POTENTIAL ECONOMIC IMPACT ON NEW ZEALAND OF THE PAINTED APPLE MOTH

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Methodology

In assessing the proposed eradication programme for the painted apple moth, *Teia anartoides* (formerly *Orgyia anartoides*), an indication of the benefits of eradication is required.

A cost-benefit analysis of eradication of the white-spotted tussock moth, *Orgyia thyellina*, was conducted by the New Zealand Forest Research Institute (NZFRI) and subsequently reviewed by the New Zealand Institute of Economic Research (NZIER). Given that the painted apple moth is closely related to the white-spotted tussock moth, the framework adopted by NZFRI and NZIER (Horgan, 1997; NZIER, 1997) was considered suitable to be used as the basis for a simplified cost-benefit analysis of eradication of the painted apple moth.

This paper outlines evaluation of the potential impact on New Zealand of the painted apple moth, based upon the methodology used for the white-spotted tussock moth, adapted for differences in host range and effects. The spreadsheet model is provided in the appendix to this paper. The potential costs to New Zealand resulting from the spread of the moth throughout the country in the absence of government intervention indicate the benefits of successful eradication.

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.

Private Amenity

The painted apple moth is reported as being a common pest on urban garden plants in Australia (Elliott *et al*., 1998). Following NZIER (1997), the impact in terms of costs incurred to avert reductions in private amenity, should the painted apple moth become endemic to this country, is evaluated in terms of increased expenditure on spraying. Most households already spraying their gardens (rose bushes and fruit tress, for example) would be likely to find their existing spray regimes sufficient to alleviate the effects of the moth. Of households not already spraying their gardens, only some would commence spraying. Households less keen on gardening are unlikely to take up spraying, especially given the inaccessibility of tree crowns where infestations are likely to be concentrated. For the white-spotted tussock moth, NZFRI assumed a 10 per cent increase in spraying of private properties (NZIER, 1997). NZIER thought this proportionate increase could be too high. Given its wider host range, the assumption of a 10 per cent increase in spraying of private properties may be reasonable for the painted apple moth. Numbers of private dwellings in the Auckland Regional Council area and throughout the rest of New Zealand are obtained from Statistics New Zealand (1996). Average expenditure on spraying per private property is set equal to $50 per moth outbreak, as used by NZFRI (NZIER, 1997), based on evidence of spending by US householders in

response to outbreaks of Asian gypsy moth (Gottschalk, 1990). Given that not all gardens would be sprayed, coverage is unlikely to be sufficient to eradicate the moth, thus spraying is assumed to be required each year (NZIER, 1997).

It is assumed that there would be an increase in spraying of golf courses and school properties also, for aesthetic reasons and as a precaution against risks to human health from contact with the moth larvae. The area of land covered by golf courses and schools in Auckland, Manukau, North Shore and Waitakere City Council areas and throughout the rest of New Zealand's main, secondary and minor urban areas is taken from Treeby (1997). Again, a 10 per cent increase in spraying is assumed. The cost of spraying these areas is set at $350 per hectare, extrapolated from the cost per private property, allowing for economies of scale. Spraying costs for these areas could be higher than this.

Botanical gardens, which contain valuable specimen trees and rare species, are already subject to high levels of maintenance, such that there may be little additional cost in controlling for painted apple moth. Only a fraction of commercial and industrial premises possess trees and gardens. In city centres space is at a premium. Some businesses may maintain gardens or landscaped areas for aesthetic reasons or if located in residential areas (e.g. hotels, medical and dental clinics). Professional gardening services, which may already include regular spraying, are likely to be employed for these areas. If trees on commercial properties were defoliated by painted apple moth, the effects may be ignored or severely affected trees may be removed but not replaced. For a small proportion of commercial properties, additional costs may be incurred for spraying or tree removal with or without replacement. In sensitivity analysis, inclusion of possible additional costs for commercial properties has little impact on the estimated private amenity costs of the painted apple moth.

