

Import Risk Analysis:
Vehicle and Machinery

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Biosecurity New Zealand
Ministry of Agriculture and Forestry
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New Zealand



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Pre-Clearance
Biosecurity New Zealand

Import risk analysis: Vehicle & Machinery

7 February 2007

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Acknowledgements

This risk analysis has been overseen by a project team comprising:

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The primary author and editor is Sandy Toy. The butterflies and moths chapter is largely a summary of a more comprehensive pest risk analysis of six high-risk moth species undertaken by Melanie Newfield. Jose Derraik has drafted the chapters on mosquitoes and spiders. Data and analysis on the efficacy of the current risk management measures have come from two surveys carried out by Biosecurity New Zealand's Biosecurity Monitoring Group.

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The analysis has been informed by input from stakeholders at a series of workshops and during a visit to Japan by project staff. These contributions are appreciated.

Staff from MAF Quarantine Service, Biosecurity New Zealand risk analysis group, BNZ operational standards group, BNZ policy group, BNZ biosecurity monitoring group and BNZ surveillance and response group have reviewed the risk analysis.

The entire draft risk analysis has also been reviewed by:

- Amy Guihot (Operations Manager, Import Clearance) and Garry Luckman (Manager, Operational Science Programme) Australian Quarantine and Inspection Service;
 - Glenn Fowler (Risk analyst) US Department of Agriculture Animal and Plant Health Inspection Service;
 - John Gardiner (Senior Advisor Biosecurity) Ministry of Health;
 - Fiona Bancroft (Biosecurity Technical Officer) Department of Conservation;
- The New Zealand Food Standards Agency, Land Transport New Zealand and the Environment Risk Management Authority also looked at the analysis and had no comments. The Ministry for the Environment will be working with MAF on the ongoing review of the import health standards.

Sections of the draft risk analysis were reviewed by:

- Dr. Scott Ritchie, Medical Entomologist, Tropical Health Unit Network, Cairns (Chapters 1-4, Mosquito chapter and summary of recommendations chapter);

- Phil Sirvid, Entomology Section, Museum of New Zealand Te Papa Tongarewa (Chapters 1-4, spider chapter and summary of recommendations chapter);
- Dr Phil Lester, Senior Lecturer in Ecology and Entomology, School of Biological Sciences, Victoria University of Wellington (Chapters 1-4, ant chapter and summary of recommendations chapter);
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NOTES FOR SUBMITTERS

The Ministry of Agriculture and Forestry (MAF) welcomes submissions from all interested parties on the risk analysis and risk management measures presented in this document.

Submissions are public information and may be the subject of requests under the Official Information Act 1982. If you consider that any or all of the information in your submission should be treated as confidential or commercial sensitive, please state this clearly in your submission. Any decision to withhold information under the Official Information Act may be reviewed by the Ombudsman.

Questions

MAF particularly welcomes specific comment on the following questions:

1. What are your views on the risk assessment for each hazard group? Are the risk assessments accurate? What changes, if any, are required? Please provide evidence to support your submission.
2. Has the efficacy of risk management measures for each hazard group been evaluated accurately?
3. Are there alternative packages of measures that will achieve the risk management objective? Please provide details.

Requirements for Submissions

Submitters are asked to include the following information in their submissions:

- the title of the discussion document;
- your name and title;
- your organisation's name (if applicable);
- your address and contact details (e.g. phone, fax, and email); and
- the number(s) of the sections you are commenting on.

Closing Date for Submissions

All submissions must be received by MAF no later than 30 March 2007. Please address submissions to:

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Process Following Receipt of Submissions

At the conclusion of the consultation period, all submissions will be reviewed and a document summarising the submissions and how they have been taken into account published and made available for viewing.

The risk analysis will contribute to the development of revised Import Health Standards, issued by the Ministry of Agriculture and Forestry (MAF) under the Biosecurity Act 1993, that specify the requirements to be met before vehicles and machinery may be imported and given biosecurity clearance.

Issues relating to the practical implementation of risk management measures are beyond the scope of this risk analysis. Public workshops will be held to discuss practical and logistical issues in more detail as part of the review of the Import Health Standards

In addition, MAF has commissioned the New Zealand Institute of Economic Research (NZIER) to undertake cost-benefit analysis of the range of risk management measures presented in this document.

The revised Import Health Standards will take account of submissions on the technical content of this risk analysis, the feedback from stakeholders on practical implementation factors, consultation with other government departments and the cost-benefit analysis and policy considerations for managing biosecurity risks offshore. It is anticipated that revised Import Health Standards will be available for public consultation in the middle of 2007.

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1 Summary

SYNOPSIS

The Ministry of Agriculture and Forestry (MAF) has evaluated the biosecurity risks posed by the importation of vehicles and machinery into New Zealand. Some high consequence pest organisms are known to be associated with imported vehicles and machinery. MAF has found that about half the imported used vehicles have contamination that could not be seen with the current visual inspection risk management regime. The risk analysis concludes that the current risk management regime will not effectively manage the risks from high consequence pests.

This risk analysis proposes mandatory treatment and cleaning of imported used vehicles; a systems-based approach for the management of imported new vehicles; and an interim package of enhanced risk mitigation measures for machinery. This risk analysis is the first stage in the development of revised Import Health Standards. The revised Import Health Standards will take account of submissions on the technical content of this risk analysis, consultation with other government departments, the feedback from stakeholders on practical implementation factors, a cost-benefit analysis, and policy considerations for managing biosecurity risks offshore. It is anticipated that revised Import Health Standards will be available for public consultation in the middle of 2007.

1.1 INTRODUCTION

This risk analysis examines the biosecurity risks posed by the importation of new and used vehicles and machinery into New Zealand, and includes recommendations to be considered for managing these risks.

MAF welcomes feedback on the technical content of this risk analysis. Guidelines for making submissions and key questions are provided on page iii.

The risk analysis will contribute to the development of revised Import Health Standards, issued by the Ministry of Agriculture and Forestry (MAF) under the Biosecurity Act 1993, that specify the requirements to be met before vehicles and machinery may be imported and given biosecurity clearance.

Issues relating to the practical implementation of risk management measures are part of the subsequent Import Health Standard review process as opposed to this risk analysis. Public workshops will be held to discuss practical and logistical issues in more detail as part of the review of the Import Health Standards commencing shortly.

In addition, MAF has commissioned the New Zealand Institute of Economic Research (NZIER) to undertake cost-benefit analysis of the range of risk management measures presented in this document.

The revised Import Health Standards will take account of submissions on the technical content of this risk analysis, the feedback from stakeholders on practical implementation factors, consultation with other government departments, the cost-benefit analysis, and policy considerations for managing biosecurity risks offshore. It is anticipated that revised Import Health Standards will be available for public consultation in the middle of 2007.

