

Painted Apple Moth – Auckland New Zealand May 1999

OUTLINE FOR CASE-STUDIES ON ALIEN SPECIES

To the extent possible, case-studies should be short and succinct summaries of experience on alien species at the country and regional levels. A case-study should focus on the prevention of introduction, control, and eradication of alien species that threaten ecosystems, habitats or species. Case-studies should include the following sections (a summary of the information may be provided under each heading, and a more detailed paper may be attached; if the information were not available, this should be indicated in the appropriate section):

1. Description of the problem

(a) Location of the case-study

The painted apple moth (PAM) was identified in the Auckland suburb of Glendene on 5 May 1999, following a report from a member of the public. A second infestation of painted apple moth was detected some 15 kilometres away in Mt Wellington on 28 September 1999, again as the result of a public report. MAF estimated that painted apple moth was present in New Zealand for at least one year prior to detection.

Note: Painted apple moth was first detected in New Zealand in 1983 when a small number of live pupae were found in Dunedin. These were on packaging material recently imported from Australia. The pupae were removed and there is no evidence that this arrival resulted in the establishment of a population.

(b) History (origin, pathway and dates, including time-period between initial entry/first detection of alien species and development of impacts) of introduction(s)

As a result of the above find, a response was initiated that included ground and aerial spraying, removal of host vegetation, release of sterile male moths and vegetation movement controls, as well as extensive monitoring.

Initial ground spraying was conducted with Lorsban 50 W and Chlorpyrifos 50 W (both are chlorpyrifos). The spray was later changed to Decis Forte (Deltamethrin) because it remains active longer than the Lorsban 50 W and Chlorpyrifos 50 W spray.

The aerial spraying programme (less than 800 hectares) targeted trees and areas inaccessible to ground spraying. BK117 helicopters were used for small scale and spraying was conducted at as low as five meters above target vegetation in uninhabited areas. In other areas spraying occurred at 45 metres above target vegetation.

Despite this early effort, in 2002 intensification of the eradication programme was required. The intensified programme included 10 aerial spray occurring at 21 day intervals and repeated spraying of persistent sites of infestation over three year (up to 40 sprays in total). The aerial spray programme utilised the biological insecticide Foray 48B. This was a commercial formulation, containing, as the active ingredient, the protein crystal products of the bacterial species *Btk*, inactive *Btk* spores, and a

number of inert components. These inerts are so named because they are not considered to contribute directly to the insecticide activity of the formulation. The term 'inert' does not necessarily reflect their potential to be a concern for the human residents within the treatment area.

These aerial operations were supported by ground spraying of known populations, removal of host vegetation, use of sterile insects to disrupt mating, implementation of vegetation movement restrictions, and trapping to monitor the size and distribution of painted apple moth populations. Communications with the public, provision of health services, and research on painted apple moth and potential public health impacts of spraying were also important aspects of the programme.

The intensified eradication effort made excellent progress. No new moths were detected in the areas covered by the controls and this population is now considered to be eradicated. Post eradication there were seven detections of male moths in traps outside the area where control was undertaken. Based on isotope testing, all seven samples were considered most likely to have spent their larval stage in Australia (apart from one sample which returned an ambiguous result which could not rule out local origin, probably due to poor quality material. These finds indicate that painted apple moth continues to cross the border into New Zealand.

Prior to this incursion and response

Painted apple moth has once been detected at the New Zealand border (on the exterior of a sea container in 1994). There has only been one other detection that has been associated with imported goods (the post-border detection on container packaging in 1983). The pathways for painted apple moth entry into New Zealand are therefore uncertain and may be numerous for this hitch hiker species.

Apart from its (temporary) establishment in New Zealand, painted apple moth has not been reported anywhere else in the world outside its native range. Largely because of this, it is a poorly known species, with most information on painted apple moth based on work done in New Zealand since it was found in 1999.

(c) Description of the alien species concerned: biology of the alien species (the scientific name of species should be indicated if possible) and ecology of the invasion(s) (type of and potential or actual impacts on biological diversity and ecosystem(s) invaded or threatened, and stakeholders involved)

Pest taxonomy

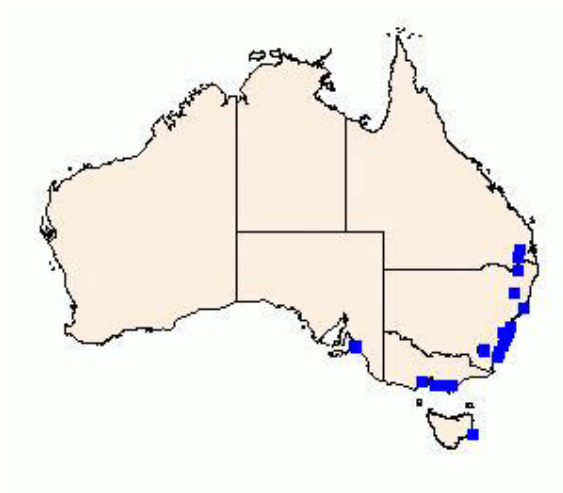
Scientific name: *Teia anartoides* Walker 1855
Synonyms: *Orgyia anartoides* Turner; *Teia pusilla* Butler

Class: Insecta
Order: Lepidoptera
Superfamily: Noctuoidea
Family: Lymantriidae
Common names: Painted apple moth (PAM)

Geographical range

Teia anartoides, the painted apple moth, is native to Australia. It occurs in all mainland states except Western Australia and the Northern Territory, as well as Tasmania. The distribution map below is based on records from the Australian National Insect Collection.