Public Amenity

In urban areas the painted apple moth would also infest street trees and trees on public property such as road reserves, parks and reserves. Following NZIER (1997), the impact of the painted apple moth in terms of costs incurred to avert reductions in public amenity is evaluated in terms of the costs to councils of removing and replacing badly affected trees. NZFRI identifies this as being of considerably lower cost than treating trees against attack, and thus likely to be the strategy favoured by councils (NZIER, 1997). Numbers of street trees and trees in road reserves, parks and reserves in main, secondary and minor urban areas of New Zealand are taken from Treeby (1997). NZIER reports that replacement costs can range from $200 for planting and tending trees in park settings to $3000 for removing and replacing specimen trees in urban streets, but that $800 per tree represents a reasonable average. NZIER reports that in Auckland City around 10 per cent of public amenity trees are of exotic deciduous species susceptible to damage by the white-spotted tussock moth (NZIER, 1997). Given that the painted apple moth "can feed on an extremely wide range of plants" (Elliott *et al*., 1998, p.47), it is assumed that around 40 per cent of street trees and trees on public property would be of species susceptible to damage by this moth. A greater proportion may be susceptible currently, but councils could be expected to avoid planting worst affected species.

NZFRI assumes a death rate from white-spotted tussock moth infestation for susceptible species of street trees of 13 per cent within five years of attack, based upon experience of Asian gypsy moth infestation in the USA (NZIER, 1997). NZIER suggests that that this may be too high, given that larvae are relatively mobile within a limited area and more likely to move to alternative food sources than to defoliate an individual tree to such an extent that it dies; tree-kill is more likely for isolated trees than for trees in streets and gardens surrounded by varied vegetation. In sensitivity analysis, NZIER adopts death rates of 5 per cent and 1 per cent of susceptible species. Given the wider host range of the painted apple moth, and therefore the greater availability of alternative food sources, the probability of tree-kill due to defoliation by this moth may be low. Defoliation may, however, result in a reduction in public

amenity in affecting the appearance of trees. “When the level of defoliation is low, damage is generally not visible from a distance but requires close inspection of individual tree crowns to be noticed. When damage is substantial (e.g. more than 20 per cent leaf loss), tree crowns look relatively bare from a distance and the damaged foliage is conspicuous when individual trees are closely examined. Defoliation exceeding 50 per cent leaf area loss can be easily mapped by aerial survey.” (Elliott *et al*., 1998, pp.39-40). Some reduction in the aesthetic value of trees would be tolerated by local communities (NZIER, 1997), such that only the worst affected trees or prominent or specimen trees damaged by the moth would be replaced. Therefore a low annual replacement rate of 1 in 500 (0.2 per cent of) public trees of susceptible species is assumed in estimating the public amenity costs of the painted apple moth.

Plantation Forestry

New Zealand’s exotic forests would also be vulnerable to the painted apple moth. Radiata pine is a known host to this moth, as are eucalypts and acacias, which are grown in some areas for timber but comprise only a small proportion of total commercial forestry. The costs to plantation forestry of the painted apple moth are likely to be dominated by the impact on radiata pine, given that this is the prevalent species in plantation forests in New Zealand (covering 90.5 per cent of the total area of plantation forest). Again, it may be unlikely that individual trees would be defoliated to such an extent that they would die, but growth rates can be affected through reduced rates of photosynthesis and transpiration. “Light defoliation (i.e. less than 20 per cent) normally has nil or very little effect on the tree. Moderate (25-50 per cent) and severe (more than 50 per cent) defoliation reduces growth rates and can predispose trees to attack by other organisms such as wood borers.” (Elliott *et al*., 1998, p.40).

NZFRI evaluates the potential costs to commercial forestry of the white-spotted tussock moth in terms of the cost to the forestry sector of controlling and limiting damage by spraying for infestation with Btk (NZIER, 1997). Spraying pine trees with insecticides is, however, very rare, given that it may be decades before the costs of spraying are recouped. “Although insecticidal sprays were used to prevent defoliation of radiata pine in Canterbury in the early 1950s, and Douglas fir in the Kaingaroa Forest in the 1970s, this method of control is only a stop-gap emergency measure to prevent widespread tree mortality.” (New Zealand Institute of Forestry, 1995, p.45).

