(^2\), guava moth\(^3\), painted apple moth\(^4\) and white-spotted tussock moth\(^5\). In addition, a further species, gum leaf skeletoniser\(^6\), was investigated; the similarities between likely arrival pathways for gum leaf skeletoniser and arrival pathways for the other species, as well as the lack of interception records, meant that detailed analysis was not considered useful. The reasons for the perceived increase in the arrival of pest moths have been considered and there are recommended approaches to inform future import health standards and border management, both for the five species investigated in detail and generic approaches that will be useful for other species.

1.2. KEY CONCLUSIONS

- The analysis indicates that all the moths, except guava moth, arrived through similar means, as hitchhikers on inanimate pathways such as transported containers or their contents, on bulk goods, vehicles or machinery.
- These moths entered New Zealand as small, camouflaged eggs or pupae. They occur in low numbers, but on high volume pathways. The risk for any single item on a pathway is low, but the high volumes multiply the risk of entry.
- Guava moth is different. It may have arrived as naturally (by flying to New Zealand), on a ship or plane, or with fruit carried by passengers.

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1 *Lymantria dispar* (Lymantriidae) from east Asia
2 *Hyphantria cunea* (Arctiidae)
3 *Coscinopteryx improbana* (Carposinidae)
4 *Teia anartoides* (Lymantriidae)
5 *Orgyia thyellina* (Lymantriidae)
6 *Uraba lugens* (Nolidae)
Specific incursions cannot be linked to specific pathways. A moth found in a trap will look exactly the same if its parents came to New Zealand on a sea container, a car or garden furniture.

The overall risk of entry differs for each pathway, and also according to a range of specific factors that may also differ for each consignment that arrives at the border.

The analysis demonstrates how difficult the problem is to manage, and that there are no immediate solutions with our current trade volumes, infrastructure and technology.

This analysis identifies a range of approaches that can be used to reduce the risk of future moth incursions. Some are already underway, including:
- improving the quality and access to interception data;
- increasing follow-up on significant border interceptions;
- planning to improve identification of intercepted insects on some priority pathways;
- improving our links with overseas countries managing similar pest problems.

1.3. SPECIES SUMMARIES

1.3.1. Asian gypsy moth

Gypsy moth is a species which defoliates trees in both its native range (Europe and Asia) and where it has been introduced to North America. It is of major concern internationally and is expected to have significant impacts on a range of values if established in New Zealand, although its impact is not expected to be as severe as that seen for gypsy moth in North America. This analysis has focused only on gypsy moth from eastern Asia, usually known as Asian gypsy moth.

Asian gypsy moth is frequently detected at the border and has been detected once in a surveillance trap. The detected moth was a male and considered most likely to be from an established population based on the life stage detected and time of year. This species is considered eradicated from New Zealand.

Most Asian gypsy moth females are capable of flight and are attracted to light. They lay their eggs on a wide range of surfaces. The egg masses persist for long periods, 9 months or longer. Asian gypsy moth is most likely to enter New Zealand as egg masses. It is essentially a hitchhiker pest, occurring on a range of pathways but comparatively unlikely to be imported associated with its host plants. Overall, the proportion of imported items that contain Asian gypsy moth egg masses is small, but it is difficult to predict which items are likely to have egg masses on them and which are not. This difficulty is partly because of the very wide range of substrates that Asian gypsy moth uses for egg laying but is also due to the information available. Asian gypsy moth is considered to occur at low frequency on a number of high volume pathways, making management difficult.

Asian gypsy moth could enter New Zealand from any temperate East Asian country, including China, Japan, the Russian Federation and South Korea. Available evidence suggested that the most likely pathway for arrival is used vehicles (specifically from Japan) and that while the current measures do reduce the likelihood of entry and establishment, they do not reduce it to a level that is negligible. There are several other pathways on which Asian gypsy moth can arrive. The measures currently in
place for most pathways will not reduce entry and establishment to negligible levels (although the measures are considered to be adequate on some pathways). The sea container pathway is of particular concern. There is limited information on the association of Asian gypsy moth with sea containers, but available information suggests that egg masses are most likely to occur on their lower surfaces making the moth difficult to detect.