Figure 1 Distribution of painted apple moth in Australia (Anonymous 2005c)



The only known populations established in New Zealand were in west Auckland and these have since been eradicated.

PAM is native to Queensland and Tasmania, Australia. The climatic and ecological similarities between these areas and New Zealand have led MAF to assume that PAM could establish throughout New Zealand.

Morphology

Eggs

Eggs are white or greyish and laid on the cocoon and about 1mm in diameter (Phillips, 1992; Riotte, 1979) (figure 2).

Figure 2 Painted apple moth egg mass, recently laid (image from Biosecurity New Zealand)



Larvae

Larvae are solitary, reaching about 3cm when fully grown. They are densely covered with brown hairs, with four brush-like tufts of white hairs on the back and two forward-pointing, horn-like tufts of black hairs behind the head (figure 3).

Figure 3 Painted apple moth larva (image from Biosecurity New Zealand)



Pupae

Pupae are hairy and reddish brown, encased in a flimsy silken cocoon that incorporates hairs from the caterpillar's body. Cocoons are approximately 2-3 cm long (figure 4). Female pupae are larger than males.

Figure 4 Painted apple moth cocoon (image from Biosecurity New Zealand)



Painted apple moth poses a serious threat to New Zealand's gardens, crops, forests, native bush, and the communities that depend on them. The pest is a voracious and indiscriminate feeder and destroys plants by eating their leaves. It is considered a minor pest in its native Australia where it and other moths are controlled by orchardists using pesticides.

PAM poses a much greater threat to New Zealand's horticulture and native forests and the moth has shown the ability to feed on native and introduced plants common throughout New Zealand.

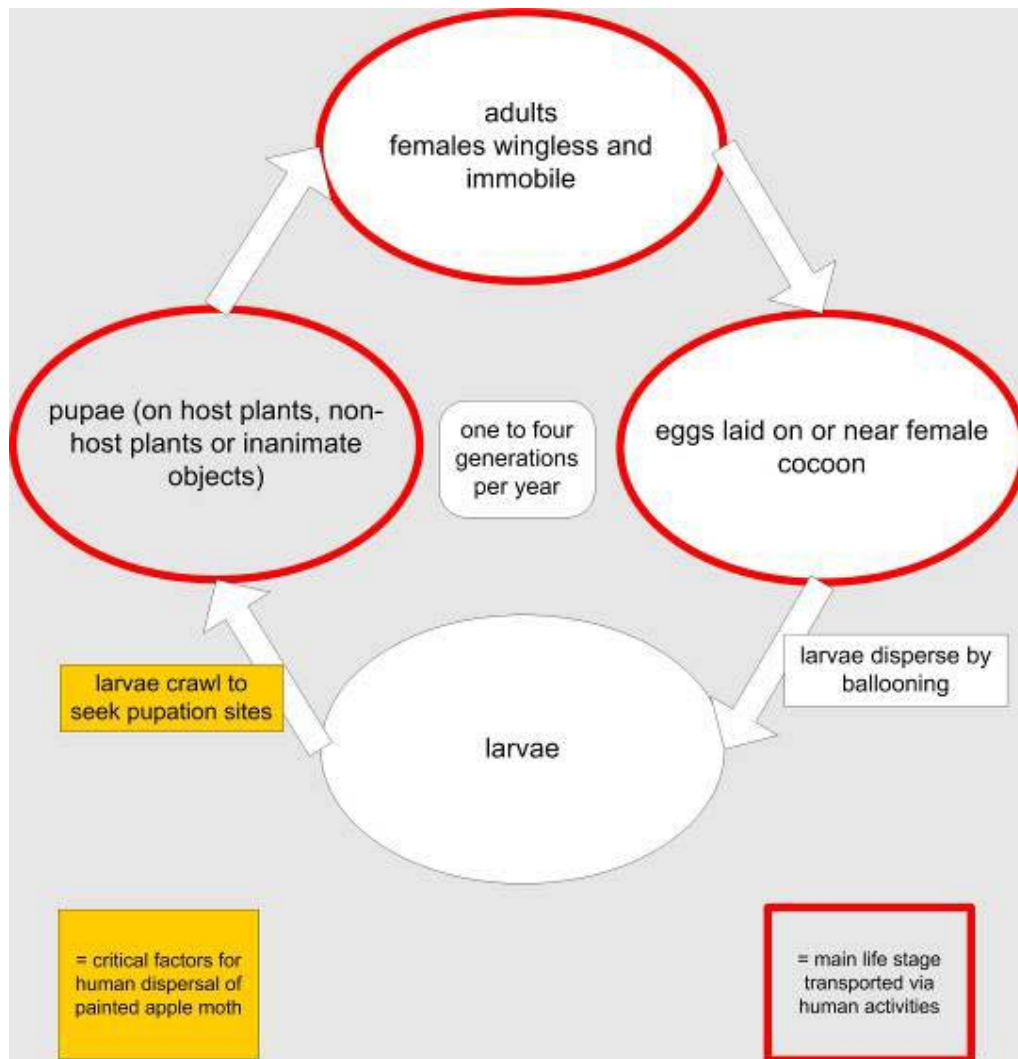
Adult

The male moth has a wingspan of about 2.5 cm and is coloured brown, black and orange. The female is densely covered with pale brown hairs, about 10mm long and very plump and round. Females are flightless with only rudimentary legs and antennae.