1.2 CURRENT RISK MANAGEMENT REGIME

The volume of vehicles imported into New Zealand doubled between 1995 and 2005, with some 176 000 used and 112 000 new vehicles imported in 2005 (New Zealand Customs, 2005). Approximately 95 percent of these come from Japan, although used vehicles have been imported from at least 80 different countries.

Three different Import Health Standards currently regulate imported **used** vehicles and machinery. They provide for all vehicles to be visually inspected for biosecurity contaminants, either abroad or on arrival at the border. There is no Import Health Standard for **new** vehicles; however any new vehicles that are detected with contamination during unloading are treated in the same way as used vehicles.

The existing Standards have not been informed by a comprehensive risk analysis. Whilst pest incursions can rarely be traced with confidence to a particular pathway, a large variety of pest organisms are known to be associated with vehicles and machinery. Due to recent incursions of serious pests such as Asian gypsy moth and white spotted tussock moth, and the large volume of imported vehicles, MAF considered a comprehensive risk analysis was necessary.

1.3 RISK ASSESSMENT

The purpose of the risk assessment is to assess the likelihood of entry and establishment of organisms via the vehicle pathway, and the consequences of their establishment.

More than 180 families of organisms were identified from interception records for imported vehicles and machinery during the period 1994-2006, and were grouped on the basis of biology. A detailed risk assessment was conducted for 11 of these groups.

The key results from the risk assessments are as follows:

1. The vehicle pathway differs from other high volume inanimate pathways (such as shipping containers) and poses particular risks:
 - The complicated construction of vehicles provides many places that can hide organisms and accumulate organic debris
 - Vehicles are stored outdoors and are sourced from, or pass through, geographic areas known to contain a number of pests of concern for New Zealand
 - Vehicles remain permanently in New Zealand and can be taken anywhere in the country, well beyond pest surveillance networks.

2. Eleven groups of organisms have been assessed as hazards on used vehicles and machinery and nine groups on new vehicles. Hazards are organisms that could be introduced into New Zealand and are capable of, or potentially capable of, causing unwanted harm.
3. Of these, ten hazard groups contain high consequence hazards, such as some moth species and mobile species that are able to hide within the structure of the vehicle such as spiders and ants. High consequence hazards are considered likely to cause unwanted impacts of sufficient magnitude that should they become established in New Zealand either eradication would be attempted or other active responses would be implemented.
4. For hazard groups such as dermestid beetles, plant seeds and micro-organisms associated with soil, animal, and plant material, the likelihood of establishment is lower. In most cases this is due to the biology of the species.
5. The frequency of contamination by any one of the high consequence hazard groups is estimated to be low (see Table 1) but due to the large volume of imported vehicles, even low frequency contaminants are likely to arrive at a frequency that results in establishment.

1.4 RISK MANAGEMENT OBJECTIVE

The risk management objective of this risk analysis is to reduce the likelihood of entry and establishment of each high consequence hazard to a negligible level. MAF recognises there are other factors relating to practical implementation to be considered before risk management measures can be agreed. These factors will be explored in detail as part of the review of the Import Health Standards.

There is currently not enough information on the species assessed in this risk analysis to suggest an acceptable threshold level of entry via this pathway below which establishment is unlikely to occur. At present therefore, in order to achieve the objective of reducing the likelihood of entry and establishment of each high consequence hazard to a negligible level, entry of low frequency, high consequence hazards should be reduced to as close to zero as is feasible because the consequences of the establishment of such hazards would be so significant.

For other hazard groups such as dermestid beetles, plant seeds and micro-organisms associated with soil, animal and plant debris, the risk analysis has demonstrated that the likelihood of establishment is lower. While it is not possible to quantify an acceptable level of slippage for organisms in these groups, a higher level of entry should be acceptable.

The Biosecurity Monitoring Group of MAF has found that under the current risk management regime based on visual inspection, about half the imported used vehicles have non-visible contamination. Whilst some of this contamination is a low biosecurity risk, visual inspection cannot detect some of the mobile and hidden high consequence pest organisms. In addition, under operational conditions it is difficult to find all contamination that is visible.

1.5 RISK MANAGEMENT MEASURES RECOMMENDED FOR CONSIDERATION IN THE REVIEW OF IMPORT HEALTH STANDARDS

A range of risk management measures has been identified through discussion with stakeholders. The efficacy of these in reducing the risks to a negligible level has been assessed for the groups of organisms identified as hazards for new and/or used vehicles and machinery. The conclusions are summarised in Table 2.

There can be no single appropriate measure to manage all the hazards associated with imported vehicles. A package of measures is proposed for consideration in the Import Health Standard review process. The measures can be applied on or offshore, although offshore risk management is preferred. As part of the review of Import Health Standards, MAF will be looking at the policy considerations around the offshore decontamination of imported vehicles and machinery.

1.5.1 Imported used vehicles (excluding machinery):

- vacuuming and pressure wash
- and**
- heat treatment at 60°C core temperature for 10 minutes or fumigation with methyl bromide at a rate of 48g/ m³ for 24 hours at 21°C
- and**
- improved facility specification including measures to prevent recontamination offshore or escape of hazards prior to treatment onshore (see 35.3.4)
- and**
- for crash damaged vehicles thoroughly spray all potential larval mosquito habitats offshore with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than eight weeks **or** thoroughly spray onshore with a 2 percent permethrin spray.

Both fumigation with methyl bromide and heat treatment will manage the risk of vehicles contaminated with mobile, low frequency, high consequence organisms such as ants, moths, reptiles, spiders. However, there are clear disadvantages associated with the use of methyl bromide (see Chapter 4) and it may not be available as a routine treatment in the longer term. This package is unlikely to fully meet the risk management objective for plant seeds and snails.

An alternative package of measures was assessed. In summary, this includes:

- vacuuming and pressure wash;
- and**
- visual inspection of all vehicles with fumigation or heat treatment as necessary, including vehicles with spider webs;
- and**
- improved facility and inspection specification including measures to prevent recontamination offshore or escape of hazards prior to treatment onshore;
- and**
- registration of Land Transport New Zealand (LTNZ) compliance centres as transitional facilities;
- and**

- for crash damaged vehicles thoroughly spray all potential larval mosquito habitats offshore with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than eight weeks **or** thoroughly spray onshore with a 2 percent permethrin spray;
- and**
- heat treatment or fumigation of all containerised vehicles imported from USA or Canada.

The main concern with this package is its low efficacy for mobile, low frequency, hidden high consequence hazard groups (e.g. ants, moths, reptiles, spiders). Because the impacts of the pests involved and the costs and consequences of even a successful eradication are high, this is not the recommended risk management package in this risk analysis. However, it is likely to be more efficacious for plant seeds and snails.