The likelihood of Asian gypsy moth establishment is lower than that for some other species because it typically only has one generation per year and its life cycle is strongly linked to seasonal changes. Therefore it must overcome the seasonal inversion from the Northern to the Southern Hemisphere. The seasonal inversion is likely to reduce the likelihood of establishment but would not prevent establishment occurring.

1.3.2. Fall webworm

Fall webworm has an extremely wide host range and is considered a significant pest overseas, although it is not usually considered to be among the most damaging species. Concern is high in China where it is a comparatively recent arrival. Significant impacts are expected should it establish in New Zealand, mainly on horticulture and on amenity plantings. There is considerable uncertainty over the likely impact on native species, forestry (low volume, high value species), shelter plantings and erosion control.

Fall webworm is considered to have entered New Zealand on 4-6 separate occasions and has once been reported as temporarily established. It is currently considered eradicated from New Zealand. There have only been three detections at the border, two dead larvae and one egg mass (viability not reported) on a used vehicle.

Fall webworm could arrive from its native range (North America) or from its introduced range (Europe and East Asia), but is particularly likely to come from China, Japan, South Korea and the USA. The most likely life stage to be transported is dormant (diapause) pupae, during the Northern Hemisphere autumn, winter and spring. Larvae crawl seeking protected sites for pupation, so pupae only occur on objects that are close to larval populations. Pupae are small and camouflaged and occur on a range of different materials. They are likely to be carried as hitchhiker pests on many pathways, including vehicles, sea containers, packaging materials and various commodities.

Fall webworm has variable numbers of generations per year (1-4) and is therefore easily capable of overcoming the seasonal inversion from the Northern to the Southern Hemisphere. However it would not establish as easily as a species arriving from the Southern Hemisphere.

For most of the likely pathways, including vehicles, the current measures are not considered to reduce the likelihood of entry to a negligible level. It is possible that sometimes quarantine officers and accredited persons detect and treat fall webworm, but because these types of organisms are not routinely identified, there is no record of any detection of fall webworm pupae (the most likely life stage) occurring. There is therefore little information available that can be used to narrow down which pathways it is likely to occur on.
1.3.3. Guava moth

Guava moth is an inconspicuous species with caterpillars that develop entirely inside fruit. Prior to its arrival in New Zealand it had a low profile, regarded as only a minor pest in Australia and with no recorded border interceptions in New Zealand. Since establishing in Northland it has become a pest on some crops in this area.

Guava moth has now established in New Zealand. Guava moth may have arrived either by wind from Australia (which is the source of most new moth arrivals), via illegally imported fruit or on a ship or plane (the first two scenarios are more likely). As it is not reported from commercial crops in Australia, guava moth is considered more likely to be transported in fruit from home gardens.

At the time guava moth arrived in New Zealand, the measures on the main pathway for illegal fruit imports (air passengers) were less stringent than they are now.

1.3.4. Painted apple moth

Painted apple moth is a poorly known species which mainly feeds on wattles in its native range in Australia, although it is known to have a wide host range, including significant horticultural species. A number of species, including New Zealand natives, have been added to the host list from New Zealand field observations. It belongs to the same family (Lymantriidae) as well known pest species such as gypsy moth. However predicting impact is difficult as New Zealand is the first place that it has been reported outside its native range.

Painted apple moth is considered to have entered New Zealand from south-eastern Australia on about 7-9 separate occasions and has previously been established. The established population in West Auckland has been eradicated, but detections in traps over the last 2 years (male moths most likely to have arrived from Australia as pupae) suggests a significant likelihood of reinvasion.

There have been only two interceptions of painted apple moth associated with imported items, the most recent in 1993. It is likely to be carried as a hitchhiker pest on a wide range of pathways, including vehicles, sea containers, packaging materials and various other commodities. Because there is limited information from Australia and so few interceptions, there is almost no information that would allow a more precise definition of the main pathways of entry.