Life cycle

The life cycle of painted apple moth is illustrated in figure 5. Painted apple moth has a variable number of generations per year, depending on temperature. Modelling predicted that in Auckland there would have most commonly been three generations per year. In Australia, all stages of the life cycle can be found at any time of the year, although caterpillars are particularly abundant in spring. Painted apple moth is not known to undergo diapause.

Figure 5 Life cycle of painted apple moth



The egg stage lasts for a variable length of time depending on conditions with means ranging from 7.8 days to 37.1 days, depending on temperature, under laboratory

conditions. However at both temperature extremes there was increased egg mortality and it is uncertain how this relates to what occurs in the field.

Following hatching, larvae disperse by crawling or ballooning. They are reported as being solitary, never aggregating even when very young.

Male larvae typically develop through five instars, with females having six. Larval development times are also longer for females, with reports of means from 20 to 50 days for females, compared with 16.3 to 36.5 days for males (different means represent different temperatures under laboratory conditions).

There is limited information on pupation sites for painted apple moth. Various reports indicated that pupae are formed on or near the food plants, and amongst the needles of pine trees. Painted apple moth pupae have been reported on inanimate objects - “near a container supported by a steel frame and which had held glass”). The pupae were on the frame. Records from the surveys conducted as part of the painted apple moth programme in Auckland have indicated a range of sites where painted apple moth can pupate including on the host plants, on non-host plants, on fences and on a letterbox.

The duration of the pupal stage is also dependent on temperature. In contrast with the larval stage, females have a shorter pupation time than males, with means ranging from 6 to 11.7 days, while males ranged from 8.6 to 19.7 days (different means represent different temperatures under laboratory conditions) There are reports of the pupal stage being as short as two weeks in the field and that pupae formed in late autumn/ winter do not emerge until the following summer. This suggests that some degree of pupal diapause may occur, although at this stage experimental work has not confirmed this.

Adult lifespan is not reported but adult Lymantriids typically do not feed so a long lifespan would not be expected. In a laboratory study, more than 70% of males survived at least 8 days, although how this relates to the lifespan in the wild is uncertain. Females emerge from their cocoons with their eggs fully developed and complete oviposition within 24 hours of mating. The female lays her eggs on or very near her cocoon as she is largely immobile.

Although there are seasons where certain life stages are considered to be particularly abundant, there is no clear seasonality for painted apple moth.

Potential Impacts

If the painted apple moth were to spread throughout New Zealand, it could, potentially, have negative impacts on:

- private amenity;
- public amenity;
- plantation forestry;
- horticulture;
- the conservation estate;
- watershed conservation;
- human health; and
- trade prospects.

Economic impact assessment

An economic impact assessment carried out by MAF conservatively estimates potential (net present value) costs of \$48 million over the next 20 years to plantation forestry, and private and public amenity plantings if painted apple moth becomes widely established. Additional to this are impacts to horticulture, watershed conservation and human health. Impacts on the conservation estate have not been estimated but the Department of Conservation considers that these could be significant.

PAM impacts on native flora and fauna in New Zealand

With the currently available information the potential ecological impacts to Conservation are uncertain. PAM does not have a history of being more than a minor pest in Australia, and is not known to have established anywhere else in the world aside from New Zealand. While we know that PAM in New Zealand can reach high numbers, may have high survivorship and feeds on additional hosts to those observed in Australia, the eradication programme has prevented PAM from spreading outside of the urban environment into areas of native or production forest. It is therefore difficult to predict the likely behaviour and impacts of PAM on native species.

Host testing

The host testing showed that PAM can complete a full life cycle on a number of native plant species. It is notable that PAM appeared to do better in terms of survivorship on kowhai (*S tetraptera*) than on the black wattle which is accepted as being PAM's preferred host. Larval weights were as high on some *Carmichaelia* species as they were on *S. tetraptera*, presumably indicating these species are as favourable as the kowhai and wattle species.

PAM completed a full life cycle on Kowhai (*Sophora tetraptera* and *microphylla*) a variety of *Carmichaelia* species, *Nothofagus solandri cliffortioides* (mountain beech), mangrove (*Avicennia marina* supsp.), karaka (*Corynocarpus laevigatus*), Black beech (*Nothofagus solandri sol.*), and Red beech (*Nothofagus fusca*).

Implications of the host testing

The implications of this host testing are not clear. This is partly a result of the fact that to date the report is incomplete. It is notable that the host testing found that survivorship of PAM on karaka was very low (6%) when field observations have reported larvae in their thousands on karaka, and karaka is listed as the fifth most common host species. It is acknowledged that the results of laboratory testing may under or overestimate the real impacts in the field and the importance of seasonality in determining palatability of host species should not be overlooked.