1.5.2 Imported new vehicles:

Nine hazard groups have been assessed as hazards on imported new vehicles. These include some high consequence pests. However, MAF considers that new vehicles are of lower risk than used vehicles because their history is more easily defined and the package of measures recommended for imported used vehicles is not justified for new vehicles. For new vehicles the main risk factors are the conditions under which the vehicle is stored and the length or time it is stored prior to shipment.

To substantially lower the risk associated with imported new vehicles, MAF recommends:

- An approach based around identifying which vehicles are most likely to be infested and then either decontaminating and/or treating those or requiring system improvements that would reduce the likelihood of infestation.
- Such an approach would incorporate surveillance for key hazard groups, appropriate storage conditions and times, and audit.
- Since it is uncertain whether this approach would achieve the risk management objective, it would be necessary to review the system after a period.
- Since the degree of contamination of new vehicles is largely unknown, it is recommended that a slippage survey is undertaken. Since most hitchhiker species occur at comparatively low frequencies, large sample sizes are required to give meaningful results.

1.5.3 New and used machinery, trucks and other vehicles capable of holding water:

The risk associated with some hazard groups is higher in association with used machinery, as well as trucks, and other open backed vehicles, than is associated with passenger vehicles. Inspection and decontamination of machinery is more specialised. There is relatively little information available on contamination of different types of machinery. A videoscope survey of used machinery planned for 2006-2007 will provide a measure of slippage. An **interim package** of measures is proposed for consideration in the Import Health Standard review process based around improved specifications for visual inspection and treatment comprising:

- inspection by MAF Quarantine Service officers, trained in the inspection of complex machinery. Offshore inspection should be encouraged given the higher risk from some

hazard groups. Shipboard inspections of machines that have not been inspected offshore should ensure that no grossly contaminated machinery is permitted to disembark;

and

- cleaning or replacement of all air filters;

and

- provision of targeted information to importers of machinery. This is likely to increase the level of protection by focussing on the highest risk vehicles;

and

- heat treatment at a core temperature of at least 60°C for 30 minutes or fumigation with methyl bromide at 48g/ m³ for 24 hours at 20 °C of all imported used trucks and machinery which have been used for transporting grain whether or not there is any evidence of contamination;

and

- removal and destruction or heat treatment at 121°C for 15 minutes or 70°C for four hours of wire ropes on used agricultural and forestry equipment; **and**

and

- disinfection of all vehicles likely to be contaminated with faecal material including garbage lorries, sewerage trucks and vehicles used for transporting livestock, agricultural products and food stuffs. Note this requires a means of identifying these vehicles;

and

- improved facility and inspection specification (see 35.3.3);

and

- offshore, all water-filled cavities must be drained and all potential larval mosquito habitats must have the surfaces thoroughly sprayed with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than 8 weeks;

or

Onshore, visual inspection for adult mosquitoes immediately on arrival. Any found must be killed immediately with a 2 percent permethrin spray. If the specimen is found inside a vehicle, the interior of the vehicle must be treated with a 2 percent permethrin spray and sealed for an hour; **and** within 12 hours of the ship berthing in New Zealand all water-filled cavities:

- a. filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
- b. must be treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **and** must be drained; **and** have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

and

Within 12 hours of the ship berthing in New Zealand all cavities capable of impounding water, whether or not they contain evidence of having held water, but which are dry:

- a. must be filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
- b. have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

1.6 OTHER RECOMMENDATIONS

It is recommended that the Import Health Standard specifically covers boats, arriving as cargo on a vessel rather than under their own power, since they are not currently covered by any Import Health Standard, but are managed in practice through the used equipment standard. This risk analysis has found that they are likely to be a significant entry pathway for exotic frogs and mosquitoes. This is intended as an interim measure whilst a risk analysis of hull fouling on vessels and a review of freshwater biosecurity risks are undertaken.

In addition, recommendations are made regarding monitoring and review of the implementation of the proposed risk management measures, and uncertainties requiring further research or investigation are identified. There are also recommendations in relation to surveillance and awareness-raising (see Chapter 35).

Table 1. Summary of the potential hazard groups associated with imported vehicles and machinery and the results of the risk assessments undertaken as part of the vehicle risk analysis.

Potential hazard group (number of families & taxa intercepted)	Potential hazard	Indicative percent of vehicles entering contaminated with hazard group	Group contains high consequence hazard (s)	Hazard on used vehicles/ machinery	Potential hazard on new vehicles	Detailed Risk assessment undertaken
Ants (1, 27)	yes	<1%	yes (including red imported fire ant; yellow crazy ant)	yes	yes	yes
Bees and wasps (16,25)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for ants	yes	no
Beetles (other than dermestids) (21,48)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for dermestid beetles & food debris	no	no
Booklice (4,2)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for plant debris	no	no
Bugs (18,17)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for plant debris and spiders	no	no
Butterflies & moths (24,58)	yes	<1%	yes (including: Asian gypsy moth, fall webworm, painted apple moth, nun moth)	yes	yes	yes
Centipedes &	no	not assessed	not assessed	no	no	no

Potential hazard group (number of families & taxa intercepted)	Potential hazard	Indicative percent of vehicles entering contaminated with hazard group	Group contains high consequence hazard (s)	Hazard on used vehicles/ machinery	Potential hazard on new vehicles	Detailed Risk assessment undertaken
millipedes (3,1)						
Cockroaches (1,5)	yes	<0.1%	no	yes	no	yes
Crickets and grasshopper (4, 5)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for cockroaches & soil	no	no
Dermestid beetles (1,14)	yes	2-4%	yes (khapra beetle)	yes (khapra beetle only on agricultural trucks and machinery)	no	yes
Dragonflies and damselflies (3,2)	no	not assessed	not assessed	no	no	no
Earwigs (2,1)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for dermestid beetles	no	no
Flies other than mosquitoes (20, 19)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for soil & moths	no	no
Frogs and toads (2,4)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for reptiles	no	no
Mantids (1,4)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for cockroaches	unknown	no
Micro-organisms in soil, plant and animal debris	yes	Soil 48% Plant material 75% Animal Material 6%	yes (including pine pitch canker, potato wilt virus)	yes	uncertain, yes on field tested vehicles	yes
Mites (4,1)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for plant debris	no	no
Mosquitoes (1,8)	yes	not able to quantify	yes (container breeding mosquitoes e.g. Asian tiger mosquito)	yes (machinery & vehicles with open areas that can hold water)	yes	yes