It is most likely to be transported as pupae, immobile adults (females) or eggs, but all these life stages get onto transported items when larvae crawl seeking pupation sites. This is similar to the way that fall webworm is transported.

Painted apple moth has variable numbers of generations per year (1-4) and because it is coming from south-eastern Australia, is coming from similar seasonal conditions. It is therefore expected to establish more easily than species coming from the Northern Hemisphere as there is no seasonal inversion to be overcome.

1.3.5. White-spotted tussock moth

White-spotted tussock moth is another poorly known species related to gypsy moth. It is native to eastern Asia and has a wide host range. It is not regarded as a significant pest overseas but has never established outside its native range apart from in New
Zealand which makes predicting future impacts more difficult. Since its host range includes important commercial species and it has shown some ability to feed on native plants, significant impacts in New Zealand cannot be ruled out.

White-spotted tussock moth was detected in New Zealand in 1996 and, following control, was declared eradicated in 1998. It is sometimes intercepted at the border on used vehicles, but, based on biology and experience with other species it is likely to occur on other pathways as well (the frequency is not known).

The most likely life stage to be transported is dormant (diapause) egg masses, but these are laid by immobile female moths on or near the cocoon in which they pupated. This behaviour means that white-spotted tussock moth, like fall webworm and painted apple moth, gets onto transported items when larvae crawl seeking pupation sites.

Like fall webworm, it has variable numbers of generations per year (1-4) and is therefore easily capable of overcoming the seasonal inversion from the Northern to the Southern Hemisphere. However it would not establish as easily as a species arriving from the Southern Hemisphere.

1.3.6. Gum leaf skeletoniser

Gum leaf skeletoniser is mainly known from eucalypts and other closely related species in its native range in Australia. Since its detection in New Zealand, it has been found on a range of other plants. While a native species, its ability to defoliate eucalypts means that it is sometimes regarded as a pest in Australia.

Gum leaf skeletoniser has entered and established in New Zealand. Initially, a small population was found at Mount Maunganui and eradicated but later, in Auckland, a much larger population was found and eradication was not feasible. There are very few interception records.

Initial investigations into the biology of gum leaf skeletoniser suggested that, although it is unrelated to any of the other species in this analysis, it is transported in similar ways. It is most likely to be transported as pupae which are well camouflaged. Like fall webworm, painted apple moth and white-spotted tussock moth, gum leaf skeletoniser gets onto items when larvae crawl seeking pupation sites. Because of similarities with other species in this analysis, gum-leaf skeletoniser has not been considered in detail.

1.4. PATHWAY SUMMARIES

Each pathway was reviewed for each species. The following section summarises all the pathways investigated for all moths.

1.4.1. Containers

Sea containers are likely to be an important pathway of entry for moth species such as Asian gypsy moth, fall webworm and painted apple moth (and also gum-leaf skeletoniser, which has now established). Asian gypsy moth egg masses have been recorded on the underside of sea containers, but available information for the other moth species is not adequate to determine where on sea containers they would be – whether inside, outside or on container packaging and contents. Because dormant life
stages (such as eggs of Asian gypsy moth or pupae of fall webworm) can persist for months and sea containers visit many different ports, a sea container coming from a country not known to have these species may still carry live eggs or pupae into New Zealand. In all cases, moth life stages are considered to occur only at low frequencies on sea containers, but the high volumes of imported containers multiply the risk greatly.

Likelihood of establishment is increased the longer a sea container is present in New Zealand and the more widely it is distributed, as transported moths will have greater opportunities to get off containers and locate host plants. The likelihood of establishment from sea containers is intermediate between that of ships (lower due to the short average visits to New Zealand ports) and that of vehicles (which enter New Zealand permanently and are widely distributed).

Risk management on sea containers is currently reducing the risk of entry of Asian gypsy moth, but not to a negligible level. There is no evidence that the entry of painted apple moth or fall webworm is being reduced at all by the current measures on sea containers.