The potential costs to plantation forestry of the painted apple moth are evaluated instead in terms of the impact of moth infestation on tree growth, for radiata pine as the prevalent species. The total area of plantation forest in radiata pine and its age distribution are derived from New Zealand Forest Industry (1999). Given that younger trees are preferred and defoliation is usually recorded only in younger stands, it is assumed that only radiata pine aged eight years or less would be susceptible to significant attack. Although, in Australia, beating of older trees yields moth larvae, their impact on these trees appears to be immeasurably low (Mark Self, per. comm.). What proportion of susceptible trees would be affected is unknown, given that the painted apple moth is new to New Zealand. In its native Australia, where this moth has a full range of natural predators, it is considered a minor pest and typically affects less than 1 per cent of individual trees in an infested radiata pine compartment (Mark Self, per. comm.). “This moth occasionally causes defoliation of young pines, usually as isolated occurrences scattered throughout compartments.” (Self *et al*., 1999, p.3). In New Zealand this moth would have no natural predators, so could be expected to affect a greater proportion of susceptible trees. Conservatively, it is assumed that 2 per cent of susceptible trees would be significantly affected. The impact could possibly be much greater than this, although pine is not the moth’s most preferred host. It is assumed that defoliation would result in a 60 per cent reduction in tree growth, based upon New Zealand research data on growth loss attributable to defoliation following *Cyclaneusma* needle cast (Mark Self, per. comm.). New Zealand Forestry Industry (1999) estimates the value of the

wood added by each year's growth to be in the range of $1600 to $2200 per hectare of forest. Loss of growth due to defoliation by painted apple moth infestation is therefore valued at an average of $1900 per hectare of affected plantation forest per annum. This simplified approach provides only a broad indication of the potential costs to plantation forestry; for example, the impact of defoliation on tree growth is more complex than assumed for the purposes of this impact assessment.

A more effective, lower cost way to control forest pests in the long term is through biological control, such as the adoption of resistant crop species or the introduction of biological agents such as parasites and predatory insects, pathogenic fungi, bacteria and viruses (New Zealand Institute of Forestry, 1995).

Horticulture

NZFRI suggests that the impact on non-organic commercial horticulture of the white-spotted tussock moth would be negligible, given that existing pest management strategies and treatments would generally be sufficient to control for the effects of this moth (NZIER, 1997). A similar assumption is made for the impact of the painted apple moth. Organic producers on no-spray regimes may face additional costs in spraying with Btk to limit the effects of the moth, but the organic sector accounts for only a small, albeit increasing, proportion of commercial horticultural activity. Produce would continue to qualify as "organic" provided that the maximum doses of Btk prescribed for organic farming systems were not exceeded (NZIER, 1997) Shelter belts of willow which are not currently sprayed, may also need spraying if defoliation were severe. NZIER notes a recent trend away from spraying in the kiwifruit industry, but kiwifruit is not a preferred food of either the white-spotted tussock moth or the painted apple moth (NZIER, 1997). The additional costs to commercial horticulture of the painted apple moth are therefore assumed likely to be relatively small.

The Conservation Estate

Given that the known and potential New Zealand hosts to the painted apple moth include native species (kowhai, ribbonwood and pohutukawa), failing to control the moth could have implications for New Zealand's indigenous ecology. Not only might the moth infest host species in indigenous forests and shrublands, but it may have secondary impacts on other organisms in the ecosystem (through competition for food sources, for example). Where defoliation is sufficient to affect the aesthetic appearance of trees, this may impact on the amenity value that members of the public gain from visiting national parks. Infestation may affect public access to some areas; in the USA, for example, forests infested by Asian gypsy moth have been closed to the public due to the risks to human health of contact with larvae (NZIER, 1997). Even for areas to which the public does not have access, society places an "existence value" on healthy indigenous forests and ecosystems and incurs considerable expenditure in attempting to limit or reverse damage to New Zealand's conservation estate by pests such as possums (Bertram and Hackwell, 1999).