Painted apple moth host list. <http://www.biosecurity.govt.nz/pests-diseases/forests/painted-apple-moth/host-list.htm>

NZ Native Hosts in NZ to date

Hosts	Common Name	Family
<i>Sophora microphylla</i>	Kowhai	Leguminosae
<i>Plagianthus regius</i>	Ribbonwood	Malvaceae
<i>Corynocarpus laevigatus</i>	Karaka	Corynocarpaceae

Avicennia marina var. *resinifera* Mangrove Avicenniaceae

Native Australian Hosts

Hosts	Common Name	Family
<i>Acacia mearnsii</i>	Black Wattle	Mimosaceae
<i>Acacia longifolia</i>	Sydney Golden Wattle	Mimosaceae
<i>Paraserianthes (Albizia) lophantha</i>	Brush Wattle	Mimosaceae

Introduced and Cultivated Plants

Hosts	Common Name	Family
<i>Malus domestica</i>	Apple	Rosaceae
<i>Rosa</i> sp.	Rose	Rosaceae
<i>Prunus</i> spp.	Peach, plum, cherry	Rosaceae
<i>Cotoneaster</i>	Cotoneaster	Rosaceae
<i>Photinia</i> sp.	Red Robin	Rosaceae
<i>Salix</i> spp.	Willow	Salicaceae
<i>Primula</i>	Primula, Primrose	Primulaceae
<i>Pinus radiata</i>	Radiata Pine	Gymnospermae
<i>Geranium</i>	Geranium	Geraniaceae
<i>Pelargonium</i>	Geranium	Geraniaceae
<i>Grevillea</i> spp.	Grevillea, spider flower	Proteaceae
<i>Albizia julibrissin</i>	Pink Siris	Mimosaceae

Additional Hosts in NZ to date

Hosts	Common Name	Family
<i>Platanus acerifolia</i>	London Plane	Platanaceae
<i>Schinus molle</i>	Pepper Tree	Anacardiaceae
<i>Medinilla</i> sp. nr <i>magnifica</i>	NCN	Melastomataceae
<i>Virgilia divaricata</i>	Virgilia	Leguminosae
<i>Lotus</i> sp. (<i>suaveolens</i>)	Hairy Birdsfoot Trefoil	Leguminosae
<i>Cytisus multifloris</i>	White Broom	Leguminosae
<i>Acacia dealbata</i>	Silver Wattle	Mimosaceae
<i>Acacia floribunda</i>	Gossamer Wattle	Mimosaceae
<i>Erica lusitanica</i>	Spanish Heath	Ericaceae
<i>Erica</i> sp.	heath	Ericaceae
<i>Salix babylonica</i>	Weeping Willow	Salicaceae
<i>Acacia decurrens</i>	Green wattle	Mimosaceae
<i>Teline stenopetala</i>	Broom	Fabaceae
<i>Begonia</i> sp.	Begonia	Begoniaceae

<i>Acacia sophorae</i> (<i>A longifolia</i> var. <i>sophorae</i>)	NCN	Mimosaceae
<i>Mangifera indica</i>	Mango	Anacardiaceae
<i>Ulex europaeus</i>	Gorse	Leguminosae
<i>Chrysanthemoides monilifera</i>	Boneseed	Asteraceae
<i>Aster subulatus</i>	Sea Aster	Asteraceae

Human health impacts of PAM

PAM is known to have human health impacts that result from exposure to the urticating hairs of larvae and pupae. Exposure can result in skin lesions, eye irritation and respiratory reactions. People who are frequently exposed to PAM caterpillars are likely to develop allergic reactions. Children and people working outdoors are most likely to be affected. The number and level of allergic reactions observed in members of the public was likely to increase if PAM was to establish widely as it would be related to the size and distribution of the population.

Health Risk assessment of treatment with Foray 40B

A Health Risk Assessment (HRA) was commissioned for the proposed aerial operations programme, with regard to any potential effects of the aerial application of Foray 48B over West Auckland. This was an independent report prepared by the Medical Officer of Health, Auckland District Health Board and staff and was updated when the operation was increased in scale. This report was challenged twice, both times it was upheld. The Health Risk Assessment's robustness is continuing to stand the test of time. Note that a health advisory steering group was established to advise MAF during the response. Details of this are provided at question 2b

At its peak, the sprayed area included some 43,000 households and 133,000 people.

(d) Vector(s) of invasion(s) (e.g. of deliberate importation, contamination of imported goods, ballast water, hull-fouling and spread from adjacent area. It should be specified, if known, whether entry was deliberate and legal, deliberate and illegal, accidental, or natural.)

Painted apple moth spends a significant proportion of its life cycle not in association with host plants. Only during the larval stages is it consistently associated with host plants. Pupation can occur on food plants but is also common on non-host material. Therefore painted apple moth is defined as a hitchhiker species, that is, a species that is sometimes associated with a commodity but does not feed on the commodity or specifically depend on that commodity for the completion of its life cycle in some other way.