Potential hazard group (number of families & taxa intercepted)	Potential hazard	Indicative percent of vehicles entering contaminated with hazard group	Group contains high consequence hazard (s)	Hazard on used vehicles/ machinery	Potential hazard on new vehicles	Detailed Risk assessment undertaken
Plant seeds (14, 37)	yes	31%	yes (including Johnson grass)	yes	yes	yes
Reptiles (3, 11)	yes	< 0.1%	yes (snakes)	yes	yes	yes
Scorpions (1,1)	no	not assessed	not assessed	no	no	No
Silverfish (1,1)	no	not assessed	not assessed	no	no	no
Snails (13,16)	yes	<0.1%	yes (including giant African snail)	yes	yes	yes
Spiders (19, 45)	yes	<12%	yes (including <i>Latrodectus</i> spp.)	yes	yes	yes
Springtails (1,2)	no	not assessed	not assessed	not assessed, assume risk will be covered by measures for soil	no	no
Stick insects (1,1)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for plant debris	no	no
Stoneflies (1,1)	no	not assessed	not assessed	no	no	no
Termites (1,1)	yes	not assessed	Yes (including <i>Coptotermes</i> spp.)	yes (machinery trucks and boats only)	no	yes
Thrips (1, 1)	yes	not assessed	not assessed	not assessed, assume risk will be covered by measures for plant debris	no	no
Woodlice (2,2)	no	not assessed	not assessed	no	no	no

Note the indicative contamination levels were derived from the current visual inspection regime. Since the Biosecurity Monitoring Group's surveys have found that many contaminants are not detected through visual inspection, actual contamination levels are expected to be higher.

Table 2. Summary evaluation of the efficacy of a range of risk management measures in reducing the risk of biosecurity hazards associated with imported used vehicles and machinery to a negligible level

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
Ants (bees & wasps)	no	yes (55°C for 30 minutes)	yes (48 g/ m ³ for 24 hours)	partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	partial (removing food source)	no	partial (likely to kill some)	uncertain (shipboard treatment with toxic bait)
Dermestid Beetles (earwigs)	yes (if not precleaned)	yes (55°C for 15 minutes) except <i>T. granarium</i> which may require 60°C for 30 minutes	yes (< 48g/ m ³ for 24 hours)	no	no	unknown (may not remove eggs)	partial (removal of mats, seat covers & back seats)	partial (likely to kill some)	surveillance by industry for <i>T. granarium</i> around grain stores
Butterflies & moths (flies except mosquitoes)	no	yes (55°C for 5 minutes)	yes (< 48g/ m ³ for 24 hours at 21°C)	partial (measure to prevent re-contamination prevention offshore and escape onshore & inspection ramps)	uncertain	no	no	unknown but may prevent re-contamination	no
Cockroaches (m antids, crickets, reduviid bugs)	no	yes (55°C for 10 minutes)	yes (<48g/ m ³ for 24 hours at 21°C)	no	no	partial (remove food supply)	no	partial (likely to kill some)	no

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
Mosquitoes	no	uncertain for vehicles containing water	yes (but adults likely to fly away before treatment)	no	no	no	no	yes (spray cavities - UV resistant formulation for offshore treatment)	partial (treatment of pooled water &/or receptacles with 10% chlorine & 4% detergent solution for 30 minutes)
Organisms associated with soil, plant and animal debris	no	no	no	partial (LTNZ compliance centres & improved screening and chlorine treatment of waste water at onshore decontamination sites)	partial together with vacuum	partial together with pressure wash	air filters for machinery	no	partial (disinfection of machinery /trucks with faecal or other infected material & provision of targeted information)
Plant seeds	no	no	no	partial (improved screening of waste water at onshore decontamination sites)	partial together with vacuum	partial together with pressure wash	uncertain (air filters)	no	no
Reptiles (amphibians)	no	yes (50°C for 10 minutes)	yes (<48 g/m ³ for 24 hours)	partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	no	no	no	partial (visual inspection of boats arriving as cargo)

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
Snails	uncertain	no	yes (128 g/ m ³ at 12.5°C for 24 hours)	partial (LTNZ compliance centres)	uncertain (audit with videoscope)	no	no	no	no
Spiders	no	yes (60°C for 10 minutes)	yes (<48 g/m ³ for 24 hours)	partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	no	no	unknown	no
Termites	yes	yes (54°C for 10 minutes)	uncertain	partial (LTNZ compliance centres)	no	no	no	unknown	no

2 Introduction

This risk analysis examines the biosecurity risks posed by the importation of vehicles and machinery into New Zealand. Recommendations from this risk analysis will contribute to the development of revised import health standards, issued by the Ministry of Agriculture and Forestry under the Biosecurity Act, 1993, that specify the requirements to be met before vehicles and machinery may be imported and given biosecurity clearance.

2.1 BACKGROUND

The volume of used vehicles imported into New Zealand is large, with some 176 000 imported in 2005 (New Zealand Customs, 2005). Approximately 95 percent of these come from Japan, although used vehicles have been imported from at least 80 different countries. Some 112 000 new vehicles were imported into New Zealand in 2005 (New Zealand Customs, 2005).

The complicated construction of vehicles provides numerous sites for organism concealment, egg laying, and accumulation of organic debris that can carry organisms such as fungi and nematodes. Additionally, many imported vehicles are stored outdoors, are sourced from geographic areas known to contain a number of pests of concern for New Zealand and are widely distributed throughout New Zealand on arrival. Used vehicles and machinery have been used in a range of environments, by operators of varying fastidiousness, and have histories that are extremely difficult to define from a biosecurity risk perspective.

A large number of different types of organisms have been intercepted on used vehicles. Some, such as Asian gypsy moth, *Lymantria dispar*, and black widow spiders, *Latrodectus mactans*, have a high public profile, others such as nun moth, *Lymantria monacha*, are less well known but regarded as major threats, and some organisms such as nematodes in soil are largely unknown to the public.

Three different import health standards currently regulate imported used vehicles and machinery. These standards have not been informed by a comprehensive risk analysis. Their provisions are discussed in Chapter 3. They provide for all vehicles to be inspected, either abroad or on arrival at the border. Approximately 55% of imported used vehicles are currently inspected by MAF Quarantine Service officers in Japan. There is no import health standard for new vehicles.

2.2 SCOPE

The commodities included in this risk analysis are the full range of vehicles and equipment covered by the current import health standards. These include used buses, cars, motorcycles, trucks, utility, vans, rubber-tyred or tracked equipment such as skidders, logging trucks, fellers, harvesters, tractors, ploughs, balers, concrete mixers, freezer vehicles, road construction machinery etc, whether self propelled, drawn, pushed or fixed in position. Imported equipment and machinery is considered in the same risk analysis as other imported vehicles, because although risk factors may differ, the potential hazards associated with the commodity are likely to be similar and the current measures for managing the risk associated with the pathway are similar to those for other vehicles. The term machinery is used in

preference to equipment, as it more clearly describes the range of commodities involved. The risk analysis covers all exporting countries. The commodity definition also includes equipment used in housing livestock, processing animals and animal products and plants and plant products from any country (Ministry of Agriculture and Forestry, 1998). It also includes boats, arriving as cargo on another vessel. These are not currently covered by any import health standard, but are managed in practice through the used equipment standard. Damaged vehicles that are not roadworthy also fall within the scope of the definition.