The risk of moth entry associated with air containers is uncertain. There is no evidence that any of the moth species in this analysis are associated with air containers. However the biology of at least some species, for example Asian gypsy moth, indicates that transport by air containers is likely to occur sometimes, although not frequently.

1.4.2. Fresh plant material
Fresh plant material pathways such as nursery stock, cut flowers and foliage, and fresh fruit are considered to be very minor pathways for the moth species considered in this analysis. Very small volumes of host material are imported and most of the moth species considered here have only a short period in their life cycle where they are associated with host plants. For example, Asian gypsy moth spends 8-9 months of the year as egg masses which are mostly laid on inanimate objects.

The associated life stages (larvae) are likely to be conspicuous on the types of material transported on fresh plant material pathways. While there is little information on the efficacy of current measures on these pathways, there are no obvious indications that they are ineffective.

1.4.3. Military
Because of the way military vehicles and equipment are used and stored both overseas and on return to New Zealand, they are particularly likely to transport hitchhiker pests, although the overall volumes are small. The international transport of military vehicles and equipment has been associated with gypsy moth and fall webworm overseas. However there has been little military transport to New Zealand from countries with the moth species in this analysis and military transport is not likely to have been associated with the recent incursions.

Changes in where troops are stationed or where exercises are conducted would result in a changed level of risk, and so the risk of species such as fall webworm being
transported to New Zealand should be considered when there are changes on the military pathway.

1.4.4. Packaging materials

Packaging materials are likely to be a significant pathway for the entry on fall webworm and painted apple moth, but there is very little information on which to base an assessment. One of the only records of painted apple moth associated with imported items was on metal packaging.

There is very little information about the association of packaging materials with the moth species in this analysis but painted apple moth or fall webworm (and probably also Asian gypsy moth, white-spotted tussock moth and gum leaf skeletoniser) show behaviours that would result on them occurring on packaging materials, if those materials were used or stored close to moth populations. It is specific use and storage conditions, and not any intrinsic property of the material that will affect whether or not they are associated with the moths considered in this analysis.

The recent changes to requirements for wood packaging (ISPM 15) are expected to reduce the likelihood of moths entering New Zealand associated with wood packaging, but only to a limited extent, as the ISPM 15 treatments are applied only once. ISPM 15 treatments do not have long-term activity against pests, so following treatment wood packaging can become reinfested. There is no evidence that any other measures are reducing the likelihood of entry of fall webworm or painted apple moth associated with packaging.

1.4.5. Passengers, baggage and unaccompanied personal effects

None of the moth species considered in this analysis are likely to be transported deliberately, but they are all associated with items that are transported as passenger baggage. On the passenger pathway, the likelihood of any one passenger transporting any one of the moth species is small, but the high volumes on the pathway mean that infrequent events pose a significant risk. Current risk management reduces the likelihood of entry on the passenger pathway to a negligible level.

Unaccompanied personal effects, such as household goods, is a much lower volume pathway but is considered a significant pathway for all species except guava moth. Outdoor furniture, because it is generally used and stored in gardens, is particularly likely to be associated with species such as painted apple moth, fall webworm, white-spotted tussock moth and gum-leaf skeletoniser. A survey has been recently conducted on this pathway and the efficacy of current measures will be assessed in the light of these results. In particular, the efficacy of measures on the unaccompanied personal effects pathway will depend on the efficacy of detecting items likely to carry moth life stages such as outdoor furniture.

Following clearance, items carried as passenger baggage or unaccompanied personal effects can go almost anywhere in New Zealand, reducing the likelihood that any incursion resulting from these pathways will be detected early.

1.4.6. Vehicles

Used vehicles are likely to be an important pathway of entry for moth species such as Asian gypsy moth, fall webworm and white-spotted tussock moth. Asian gypsy moth
egg masses are commonly recorded from imported used vehicles, with white-spotted tussock moth egg masses recorded less frequently. There are a small number of records of fall webworm from used vehicles, but none of pupae. While pupae are the most likely life stage of fall webworm to be transported, they are small and cryptic and are unlikely to be detected visually.