Because painted apple moth is a hitchhiker species, there is a wide range of commodities and pathways on which it could occur. These include the following:

- containers (air and sea)
- live plant material
- packaging materials

- passengers (air and sea), including accompanied and unaccompanied personal effects
- vehicles (new and used) including machinery
- other commodities

Aerial ballooning is believed to be an additional pathway for introduction of this species. While no confirmatory data exists, many taxa including mites, insects and spiders are blown over and arrive alive in New Zealand.

(e) Assessment and monitoring activities conducted and methods applied, including difficulties encountered (e.g. uncertainties due to missing taxonomic knowledge)

Progress against the milestones of the eradication programme was monitored using a statistical model developed by AgResearch Limited. The model incorporated data on weekly trap catches back to June 2001, the known residual larval populations, and the number and locations of traps.

Trapping

In an attempt to accurately determine the area in which painted apple moth populations were present a trapping programme using live female moths was initiated. An initial grid of 153 traps was set up within the infested areas of west Auckland and Mt Wellington in December 2000. When a larger number of female moths became available, a larger trapping grid comprising some 282 traps was established in late May 2001 encompassing Avondale, Glendene, Glen Eden (including Waikumete Cemetery), Kelston and Titirangi. In addition a second grid of about 68 traps was re-established in the area of Mt Wellington.

From the period beginning May to mid October 2001, 942 moths were trapped; three in the Mt Wellington trap grid (during August 2001) and 939 (from 129 traps) in the west Auckland trap grid. In February 2002, at the peak of the campaign, a total of 2,316 moths were trapped. At the height of the operation there were up to 1,880 traps baited and serviced weekly over an area of up to 62,000 hectares.

The grid locations and GIS data were combined. This reduced the risk of missing key location data. The accuracy of the trap locations was increased during the course of the programme. New populations were quickly identified and followed up with ground surveys.

Surveying

Ground surveying of painted apple moth life stages was carried out on a property by property basis throughout the infested and potentially infested areas by the surveying team. Ground surveys were also initiated around any trap catches. Surveying was conducted to establish the presence and the extent of the larval population. All properties confirmed to be infested and adjacent properties were surveyed on a regular basis.

The production of high quality maps from the surveying data has led to the permanent capture of this valuable information. The latest technology available was utilised throughout the programme. For example, surveyors were given updated GIS maps each day which enabled the efficient location of the properties to be surveyed. In addition to operational benefits, having geospatial trapping results immensely aided in

the formulation of treatment strategies and monitoring the impact of treatment programmes.

The development and documentation of procedures has led to generic surveying specifications being established. The capability was developed for the mobilisation and deployment of surveying teams. These teams consisted of up to 40 surveyors spread over four to six survey zones.

A system has been developed which utilises the base of existing experience and also develops new expertise. This involves an experienced surveyor pairing up with an inexperienced surveyor to ensure a thorough induction process into field operations. There were also daily briefing sessions to keep all team members informed of latest developments

Monitoring

Monitoring involved the visiting of all properties listed as being a monitored site on a frequency determined by TAG. Identified preferred hosts were inspected to determine the presence/absence of painted apple moth larvae, pupae, adults, and egg masses.

2. Options considered to address the problem

(a) Description of the decision-making process (stakeholders involved, consultation processes used, etc.)

Response Management

The PAM eradication programme was managed by a dedicated MAF project team, who reported to a Steering group chaired by the Chief Executive of MAF. The project team operated according to strong project management disciplines and was responsible for project planning, budgeting, contract management as well as the development of strategies for operations, health, communications, science and disaster planning.

Agriquality New Zealand Limited (a state owned enterprise) was appointed to manage the Auckland based operations including coordinating communications and health support.

The main decision making process utilised is the formal cabinet paper development, consultation and the approval process.

(b) Type of measures (research and monitoring; training of specialists; prevention, early detection, eradication, control/containment measures, habitat and/or natural community restoration; legal provisions; public education and awareness)

Science and research

A range of science and research programmes supported the eradication programme and also supported the development of longer term control measures preparing for the event that the eradication programme failed or a future incursion of PAM or similar pest occurred. These programmes included the production of female moths for baiting traps, production of sterile male moths to disrupt mating, host testing work, the development of a synthetic pheromone-based attractant, investigation of potential biological controls and investigating the effect of the spray on non target species.

Legal provisions

Painted apple moth was determined to be an unwanted organism under section 164c the [Biosecurity Act 1993](#) by MAF's Chief Technical Officer (Forest Biosecurity) on 30 November 1999, and made notifiable (section 45 of the Biosecurity Act 1993) by Order in Council on 21 September 2000.

Note: A Chief Technical Officer is an independent statutory decision maker appointed under section 101 of the [Biosecurity Act 1993](#).

Use of a Vegetation control zone

MAF has established a vegetation control zone under the Biosecurity Act 1993 to limit the spread of the painted apple moth. The pest could be easily spread by moving plants they are living in so the vegetation control zone establishes a containment area that vegetation cannot be moved out of. The vegetation control zone extended beyond areas where painted apple moths were found and beyond the area covered by aerial operations. Violating the vegetation control zone is an offence under the Biosecurity Act carrying a penalty of up to 3 months imprisonment or a fine of up to \$50,000. For a corporation the penalty is a fine of up to \$100,000.