A used vehicle is defined in the current import health standards as any motor vehicle which has been:

- supplied to the consumer market and sold; or
- used as a demonstration, test or courtesy vehicle by its manufacturer or importer; or
- used for training or testing purposes; or
- previously registered or licensed; or
- regarded as a new vehicle but which, upon arrival, an inspector considers has been contaminated by contaminants specified in the standard (Ministry of Agriculture and Forestry, 2001). This latter is to enable MAF Quarantine Service to require decontamination of any new vehicles that they happen to find contaminated.

Note that contamination refers to biosecurity contamination which is defined in the standards.

Since there is very little information available on the risks associated with new vehicles, the analysis will merely identify the hazards associated with this part of the pathway and assess whether risk management measures are justified.

It was recognised at the outset of the review that there are significant gaps in the information available to inform the risk analysis. Areas of significant uncertainty are highlighted in the analysis.

This analysis does not address detailed issues relating to the practical implementation of risk management measures. They will be explored in more detail as part of the review of the import health standards.

The importation requirements for used tyres are covered by separate import health standards, which are not covered by this review. Vehicle parts are also excluded.

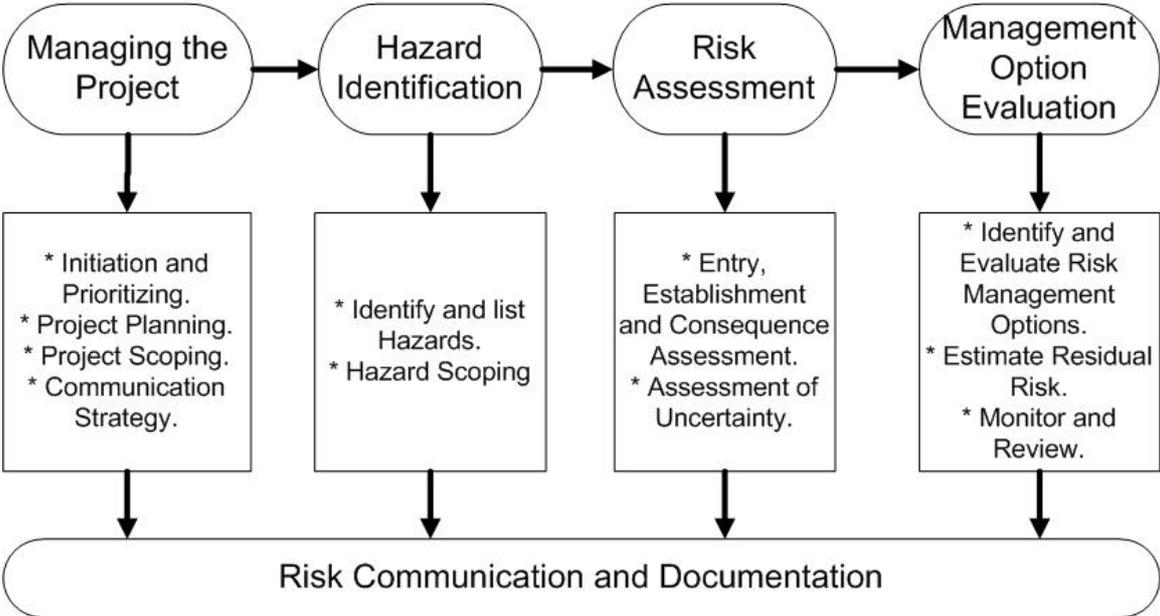
2.3 METHODOLOGY

The analysis starts with a description of the vehicle and equipment pathway and the way in which it is currently managed (Chapter 3). This provides a generic overview to inform the subsequent analysis.

This risk analysis follows the Biosecurity New Zealand risk analysis procedures (Biosecurity New Zealand, 2006). These procedures combine the guidelines in the international Terrestrial Animal Health Code of the Office International Des Epizooties (2001) and International Plant Protection Convention guidelines (ISPM No. 2 Guidelines for Pest Risk Analysis and ISPM No. 11 Pest Risk Analysis for quarantine pests, including analysis of environmental risks and modified living organisms). The procedures provide a framework which adheres to the requirements set out under the World Trade Organisation Agreement on the application of Sanitary and Phytosanitary measures (World Trade Organisation, 1995) and in the Biosecurity

Act, 1993. Risk management measures are recommended for the full range of biosecurity hazards. In many cases a single measure will act as a sanitary, phytosanitary, health and Biosecurity Act measure all at once.

Figure 1: The Biosecurity New Zealand risk analysis framework



2.3.1 Hazard identification and hazard scoping

The first step in the risk analysis is hazard identification. Hazards are organisms that could be introduced into New Zealand and are capable of, or potentially capable of, causing unwanted harm. The hazard identification process begins with the collation of a list of organisms associated with the commodity. This is usually derived from formal lists of organisms associated with the commodity in the country (ies) of origin. This approach is not feasible for the vehicle and machinery pathway because it is virtually impossible to determine which specific organisms will be associated with the commodity. Most of the organisms will either be ‘hitchhikers’ (organisms that are carried on/in the commodity but are not a pest of the commodity and are not dependent on it for survival) or be associated with other contaminants in/on the imported vehicles or machinery.

An alternative approach to hazard identification, adopted in this analysis, is to analyse records of border and post-border interceptions of organisms on imported vehicles and machinery. This provides direct evidence of association with the pathway, but does not provide a complete list of potential hazards. Some of the organisms associated with imported vehicles will have been removed by various cleaning treatments prior to export, and some organisms present may never have been intercepted, let alone identified. Additional limitations include:

- contaminants found on imported vehicles are not routinely recorded or identified. Therefore interception records do not provide an absolute measure of frequency of contamination of the commodity;

- interceptions are most often recorded when a survey is carried out and may provide only a snapshot – they do not provide any indication of seasonality;
- Interception records are generally limited to groups of organisms that are readily detected by the naked eye. Organisms associated with soil and plant debris are very rarely identified and recorded;
- most interceptions are identified taxonomically only at Order or Family level rather than at the species level;
- in many cases the viability or life stage of an organism is not recorded, or is inaccurately recorded. For instance, reptile specimens sent for identification are often recorded as dead but their condition and subsequent enquiry reveals they were alive when found (T. Whitaker, pers. comm.). Live organisms are probably more likely to be identified and recorded than dead ones, since dead organisms are not a direct biosecurity risk. For these reasons, the records can not be used to identify the proportion of a given hazard group that are alive on entry.