The likelihood of a particular vehicle carrying moth species such as Asian gypsy moth or white-spotted tussock moth depends on specific use and storage conditions prior to export, such as whether it was parked outdoors at night during the flight season or whether it was parked near host trees.

Risk management on used vehicles is currently reducing the risk of entry of Asian gypsy moth and white-spotted tussock moth, but not to a negligible level. There is no evidence that the re-entry of fall webworm is being reduced at all by the current measures on used vehicles.

New vehicles are considered less likely to carry moth species than used vehicles, but they are sometimes stored outdoors for weeks or months. The biology of the moths indicates a significant risk if new vehicles are stored outdoors at certain times of year in proximity to host plants. The likelihood of a particular new vehicle carrying moth species will differ based on supply chain factors such as where the vehicles were made, when they were made and when they were shipped. There is no evidence that current risk management for new vehicles is reducing the entry of any of the moth species in this analysis.

Following clearance, vehicles can go almost anywhere in New Zealand, reducing the likelihood that any incursion resulting from imported vehicles will be detected early.

### 1.4.7 Vessels and aircraft

Ships are an important pathway of entry for Asian gypsy moth only, but ships are also a minor pathway for guava moth. None of the other moth species in this analysis are likely to be transported on ships.

There is a well documented link between Asian gypsy moth and ships from far eastern Russia. Depending on port conditions, ships from other countries would also carry Asian gypsy moth egg masses although it is unlikely that ships from other countries have the high numbers of egg masses observed on ships visiting ports in far eastern Russia.

In order for Asian gypsy moth to enter New Zealand via ships, the egg masses would need to hatch and larvae balloon to shore while the ships are close to land. This substantially lowers the risk from ships compared to items that are temporarily present on shore, such as containers, or items which arrive permanently, such as vehicles.

Current risk management is directed at ships that have visited ports in far eastern Russia, and substantially reduces the likelihood of entry for Asian gypsy moth associated with these ships, but not ships from other countries with Asian gypsy moth.
There is no evidence that aircraft are a significant pathway for any of the moth species in this analysis, although live moths are occasionally carried to New Zealand on aircraft and so aircraft are considered a minor pathway for moth transport.

1.4.8. Wind

Most new moths entering New Zealand arrive on wind currents from Australia during periods of strong westerly winds. However, of the species in this analysis, wind currents are a likely pathway for guava moth only.

Only adult moths are likely to arrive via wind currents from Australia, and of these, species with adults capable of feeding are much more likely to live long enough to establish populations. There is no evidence that ballooning larvae of moths ever travel far enough on wind currents to cross the Tasman Sea.

1.4.9. Others

A great variety of other commodities are imported into New Zealand. Apart from some specific cases where there are special circumstances that affect that pathway (for example, live host plant material and items used in the outdoors such as vehicles, which are both covered separately), the likelihood of different commodities transporting moths is not particularly dependent on the nature of the commodity. The important factor is use and storage conditions prior to transport to New Zealand. The currently available information does not allow the identification of higher and lower risk pathways within this general group.

1.5. UNCERTAINTY

Some major areas of uncertainty were identified in this risk analysis. In the case of fall webworm, painted apple moth and white-spotted tussock moth, the critical uncertainties were the distances that larvae crawl when seeking pupation sites and the factors that influence the selection of pupation sites. There was minimal information on these factors in the scientific literature, but this is crucial for understanding which imported goods are likely to contain viable life stages of these three species.

In general, one of the most critical uncertainties relates to information on interceptions. Interception records cannot be considered an accurate indication of the true contamination rates on a pathway. The recent trap detections of painted apple moth and fall webworm clearly show the drawbacks of relying on interceptions to indicate arrivals – the post-border surveillance trap detections indicate that these species have arrived in New Zealand and crossed the border undetected on a number of separate occasions during 2005/2006, but there are no recorded interceptions of these species at the border during the same time period. This indicates that the current risk management regimes for the main entry pathways are not effective in detecting and recording these species.