Map of the vegetation control zone. <http://www.biosecurity.govt.nz/files/pests-diseases/forests/painted-apple-moth/images/veg-control-hi.jpg>

Legal implications of a successful eradication

The announcement that painted apple moth has been eradicated has raised a possible legal issue around future operations. Techniques for managing painted apple moth include rearing colonies of the moth, for use in the trapping programme and the release of sterilised males to disrupt mating. Now that eradication has been declared, releases of painted apple moths for these purposes may technically fall under the new organisms provisions of the Hazardous Substances and New Organisms Act 1996.

Communication/Public awareness

MAF operated a comprehensive PAM communication programme to provide advice and information to the public. The programme highlighted when aerial operations were occurring and the practical support measure available to people with health concerns. It was also designed to allay the concerns residents may have about aerial operations and improve awareness about potential environmental. Communication efforts included mass media delivered via radio, television and the newspaper (New Zealand Herald), through to suburban newspapers, direct mail, an 0800 free phone service, and face to face communication to community groups and schools.

MAF also provide the public with direct access to material on their website. In particular a page entitled "Frequently asked questions by painted apple moth zone residents" answered the many questions that the public had about "operation wipe out painted apple moth" and its vegetation control zone and aerial operations.

Provision of Health Services during the response

In late 2001, as a result of increasing community-based concern, a PAM health steering group was convened to discuss the health support and monitoring need of the project and the affected communities. The group comprised representatives from the Auckland District Health Board, Auckland and Wellington Schools of Medicine, Health Research Council, Royal College of General practitioners, independent

epidemiological experts, the PAM Community Advisory Group, and various scientific and policy project staff.

The Health Service provided a variety of health support mechanisms including:

- spray day warnings – early on the morning of the spray day members of the health service telephoned those who had been assessed to warn of the impending aerial operations;
- a meal programme – some people avoided the spray by attending a MAF provided (and funded) meal away from the spray area;
- motel accommodation – individuals assessed as requiring longer-term avoidance of the spray were provided with accommodation away from the area before during and after the spray operation for periods determined by their clinical needs.
- In-home support – in a small number of cases the health Service provided funds to allow in home support during spray operations.
- Advice to schools – the health service also provided information on the programme to all schools in the spray zone. Aerial sprays were not undertaken during times when children were likely to be travelling to or from school or in the playground over lunch

Note for the period 2002/2003 \$4.0 million was budgeted to provide the above health service support.

(c) Options selected, time-frame and reasons for selecting the options

Two options for management were considered with this response, eradication and or long term management. Long term management (in 2002 the estimated cost of a programme towards long term management was \$11.4 million over five years) would rely on landowners assuming responsibility for PAM control. Affected landowners included the Department of Conservation, local authorities, industry groups and members of the public.

The long term management option would have required a number of cost effective management tools to be developed. Of the tools proposed, biological control options and mating disruptions pheromones, and the use of sterile males were identified. Note that research on a number of these options was instigated in support of the eradication programme.

(d) Institutions responsible for decisions and actions

The Ministry of Agriculture and Forestry (MAF) was the lead biosecurity agency for this response and had full responsibility for decisions and actions involved.

MAF were however supported by the Ministry of Health not only because of the health issues associated with PAM but because of the potential health implications associated with large scale spraying of *Btk*.

The Department of Conservation assisted with advice to protect at risk species and had a representative on the Technical Advisory Group.

3. Implementation of measures, including assessment of effectiveness
(a) Ways and means set in place for implementation

Robust project management disciplines were applied to ensure delivery. An annual project management plan was developed and delivered to, and a response specific project team was established.

(b) Achievements (specify whether the action was fully successful, partially successful, or unsuccessful), including any adverse effects of the actions taken on the conservation and sustainable use of biodiversity

The Minister for Biosecurity announced the successful eradication of painted apple moth in March 2006. The last adult painted apple moth found in western Auckland was captured in January 2004. Eradication was confirmed after two years' monitoring using an extensive grid of traps and ground searches found no painted apple moth life stages.

To confirm eradication in western Auckland, a widespread trapping grid was retained for two years after the last moth was trapped. As a precaution this grid extended beyond western Auckland, and during 2005 and 2006 seven painted apple moths were trapped in other parts of Auckland. The moths were examined with a variety of techniques to determine their origins. Testing indicated that six of the seven had developed in a climate more arid than Auckland, and were new incursions from Australia. The fifth moth may have had a New Zealand origin but could not be definitively determined. Continued trapping and ground searches have so far found no evidence of an established population.

Future direction

The PAM Technical Advisory Group has recommended that Biosecurity New Zealand continue monitoring the locations where painted apple moths were trapped during 2005 to ensure that no new population has established.

(c) Costs of action

PAM cost \$ 62.4 million to eradicate.

Post eradication surveillance at high risk sites during 2006/07 cost a further \$1.397 million.