Despite these limitations, interception records are the best indication of the range of potential hazards associated with imported vehicles and machinery. As such they are used as the starting point for the risk analysis to identify potential hazards. Most of the records are derived from onshore inspections since very little identification, with the exception of lymantriid moths, is done of organisms intercepted on vehicles offshore.

Records of organisms intercepted on newly imported vehicles and machinery are kept for a variety of reasons and are maintained on a number of different databases/recording systems. The following data sources were used to compile a list of potential hazards for the used vehicle and equipment pathway:

- results of one-off surveys/ analyses including:
 - Biosecurity Monitoring Group videoscope survey (Biosecurity Monitoring Group, 2006);
 - Biosecurity Monitoring Group vehicle slippage survey (Wedde et al. 2006);
 - New Zealand Forest Research Institute study on the risk to New Zealand's forests and trees from plant debris and soil on imported used vehicles and machinery (Forest Research Institute, 1996);
 - records of all ants found by MAF Quarantine Service inspectors on vehicles and agricultural and forestry equipment during the period December 2004 to June 2005 (unpublished MAF data);
 - MAF Quarantine Service spreadsheet of lymantriid moth interceptions;
 - results of DNA testing of suspected lymantriid interceptions (Armstrong et al. 2003);
 - A.H. Whitaker's database of intercepted reptiles and amphibians.
- Biosecurity New Zealand's Specimen Tracking and Reporting System (STARS) database of organisms associated with border pathways. This includes post-border interceptions reported by the public. A report of organisms associated with 'Vehicle' and 'Agricultural machinery' host fields for the period October 2002 to September 2005 was extracted from STARS. No data are available from this database for the period prior to October 2002;
- Biosecurity Monitoring Group interceptions database. This comprises records of organisms intercepted by MAF Quarantine Service staff at the border since 1994 as well as records from a number of other databases including Ensis records and records from the Forest Research Institute BUGS database. Due to the multiple data sources incorporated in this database, the information for records in the database is often incomplete. For instance, the viability field is frequently blank. There has also been inconsistent data

entry, particularly in relation to country of origin which generally does not reflect any transshipment ports. A report of organisms associated with vehicle related host fields was obtained for the period up to April 2006.

The various data sources were cross-checked to ensure as far as possible that records were not duplicated.

Table 1 summarises the results from searches of the above sources of this initial stage of hazard identification. Fungi, nematodes, viruses and bacteria are not included because they are associated with contaminants such as soil and plant material in vehicles which are not routinely recorded in the databases or sent to the labs for analysis. Organisms in at least 25 different orders and approximately 186 different families have been recorded in association with imported vehicles and machinery, but relatively few have been identified to species level. There has been no requirement to identify organisms found on imported vehicles.

A review of MAF interception records between 1955 and 1982 reveal few records, presumably reflecting both the low volume of trade and the limited inspection undertaken during this period. Most records were from vehicles originating in the UK, Australia and other Commonwealth countries, with very few from Asia. Most records were only identified to family level. Ants (Formicidae) were most frequently intercepted and interestingly there is a record for Argentine ant (*Linepithema humile*) before it became established in New Zealand.

Interception records of organisms on imported vehicles and machinery were obtained from the Australian Quarantine and Inspection Service for comparison. These were not analysed in detail, but a similar range of organisms were recorded.

Table 1. Summary of intercepted organisms recorded in association with the imported vehicle and equipment pathway from the sources listed above

Type of organism	Order	Number of families in order intercepted	Number of genera identified	Number of species identified
insect, roaches	Blattoidea	1	3	5
insect, beetles	Coleoptera	22	53	46
insect, springtails	Collembola	1	2	0
insect, earwigs	Dermaptera	2	1	1
insect, flies	Diptera	20	19	14
insect, bugs	Hemiptera	18	15	11
insect, bees, wasps, ants	Hymenoptera	17	38	36
insect, termite	Isoptera	1	1	0
insect, butterflies, moths	Lepidoptera	24	52	48
insect, mantids	Mantodea	1	4	4
insect, dragonflies & damselflies	Odonata	3	2	0
insect, crickets	Orthoptera	4	5	2
insect, stick insects	Phasmatodea	1	0	0
insect, stoneflies	Plecoptera	1	0	0

Type of organism	Order	Number of families in order intercepted	Number of genera identified	Number of species identified
insect, booklice	Psocoptera	4	2	1
insect, thrips	Thysanoptera	1	0	0
insect, silverfish	Thysanura	1	1	1
mite	Acarina	4	1	1
mollusc, snails	Stylommatophora	15	16	7
scorpion	Scorpionida	1	1	1
centipede	Scolopendrida, Polydesmida	3	1	0
crustacean, woodlice	Isopoda	2	2	0
spider	Araneae	19	30	24
amphibian	Anura	2	3	4
reptile	Squamata	3	8	12
plant		14	37	11
Total*		186	291	228

*Since most intercepted organisms are not identified, this is not a complete list.

The interception records for each group of organisms listed above are assessed to determine whether the organisms are present in New Zealand. Organisms are considered to be potential hazards if they meet one or more of the following criteria:

- they are not established in New Zealand or are under an official control programme;
- there are known potentially harmful sub-species, strains or host associations that do not occur in New Zealand;
- they are known to vector organisms or disease agents that are not present in New Zealand;
- present in New Zealand, and the nature of the import is such that it would significantly increase the existing hazard.

2.3.2 Risk assessment

A risk assessment is undertaken for each group of organisms identified as potential hazards associated with the pathway. The Biosecurity New Zealand Risk Analysis Procedures (Biosecurity New Zealand, 2006) gives several options for descriptors for critical attributes of risk (Table 2).

Table 2. Descriptors for critical attributes of risk

Risk Attributes	
Negligible	Not worth considering; insignificant
Non-negligible	Worth considering; significant
Risk Descriptors (not all may be used)	
Very Low	Close to insignificant
Low	Less than average, coming below the normal level
Medium	Around the normal or average level
High	Extending above the normal or average level
Very High	Well above the normal or average level

For this risk analysis risk descriptors are not used. In order to be able to apply such descriptors, reliable information is needed on factors such as the frequency with which the pest occurs on the commodity or the relative infestation levels of different commodities. With no indication of what an average level is, assigning such risk descriptors is not meaningful.

The likelihood of entry and establishment is described as negligible or non-negligible. Where there is some information to suggest the relative likelihood of entry or establishment on the pathway, this is noted in a comment.