Interception data have the potential to be a valuable tool in reducing the risk associated with these species, but need to be gathered and stored in an appropriate manner. The use of interception data is discussed further under the recommended measures.
1.6. MOTH NATURALISATION TRENDS
No strong trend of increasing moth naturalisation was found. Over many years, the majority of new moth arrivals and naturalisations have come from Australia and many arrived naturally via trans-Tasman winds. This is still considered to be the case, but there have been some changes in naturalisation patterns highlighted in this analysis. One notable change is that, prior to 1986, no moth species from Asia established in New Zealand, but since that time at least 10 Asian species have established in New Zealand (in addition, fall webworm, while not native to Asia, is also considered most likely to have arrived in New Zealand from Asia). The changing arrival pattern reflects changing trade patterns.

1.6.1. Moths as hitchhikers
All of the recent incursion responses for moths have been for species that are most likely to have entered as hitchhiker pests. (This excludes guava moth, for which there was no incursion response.) Hitchhiker pests are defined in various ways, but are usually considered to be those species that have an opportunistic association with transported commodities or other items (like sea containers) with which they have no biological host relationship. Because the association is opportunistic, they are frequently associated with a wide range of different items, usually at low frequency but often on high volume pathways, in an apparently random manner. While the association appears random, it is not for the species in this analysis. Rather, the information required to detect the pattern is not available. For example, most of the moth species in this analysis are likely to get onto objects when larvae crawl seeking pupation sites, therefore any object containing pupae of these species must have been close enough to host plants for a larva to crawl off a host plant and onto the object. The exception is Asian gypsy moth, where most females fly before laying egg masses. However factors such as lights of certain wavelengths are known to influence the flight of Asian gypsy moth, so the positioning of an object in relation to lights will affect its likelihood of having egg masses laid on it.

It is the use and storage conditions for transported items (i.e. both the goods and associated containers and packaging) prior to export that influence whether or not these items carry moth species. The random appearance of this type of hitchhiker is not because they occur randomly, but because available information does not indicate the use and storage history in most cases.

Species such as painted apple moth, fall webworm and even Asian gypsy moth are uncommon contaminants of imported goods and other items. However because the overall volumes on these pathways are very high, arrivals occur at a frequency that is likely to result in establishment. Low frequency, high consequence pests on high volume pathways are particularly difficult to manage because of the apparently random nature of their occurrence. A better understanding of the factors that influence contamination (that is, having information that allows the pattern to be seen) can be used to manage hitchhiker pests more effectively. This strategy is discussed under the recommended measures.

1.7. RECOMMENDED MEASURES
While four moth species have been successfully eradicated over the last decade, the likelihood of reinvasion for all of these species, particularly Asian gypsy moth, fall
webworm and painted apple moth, remains significant. This section considers risk management approaches for all the species that have been successfully eradicated, that is, Asian gypsy moth, fall webworm, painted apple moth and white-spotted tussock moth, but not gum-leaf skeletoniser or guava moth (which are established in New Zealand).

All of these species are primarily hitchhiker species and are transported in similar ways on similar pathways. In most cases, risk management measures for the different species are very similar. Therefore, measures are not separated out by the different moth species.

A number of these measures will also have significant benefits in managing future risks from new moth species, both those which are known pests identified as a threat to New Zealand, such as the European form of gypsy moth (present in Europe and North America), nun moth\(^7\) and Douglas fir tussock moth\(^8\), and other less well known species such as some of the Australian lymantriids.

1.7.1. **Goal of risk management**

The recommended goal of risk management for Asian gypsy moth, fall webworm, painted apple moth and white-spotted tussock moth is to reduce the likelihood of entry to a level where further establishments (and potential incursion responses) of these species are not likely to occur. Defining this level more precisely is not currently possible.