4. Lessons learned from the operation and other conclusions

(a) Further measures needed, including transboundary, regional and multilateral cooperation

MAF are presently assessing the risk associated with a range of lymantrid species in order to identify potential risk mitigation options that can be taken either offshore or at the border. Risk profiling offshore (i.e. of lymantrid outbreaks such as the recent Asian Gypsy Moth explosion in Russia is being followed closely) will mean that targeted surveillance of goods and vehicles (including ships and aircraft) from high risk countries can occur. Wherever possible risk mitigation is being promoted at the country of export. New Zealand imports a large number of used vehicles from Japan.

These vehicles have been shown to carry lymantrid egg masses. Recently MAF undertook a study to assess the effectiveness of heat treatment of used cars in Japan to reduce the risk of viable egg masses arriving here.

Additional information

Executive summary of MAF PAM close out report.

The painted apple moth (PAM) response was a complex programme with a high public profile. A number of obstacles were overcome to reach the goal of successful containment of PAM, with eradication to be initially considered in February 2006. The areas of operational logistics, communications and public health were particularly challenging and at times controversial. MAF, with the assistance of other government agencies, research providers and its contractors, succeeded in achieving the desired outcomes in all of these areas.

The knowledge and learnings from the white spotted tussock moth project (a previous successful eradication programme requiring aerial spraying over parts of Auckland city) were not captured and transferred to the PAM response as well as they could have been. This made the initial phase of the response more difficult to establish. However MAF did learn from this experience. MAF's willingness to adapt and grow throughout the response has led to a greater organisational capability which has, in turn, been transferred to similar projects such as fall web worm (Auckland) and Asian gypsy moth (Hamilton).

MAF has taken this development further at an organisational level with the establishment of Biosecurity New Zealand (BNZ). This new organisation is well placed to imbed the lessons learnt and new methodologies developed by the PAM response and continue to build on them.

Response Management

During the initial stages of the response MAF underestimated the scope of work. Resourcing issues eventually lead to performance issues. An early understanding of the scope and complexity of the programme would have allowed MAF to put in place the appropriate resources and response structure.

In November 2001 AgriQuality was appointed to run the operational aspects of the response. This decision proved crucial to the overall success of the programme. It freed up MAF resource from non-core activities, enabling them to concentrate on the strategic management, policy, and scientific aspects of the response.

The establishment of the stand alone PAM project in May 2002 marked a turning point. Strong leadership and the formulation of the formal operational project plan were important features of this period.

Risk management was carried out in an informal fashion until June 2002 when an initial risk workshop was held and a formal risk register was established. A further review of project risks was carried out in August 2003. Reporting was highlighted as being generally insufficient due to poorly defined reporting procedures and requirements in the early stages of the response. The establishment of the PAM

project and clearly defined reporting requirements was key to managing the response's diverse range of stakeholders and rectifying deficiencies in this area.

Document management was initially inadequate for the size of the response. Prior to 2002 documentation was at best sparse and even missing in some areas. This improved substantially as the response progressed. The use of an electronic document management system would have increased the efficiency of storage and retrieval of information.

Several key audits were carried out during the response including:

- the Liebhold-Simpson Report (May 2001),
- Cardno Audit Report and the Report of the Auditor-General. (May 2002).

The recommendations from these reports were actioned by MAF and resulted in improvements being made. Although the response was initially under-funded, resulting in over runs, once the size and scope of the response was identified sufficiently, funding was secured. This was managed within budget throughout the response.

While contact with Māori was established early in the response, the relationship was not sustained. The development of the Memorandum of Understanding and the Cultural Heritage Report helped re-establish and strengthen this relationship. A dedicated resource may have helped to maintain relationships in this area.

Policy

Policy advice was a key area of the response. Relationships with officials were managed well, with all Cabinet Papers gaining approval, however the first Cabinet Paper could have been presented earlier rather than waiting until MAF was unable to fund the response from baseline funding. Early advice to Cabinet during the initial phase of the response would have helped to establish this crucial relationship.

The MAF Policy team was not involved as early as they could have been by the response team, but once they were a close relationship developed. This proved to be invaluable for the preparation of replies to ministerial correspondence requests, Ombudsmen investigations and parliamentary questions during the response.

Compensation

Claims for compensation were made to MAF as a result of the aerial operations. MAF needed to clarify the criteria for a successful claim to avoid ineligible requests for compensation. In due course MAF established procedures for dealing with biosecurity claims, which were not present at the outset of the programme.

Legal

Legal compliance was an important area of the response, including:

- indemnities,
- approvals for entry to private property for surveyors and inspectors,
- approval for aerial operations in identified areas, and
- approval to undertake research under the Biosecurity Act 1993.

Establishing close links with the legal team was crucial to the operation. Ongoing

maintenance of these links remains essential as a lack of legal compliance would have put the operation in jeopardy.

Contracts

During the initial phase of this response all contracts were managed by MAF. MAF established contracts with Forest Health Dynamics, VIGIL, North Shore Helicopters, Consultus, First Contact, NuFarm, Wanganui Aeroworks, AgriQuality and Aer'Aqua.

The decision to appoint a head contractor was significant. It was crucial for the response team to maintain very close links with MAF's contract experts to ensure MAF's compliance to its commercial obligations. In a response of this nature MAF's commercial responsibilities are significant.