As in urban environments and plantation forests, the moth may be unlikely to defoliate individual trees to such an extent as to cause them to die, given the availability of alternative food sources. "Native insects, such as the moth *Proteodes carnifex*, and the beech leafroller moth (*'Epichorista' emphanes*) can cause periodic defoliation of mountain beech stands but this does not cause lasting damage. No introduced insects have yet caused serious problems to indigenous forests." (Ministry for the Environment, 1997, p.8.43). Some defoliation may be tolerated without detracting from the amenity and existence values to society of indigenous forests; "because 'natural' disease processes are not viewed as being necessarily detrimental to indigenous forests, because wood quality is not generally of importance in indigenous forests, and because regeneration after dieback may be a near-perfect substitute for the original crop, it is possible to advance the argument that the values of indigenous forests are less at risk from insects and diseases than those of plantation forests." (Baddeley, 1989, p.253). Even where defoliation is sufficient to affect tree growth,

reduced growth rates in indigenous forests may be considered to be of minor concern (Baddeley, 1989).

Nevertheless, where the impact on indigenous species is uncertain, a precautionary approach may be favoured, given that if the moth were found to thrive in New Zealand's indigenous forests, there may be no known effective control measure (NZIER, 1997).

Watershed Conservation
Willow trees have been identified as a food source for the painted apple moth. Willow has been planted widely for soil and watershed conservation. "However, unless trees are sufficiently defoliated to kill the tree, the root structure and soil retention properties of these plantings are likely to remain intact, and this seems unlikely to be a major source of impact from the [white-spotted tussock] moth." (NZIER, 1997, p.14). Given the wider host range of the painted apple moth, it is assumed unlikely that willow trees would be defoliated to such an extent as to impact on their contribution to watershed conservation.

Human Health
A small proportion of people coming into contact with painted apple moth larvae suffer negative reactions, such as skin rashes and respiratory problems, due to the irritant effects of the urticating hairs these larvae possess. Symptoms are generally mild, but hospitalisation and even fatality can occur in extreme cases, with repeated exposure of susceptible individuals. Costs incurred would include medical treatment costs for consultations, medication and hospitalisation, productivity losses due to absence from work, and loss of life. NZFRI provide indicative unit costs for medical treatment (NZIER, 1997, p.8), but no information is available on the illness severity distribution or treatment requirements. Moderate levels of Asian gypsy moth infestation are associated with 0.2 to 1 per cent of exposed individuals developing adverse health effects (NZIER, 1997). The probability of fatality from exposure to the larvae of the white-spotted tussock moth appears to be very low (NZIER, 1997). Given that both the number of people likely to be affected and the probability of severe reaction are low, the costs imposed by the painted apple moth in terms of human health effects are likely to be relatively small. In sensitivity analysis, inclusion of possible human health effects has a minor impact on the estimated total costs to New Zealand of the painted apple moth.

Trade Prospects
New Zealand's only export destination currently requiring declaration for painted apple moth is Canada. If the painted apple moth became endemic to New Zealand, exports to Canada would routinely have to be inspected for and certified free from painted apple moth. Existing inspection procedures for similar pests would be adequate to detect the presence of painted apple moth and a declaration of freedom from painted apple moth could be added to existing declarations at no extra cost. Thus for shipments free of painted apple moth, no additional costs would be incurred. If inspection revealed the presence of suspected painted apple moth, there would be a delay whilst identification was confirmed, following which the shipment would be diverted to an alternative destination and/or, in the case of logs or wood products, fumigated, if not already. Log exports to North America are debarked anyway and thus less likely to harbour such pests. Given that shipping delays incur substantial costs, producers invest considerable effort in ensuring that produce intended for export arrives at ports free of pests that would cause it to be rejected (for example, horticultural produce is inspected at packing houses prior to transportation to port). The number of shipments found to be infested with painted apple moth could therefore be expected to be fairly low. Although it is possible that egg masses may become attached to vehicles during transit to the port, it can be argued this is of low probability, given that vehicle depots and container yards are unlikely to be located close to moth populations and provide little food for the larvae when they emerge (NZIER, 1997). If the painted apple moth were to become endemic to New