The risks associated with micro-organisms associated with soil, plant and animal debris are assessed in Chapter 20. The approach in this chapter differs from the others because the contaminants themselves i.e. the soil, plant or animal debris, are not potential hazards. It is the organisms associated with the contaminants that are of interest. However, given their microscopic nature they are not identified or recorded. The risk assessment in this chapter is generic rather than for a specific organism(s).

Under the Biosecurity New Zealand risk analysis framework (Biosecurity New Zealand, 2006), risk assessment consists of four inter-related steps:

- assessment of likelihood of entry into New Zealand;
- assessment of likelihood of exposure and establishment in New Zealand;
- assessment of consequences of entry, exposure, establishment and spread;
- risk estimation - a conclusion on the risk posed by the organism based on the entry, establishment and consequence assessments. If the risk is non-negligible, then the organism is classified as a hazard.

Not all of these steps are necessary in all risk assessments. If the likelihood of entry for a potential hazard group is negligible, then the risk estimate is automatically negligible and the remaining steps of the analysis need not be carried out. The same situation arises if the likelihood of establishment of a potential hazard group is negligible, or if the consequences of establishment are negligible. Where sufficient information is available, high consequence hazards are identified. These are defined in the Biosecurity risk analysis framework as those considered likely to cause an unwanted impact to people, the New Zealand environment or the New Zealand economy of sufficient magnitude that should it become established in New Zealand either eradication would be attempted or other active response options would be implemented.

Where a hazard group is found to be sufficiently similar in biology and behaviour to another hazard group, such that additional risk management measures would not be required, then a full risk assessment is only undertaken for one of the groups. For instance, it is assumed that risk management measures proposed for reptiles will manage the risks associated with amphibians, and a full risk assessment is not undertaken for amphibians.

Where possible, the risks associated with each potential hazard group are assessed using one or more individual species or genera as an example of the wider group of organisms. These assessments are used to support proposed risk management measures for the larger group of related organisms. Species or genera are selected for more detailed assessment on the basis of one or more of the following criteria:

- clear identification and association with the pathway;
- known to be of concern to animal, plant or human health;

- known to occur in one or more of the main source countries for imported vehicles (see Chapter 3). In each case there is an example species from Japan, and in some instances, examples have also been selected from other vehicle exporting countries, notably the USA and Australia;
- known to be one of the more difficult organisms of its type to control.

This approach is based on the assumption that the biosecurity risks posed by all other organisms in the same group of potential hazards and likely to be associated with the pathway, can be managed by the measures recommended for the example species/genus. It reduces the scope of the analysis to a more manageable level as well as enabling the risks posed by unknown potential hazards to be accommodated. The conclusions of this analysis may need to be reassessed should the main vehicle exporting countries change, or if evidence is found that the recommended risk management measures are not effective against particular hazards.

For the purposes of this risk analysis, the commodity is divided into the following types:

- new vehicles and machinery;
- used vehicles;
- used machinery.

For each group of potential hazards under consideration, the risk assessment process considers each of these commodity types.

The likelihoods of entry and establishment of potential hazards are assessed on the basis of no risk mitigation measures on the pathway. This causes some difficulties because the interception records used in the assessment are obtained as a result of the current risk management regime, which can distort the results. For instance, some vehicles are cleaned prior to inspection by MAF Quarantine Service inspectors (see section 3.3), and this may result in misleading estimates of frequency of some types of contaminants. Such instances are identified in the following chapters.

Given the limitations of the data, the risk analysis is qualitative rather than quantitative.

2.3.3 Risk management

Risk management consists of the following steps:

- Risk management objective. Since zero-risk is not a viable option, the guiding principle for risk management should be to manage risk to achieve the required level of protection that can be justified;
- Option evaluation to identify the options available for managing the risk, and to consider risk reduction effects. The range of measures and their applicability to the pathway is discussed in Chapter 4. A subset of feasible measures is identified. The subsequent risk assessment chapters assess the efficacy of these measures, including the current regime in managing the particular hazard group;
- Recommended measures to meet the risk management objective, whilst minimising compliance costs;
- Monitoring and review. Monitoring of the implementation of recommended measures as set out in a revised import health standard is necessary to ensure that they are achieving the results intended. It may be necessary to review the risk analysis or the implementation of the recommended measures in the light of monitoring results. To avoid duplication,

monitoring and review, as well as the expected performance of the measures and associated residual risk is discussed in relation to the whole pathway in Chapter 35, and not separately for each hazard group.

2.3.4 Risk communication

A number of stakeholder meetings have been held as part of the review of the import health standards for the vehicles and machinery pathways and information from these meetings have informed the risk analysis (Toy and Glassey, 2006; Wards, 2006).

2.4 SPECIAL CONSIDERATIONS

New Zealand imports substantially more used vehicles than other countries except Russia and United Arab Emirates (Anonymous, 2006). For instance, Australia imports approximately 10 000 used vehicles a year (D. Ironside, pers. comm.) compared with New Zealand's 176 000 used vehicles in 2005. The risk associated with the pathway and required management measures will, therefore, be different from those in other countries. In addition, as a result of New Zealand's geographic isolation it remains free from numerous pests and diseases that are already present in many countries.

Most of the organisms identified as hazards on the vehicle pathway are either 'hitchhikers', or are associated with other contaminants in/on the vehicles and machinery. They are not pests of the vehicle and are generally not subject to international standards for export and inspection. It has been suggested that many of the invertebrate species that have eluded border controls and become established in recent years are hitchhiker pests (Barlow and Goldson, 2002).

It is assumed that the most important risk factor for hitchhiker organisms is use and storage conditions prior to export. These cannot necessarily be inferred from information routinely available such as country of origin or the type of commodity. For example a vehicle stored outside under a streetlight is more likely to be contaminated with moth life stages than when stored under cover (Biosecurity New Zealand, 2007).

Little is known about many hitchhiker organisms and it is not always possible to predict which species will be considered a problem and which will be innocuous. Studies of historic establishments, for instance, the clover root weevil, *Sitona lepidus* indicate that the overseas literature is not always helpful in predicting invasiveness in New Zealand, (Barlow and Goldson, 2002). Hitchhiking organisms are frequently environmental pests and the Biosecurity Strategy recognises that new approaches to import health standard development may be needed to address the shortcomings of the established biosecurity system in managing unidentified, environmental and aquatic pests (Biosecurity Council, 2003).

The likelihood of establishment in a new environment is extremely difficult to predict for any organism, because the effects of potential enemies and of competition will not be fully known. Moreover, real population systems are subject to random perturbations and do not develop in a fixed, predictable way (Lawton et al. 1986). Incursion records from New Zealand or other countries with similar environmental conditions are a possible indicator that an organism is likely to establish. However, most incursions of exotic species in New Zealand are detected through targeted surveillance at high-risk sites or through investigation of post-border interception records. The vehicle pathway poses a particular challenge for surveillance because vehicles can be taken to any part of the country. A lack of post-border incursion

records does not necessarily mean that an organism has not established. This is illustrated by a review of three recent cases in the USA, which found that several years elapsed between arrival of a new organism and its discovery (United States Government Accountability Office, 2006). A paucity of incursions linked to the vehicle pathway cannot be taken to mean that no such incursions have occurred, and indeed whilst not conclusive it is likely that imported vehicles have been the entry pathway for white spotted tussock moth, *Orgyia thyellina*.