Because it is not possible to narrow down which items are most likely to carry these moth species, and which are not, achieving this goal would mean treating all the identified risk goods (including, for example, more than 500 000 sea containers per annum). With the currently available techniques and technologies, identifying and treating all risk goods is not possible for all pathways, although it is possible for some.

For those pathways where this goal cannot be achieved, a progressive approach to reducing the risk is suggested as an alternative. Achieving the alternative goal would mean that incursions are still expected to occur but there would be fewer over time.

1.7.2. **Generic recommendations**

Seven general approaches to risk management are outlined. These are approaches that can be used on any pathway. For each pathway, a subset of these measures is recommended and prioritised.

- Support increased identifications for priority organisms (in particular pupae and other life stages that may be moths), capture the data in a more usable way and use to inform future risk management such as profiling – high priority (highest priority recommendation in this analysis).
  - this approach also includes making further use of new technologies to get more information out of detections, such as DNA testing and isotope tracing.
- Conduct targeted surveys on some pathways (these are stated under the pathway recommendations). Survey design and analysis needs to consider the problem of

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\(^7\) *Lymantria monacha*

\(^8\) *Orgyia pseudotsugata*
lower frequency, high consequence pests on high volume pathways. On their own,
targeted surveys, especially those that run for short periods of time, cannot
provide all the necessary information for the management of the moth species
considered in this analysis.

- Continue to develop and expand multi-country approaches to managing pests.
  Where this approach is considered particularly important for certain pathways, it
  is stated under the pathway recommendations. The priority for implementing such
  approaches is high but is a long-term goal.
- Enhance surveillance (using a combination of surveillance approaches) for the
  moth species in this analysis. If the recommended goal of reducing entry to a level
  where further establishment was unlikely could be achieved, enhanced
  surveillance for these species would not be required. However because further
  incursions of these, or other, species are expected, enhanced surveillance is
  necessary to increase the likelihood that incursions will be detected while they are
  still eradicable. Surveillance is an important part of overall biosecurity
  management but is not considered as a substitute for measures to reduce the entry
  of the moths considered in this analysis, because there are substantial costs and
  consequences of repeated incursions and eradications, even when the eradications
  are successful.
- Continue to use and refine current management approaches. For many pathways,
  visual inspection will continue to play an important role in risk management for
  these moth species in the short term. Increased use of methodologies that treat
  concealed organisms, such as heat treatment and fumigants, is recommended, as
  visually locating small, cryptic organisms is difficult and not generally a practical
  approach. The effectiveness of current techniques and technologies should be
  improved by better targeting (i.e. improved identification of which items are most
  likely to be contaminated) and improved information on efficacy is required.
- Conduct further investigation on the technologies listed here, as the preferred risk
  management goal cannot be achieved unless new technologies are developed.
  Where these are considered directly relevant to particular pathways these are listed
  under the pathway.
  - quarantine detector dogs;
  - electronic detection;
  - camera-based inspection;
  - residual insecticide;
  - automated insecticide;
  - automated washing;
  - alternative fumigants.
- Undertake research to address uncertainty in a range of areas. Important areas for
  research include larval behaviour in seeking sites for pupation, Asian gypsy moth
  hatching and measures efficacy.

Many of the measures listed above will also reduce the risk associated with exotic
moth species other than those assessed in detail in this analysis.

It is also recommended that recent moth detections in New Zealand and progress on
risk management for high impact moth species be reviewed in five years. By this time
it is expected that substantial progress on information management and technological
developments will have been made and therefore the goal of having no further establishments will be more achievable.
1.7.3. Recommendations by pathway