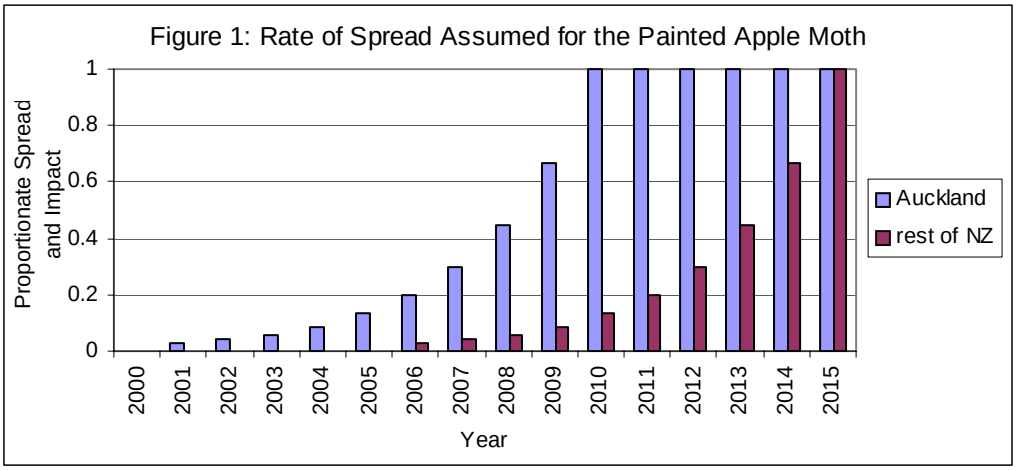
Zealand, the additional costs incurred in meeting current declaration requirements would therefore probably be relatively small.

It is possible, however, that trading partners currently free from painted apple moth may alter their declaration requirements and impose restrictions on imports from New Zealand in order to exclude the moth. With respect to the white-spotted tussock moth, both NZFRI and NZIER consider the risk of damage to New Zealand's trade prospects to be low (NZIER, 1997). This risk may be similarly low with respect to the painted apple moth. There is, however, some uncertainty as to how New Zealand's export destinations would react, in addition to which there is a risk that phytosanitary concerns may be used, as they have been in the past, as an excuse to erect trade barriers.

Rate of Spread

Based upon the rate of spread assumed for the white-spotted tussock moth (NZIER, 1997), the length of time taken for the painted apple moth to spread throughout Auckland is assumed to be 10 years. Spread to other areas is likely if the moth becomes established in Auckland. The length of time taken for the moth to spread throughout the rest of New Zealand is set at 10 years also, but lagged behind Auckland by 5 years. The economic impacts of the moth are phased in over time, reflecting this gradual spread. The painted apple moth is, therefore, modelled as beginning to have an economic impact in Auckland in 2001, reaching full impact across Auckland in 2010, and beginning to have an economic impact in the rest of New Zealand, including plantation forests, in 2006, reaching full impact across the rest of New Zealand in 2015. Rather than using a straight line rate of increase, it is assumed that the area affected by the moth, and the resulting economic impact, increases by a factor of 1.5 each year over the 10 year spread periods. This rate of spread is illustrated in Figure 1.

Figure 1: Rate of Spread Assumed for the Painted Apple Moth



Following NZFRI (NZIER, 1997), the discount rate is set at 10 per cent. The discount period is limited to 20 years, given that it is likely that, within this time period, biological controls or improved tree strains would have been introduced in plantation forestry (NZIER, 1997) and there would have been a shift away from using the most adversely affected tree species in public places and private gardens.

Results

The model suggests that if, in the absence of government intervention, the painted apple moth were to spread throughout New Zealand, the costs to plantation forestry and private and public amenity would amount to $24.2 million per annum in the medium term. Reduced growth rates in plantation forestry represent 57 per cent of these costs. Additional spraying of private gardens, golf courses and school lands represents 29 per cent of these costs, and

removal and replacement of selected trees in streets or other public places would account for the remaining 14 per cent of total costs. Allowing for the possible rate of spread of the moth throughout New Zealand, the present value cumulative costs are estimated, conservatively, to amount to $47.6 million over the next 20 years. Additional to this are impacts on horticulture, watershed conservation and human health, which are assumed likely to be small, and impacts on the conservation estate and trade prospects, which are uncertain. Thus the present value of the potential impact on New Zealand of the painted apple moth is indicated to be at least $48 million over the next 20 years. These potential costs represent the benefits of successful eradication.