Communications

The importance of communications in any response with a high public profile cannot be underestimated. This area was identified as being inadequate during the initial stage of the response. The development of the Communications Plans Stage 1 and Stage 2 and the engagement of professional communications experts greatly improved effectiveness in this area.

An extensive communications campaign was developed to advise the public on details of the aerial operations, this included radio and print advertising and direct mail to residents in the affected area. As a result of this, a blueprint was developed for future response communications. The knowledge gained during the response has been captured and documented.

Health

To some in the community the success of the response depended upon the success of the health service. The size of the health service was dependent on public demand. This high level of unpredictability made budget forecasting extremely difficult. The health service was successfully developed during the response and the knowledge and experience gained was able to be transferred to the Asian gypsy moth response in Hamilton.

Work is continuing on the development of a robust and transferable health service for use in future responses of this nature. The Health Advisory Group (HAG) identified and prioritised possible research projects into potential impacts on human health. A number of these have been commissioned. The Ministry of Health has worked closely with MAF in relation to this work.

Operations

There was a lack of operational coordination during the early stages of the response. This was recognised in 2001 and AgriQuality was appointed to manage ground operations. Subsequently the operational component of the project was successful and ran very smoothly. Forty aerial operations were carried out successfully and the operational procedures continued to be refined throughout the project. MAF, in conjunction with its contractors, has designed a set of generic operational procedures which continue to be invaluable for responses of this nature. A number of lessons have been learnt and documented to aid with future programmes. Expertise developed during the aerial operations needs to be captured to reduce the preparation time for future operations of this type.

Science

The urgent need for scientific research on PAM was not recognised at the outset of the response. Sound science and technical advice are needed at the outset of any response.

Research needs to be underway as early as possible. This information is required as the basis for the development of operations, health and communications components. The more that can be found out quickly and accurately about hosts, control techniques and environmental impact, the greater the chance of successful eradication. In the initial stages of the response some research opportunities were missed, such as host testing, as they were not undertaken quickly enough. There have, however, been great successes achieved in the science area with the Sterile Insect Technique being developed and refined during this response. The Sterile Insect Technique could prove to be a viable complementary control method for use in any future response. The successful collaboration between Crown Research Institutes led to greater efficiencies with the pooling of resources.

As a result of the seven single PAM finds (post eradication) MAF continued to survey six high risk sites in 2006/07 at a cost of \$1.4 million. Currently an extensive review of New Zealand's biosecurity surveillance activities is occurring. The risk of further incursions of PAM and what if any precautionary targeted surveillance is required, will be addressed in this review.

(b) Replicability for other regions, ecosystems or groups of organisms

The response actions, processes and procedures are replicable to other regions and ecosystems but successful transfer will depend on the scale and significance of the incursions. A similar process to that used for PAM could be used for other similar Lymantrid species depending on the acceptability (both publicly and legally) of aerial spraying in urban areas. The find of a single Asian Gypsy Moth (AGM) in a pheromone trap in Hamilton in March 2003 led to a rapid incursion response again utilising aerial spraying of *Btk* as the preferred eradication method. Lessons learned during the PAM response around effective public communication, response actions and public health concerns facilitated a positive outcome for AGM.

(c) Information compilation and dissemination needed

MAF Painted Apple Moth site

<http://www.biosecurity.govt.nz/pest-and-disease-response/pests-and-diseases-watchlist/painted-apple-moth>

Facts and Question on Painted Apple Moth

<http://www.biosecurity.govt.nz/faq/term/911>

Frequently asked questions by painted apple moth zone residents

<http://www.biosecurity.govt.nz/pests-diseases/forests/painted-apple-moth/operation-faq.htm>

Health Risk Assessment of the 2002 Aerial Spray Eradication Programme for the Painted Apple Moth in Some Western Suburbs of Auckland
A Report to the Ministry of Agriculture and Forestry, Public Health Service
Auckland District Health Board
March 2002 <http://www.biosecurity.govt.nz/files/pests-diseases/forests/painted-apple-moth/pam-health-ras.pdf>

Potential Economic Impact on New Zealand of the Painted Apple Moth MAF Policy, July 2000
<http://www.biosecurity.govt.nz/files/pests-diseases/forests/painted-apple-moth/pam-economic-impact2000.pdf>

Painted Apple Moth: Reassessment of Potential Economic Impacts. Ministry of Agriculture and Forestry 7 May 2002
<http://www.biosecurity.govt.nz/files/pests-diseases/forests/painted-apple-moth/pam-reassessment-economic-impacts.pdf>

Report to Agriquality: Limited a Comparison of Presentations of Householder Concerns to the Painted Apple Moth (PAM) and Asian Gypsy Moth (AGM) Health Services June 2005
Aeraqua® Medical Services Ltd
<http://www.biosecurity.govt.nz/files/pests-diseases/forests/painted-apple-moth/pam-agm-comparision-study.pdf>

Environmental Impact Assessment of Aerial Spraying *Btk* in New Zealand for painted apple moth February 2003
<http://www.biosecurity.govt.nz/pests-diseases/forests/painted-apple-moth/environmental-impact.htm>