Table 1. Summary of risk management recommendations by pathway

<table>
<thead>
<tr>
<th>Priority</th>
<th>Pathway</th>
<th>Proposed measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>sea containers</td>
<td>Improve identification and recording for interceptions associated with sea containers. Use this information in conjunction with the current management approaches to better target profiling and risk management measures. Continue to use six-sided inspection and treatment on containers identified as high risk based on profiling and interception data. Conduct a slippage survey on selected south-eastern Australian commodities and associated containers and packaging. Develop international approaches to reducing the risk associated with sea containers – long term Continue to support the development of new technologies that have potential for reducing the risk associated with sea containers – long term. Determining which are the most useful will to some extent depend on the outcomes of the first action.</td>
</tr>
<tr>
<td>High</td>
<td>used vehicles</td>
<td>Measures are proposed in the Import Risk Analysis: vehicles and machinery and are currently under review.</td>
</tr>
<tr>
<td>High</td>
<td>new vehicles</td>
<td>Measures are proposed in the Import Risk Analysis: vehicles and machinery and are currently under review.</td>
</tr>
<tr>
<td>High</td>
<td>packaging materials</td>
<td>Improve identification and recording for interceptions associated with packaging materials. Use this information in conjunction with the current management approaches to better target profiling and risk management measures. Treat those materials that are identified as high risk based on profiling and interception data (note this treatment is in addition to ISPM 15 requirements that do not address recontamination issues). Conduct a slippage survey on selected south-eastern Australian commodities and associated containers and packaging. Develop international approaches to improving use and storage practices for packaging materials – long term. Continue to support the development of new technologies that have potential for reducing the risk associated with packaging materials – long term.</td>
</tr>
<tr>
<td>High</td>
<td>other commodities</td>
<td>Improve identification and recording for interceptions associated with imported commodities. Use this information in conjunction with the current management approaches to better target profiling and risk management measures.</td>
</tr>
<tr>
<td>Priority</td>
<td>Pathway</td>
<td>Proposed measure</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td></td>
<td></td>
<td>Treat those goods that are identified as high risk based on profiling and interception data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conduct a slippage survey on selected south-eastern Australian commodities and associated containers and packaging.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Develop international approaches to improving use and storage practices for commodities identified as high risk – long term</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continue to support the development of new technologies that have potential for reducing the risk associated with imported commodities – long term</td>
</tr>
<tr>
<td>Moderate</td>
<td>air containers</td>
<td>Improve identification and recording for interceptions associated with air containers. Use this information in conjunction with the current management approaches to better target profiling and risk management measures.</td>
</tr>
<tr>
<td>Moderate</td>
<td>cut flowers and foliage</td>
<td>Consider these moth species in the review of the cut flowers and foliage standard – incorporating recent survey results</td>
</tr>
<tr>
<td>Moderate</td>
<td>unaccompanied personal effects</td>
<td>Consider the results of the unaccompanied personal effect survey in relation to these moth species and determine whether review is necessary – incorporating recent survey results</td>
</tr>
<tr>
<td>Moderate</td>
<td>ships</td>
<td>Improve identification and recording for interceptions associated with ships. Use this information in conjunction with the current management approaches to better target profiling and risk management measures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inspect a subset of ships coming from other countries where Asian gypsy moth is known to occur (as well as continuing current approach for ships visiting ports in far eastern Russia during the flight season).</td>
</tr>
<tr>
<td>Low</td>
<td>cut flowers and foliage, nursery stock</td>
<td>Improve identification and recording for both pathways. Use this information in conjunction with the current management approaches to better target risk management measures.</td>
</tr>
<tr>
<td>Low</td>
<td>military</td>
<td>Improve identification and recording for interceptions associated with military transport. Use this information in conjunction with the current management approaches to better target risk management measures.</td>
</tr>
<tr>
<td>Low</td>
<td>unaccompanied personal effects</td>
<td>Improve identification and recording for interceptions associated with unaccompaniedpersonal effects. Use this information in conjunction with the current management approaches to better target profiling and risk management measures.</td>
</tr>
<tr>
<td>Low</td>
<td>passengers and passenger baggage</td>
<td>Improve identification and recording for interceptions associated with passengers and passenger baggage. Use this information in conjunction with the current management approaches to better target profiling and risk management measures.</td>
</tr>
<tr>
<td>Low</td>
<td>ships</td>
<td>Review requirement for offshore inspection of ships that have visited far eastern Russian ports</td>
</tr>
</tbody>
</table>