Sensitivity analysis identifies the proportion of susceptible plantation forest trees affected as highly significant in determining the total costs to New Zealand of the painted apple moth. A conservative value of 2 per cent is used. Increasing this coefficient to 5 per cent (reduced growth for 1 in 20 susceptible trees) raises the estimated present value cumulative costs incurred over the next 20 years to $84.3 million.

Given the sporadic and unpredictable nature of incidental movements of the moth's eggs and larvae by human activity, there is considerable uncertainty as to how long it would take for the painted apple moth to spread throughout Auckland and, subsequently, the rest of New Zealand. A slower rate of spread of 15 years in duration, with the rest of New Zealand lagged 5 years behind Auckland, reduces the estimated present value cumulative costs incurred over the next 20 years to $16.5 million. A more rapid rate of spread of 5 years in duration, with the rest of New Zealand lagged behind Auckland by 3 years increases the estimated present value cumulative costs incurred over the next 20 years to $115.1 million.

A further consideration is the frequency of reincursion. If the proposed eradication programme were to succeed but a future incursion go uncontrolled, the potential costs to New Zealand of the painted apple moth would only be deferred. There, is however, a benefit in deferring costs, as reflected by discount rates. Deferring the impact of the painted apple moth by 10 years, for example, would reduce the present value of the cumulative costs over the 20 years following incursion (in this case 2011 to 2030) to $18.4 million.

References

Baddeley, C. (1989) Detection of New Insects and Diseases in Indigenous Forests in New Zealand. *New Zealand Journal of Forestry Science*, 19, 2/3, pp.250-255.

Bertram, G. and Hackwell, K. (1999) *The Economic Impact on New Zealand of Introduced Pests*. Paper presented to the New Zealand Pest Summit Conference, Palmerston North, April, 1999.

Elliott, H.J., Ohmart, C.P. and Wylie, F.R. (1998) *Insect Pests of Australian Forests: Ecology and Management*. Reed International Books, Australia.

Gottschalk, K.W. (1990) Economic Evaluation of Gypsy Moth Damage in the United States of America. *Proceedings of the IUFRO XIX World Congress*, Montreal, Canada, vol.4, pp.235-246.

Horgan, G. (1997) *White-spotted Tussock Moth Eradication – Cost-Benefit Analysis Revisited.* New Zealand Forest Research Institute Ltd., Rotorua.

Mathys, G. and Baker, E.A. (1980) An Appraisal of the Effectiveness of Quarantines. *Annual Review of Phytopathology*, 18, pp.85-101.

Ministry for the Environment (1997) *The State of New Zealand's Environment*. Ministry for the Environment, GP Publications.

New Zealand Forest Industry (1999) *Facts and Figures 99*. Produced by New Zealand Forest Owners Association, Inc., Ministry of Agriculture and Forestry and New Zealand Forest Industries Council.

New Zealand Institute of Economic Research (1997) *White-spotted Tussock Moth: Review and Reappraisal of Cost-Benefit Analysis of Eradication*. Report to the Treasury, prepared by Peter Clough and Chris Nixon with assistance from Stephen Gale, October 1997.

New Zealand Institute of Forestry (1995) *Forestry Handbook 1995*. Edited by Don Hammond.

Self, M., McDonald, J. and DeBaar, M. (1999) *Forest Health Surveillance Report: Dalby District 1998/1999*. Forestry Research Institute, Department of Primary Industries, Queensland.

Statistics New Zealand (1996) *1996 Census of Population and Dwellings: Regional Summary*. Statistics New Zealand, Wellington.

Treeby, B. (1997) *Urban Tree Estate Amenity Values and Pest Risk*. Report prepared for Forestry Biosecurity Standards Team, Ministry of Forestry, December 1997.