An additional difficulty in interpreting post-border incursions is that hitchhiker organisms such as Asian gypsy moth, *Lymantria dispar* and several ant species are associated with a number of pathways (Biosecurity New Zealand, 2007; Ward et al. 2006), making it difficult to link an incursion to any one pathway.

The number of imported used vehicles has grown from 88 000 in 1995 to 176 000 in 2005 (New Zealand Customs, 2005). It is assumed that the greater the volume of imports, the greater the likelihood of entry and of establishment of pests, assuming a consistent level of mitigation. Since there is often a time lag between an organism becoming established and an obvious population erupting (Stohlgren and Schnase, 2006), establishments arising from the current high volume of imported vehicles may not be discovered for a number of years.

Identification of an appropriate risk management objective is not straightforward for hazards on the vehicle and equipment pathway. The probit 9 standard for quarantine treatment efficacy (99.9968 percent mortality) was originally recommended for tropical fruits heavily infested with fruit flies, and centres on high mortality to achieve quarantine security (Follett and McQuate, 2001). This standard may be too stringent for quarantine pests in commodities that are rarely infested, or for hitchhikers on inorganic commodities. A good information base is generally a pre-requisite in applying a risk-based treatment efficacy approach but is not available for the vehicle pathway. The types of information available in the literature are not necessarily useful for establishing the nature of the relationship between a pest and a particular pathway, particularly when the pest is a hitchhiker. The critical information for this is a record of actual interceptions on the pathway for an extended period. Currently the level of identification done and the way that the observations and actions of quarantine officers at the border are captured does not meet these needs.

A risk management objective based on a percentage of acceptable slippage will result in the level of risk varying with the volume of imported commodity and the detectability of the hazard and can only be specified if an acceptable entry threshold can be identified. This approach has therefore not been adopted in the risk analysis. Instead, an objective of reducing the likelihood of entry via the vehicle pathway to such a level that there are unlikely to be incursions and therefore responses and/ or establishments of hazard groups is the approach taken.

Many hitchhiker species occur at comparatively low frequencies across a wide range of pathways. Several of the species assessed in this risk analysis have also been intercepted from sea containers for example, which are imported into New Zealand in even larger numbers than vehicles. Significant differences between the used vehicle and other pathways include the greater complexity of vehicle structure, the unknown history of use and storage of imported vehicles, the length of time that imported vehicles and machinery remain in New Zealand and their ability to be distributed throughout New Zealand, beyond the reach of formal surveillance programmes (MAF Biosecurity Authority, 2003b). In contrast, all containers go

to transitional facilities which have staff trained in biosecurity awareness and the locations of which are known (MAF Biosecurity Authority, 2003a).

This analysis is restricted to the vehicle and machinery pathway. Our lack of knowledge about, or different measures on, other pathways will not be a reason for not recommending justifiable measures on the vehicle pathway. Each of these pathways has been or will be assessed separately.

The assumptions and uncertainties in this risk analysis are documented and subjected to peer review to ensure rigour.

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3 Pathway description

This chapter provides a description of the vehicle and machinery pathway and the way in which it is currently managed from a biosecurity perspective. This provides a generic overview to inform the subsequent analysis.

3.1 GENERAL

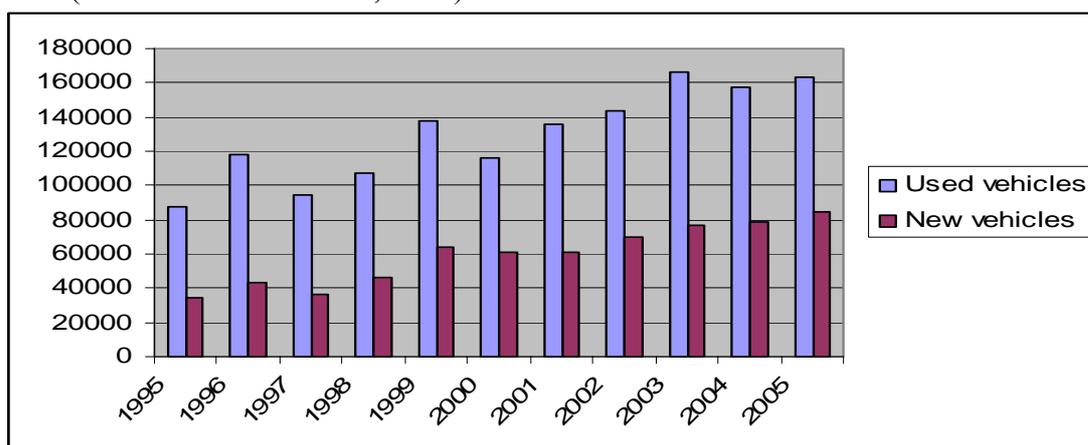
Used vehicles spend months or years in urban or rural areas prior to export. New cars may also be stored outdoors in a variety of conditions prior to export. The length of time between manufacture and export of a vehicle can vary. Storage areas for new vehicles are not controlled in any way and may be located in situations where contamination is possible (Alexander, 1997). Motor vehicles for export (both new and used) usually spend some time at the port in a variety of circumstances prior to loading (Toy and Glassey, 2006).

The Ships' Atlas (Shipping Guides Ltd., 1998) gives the transit time from Yokohama to Auckland as 12.5 days. In practice journey times range from a minimum of 12 days from Kawasaki direct to Auckland to a maximum of 28 days from Osaka to Nelson via 11 intermediate ports (Toyofuji Shipping Company Ltd., 2006). The journey time from San Francisco averages 15.4 days: from Singapore 13.2 days: and from Australia four days.

3.2 VOLUMES, TYPES AND COUNTRIES OF ORIGIN OF IMPORTED VEHICLES AND MACHINERY

Figure 1 shows the trend in imported vehicles over the last ten years. Total vehicle imports have more than doubled with new vehicles imports increasing at a slightly greater rate than used vehicles.

Figure 1 Number of vehicles imported from all countries annually between 1995 and 2005 (New Zealand Customs, 2005).



Note buses, trucks and commercial vehicles are excluded from these figures.

Table 1 presents numbers of vehicles imported into New Zealand in 2005 by type and by main exporting country. Vehicles are imported from more than 60 countries. Note these figures also include buses and trucks. The country of export is not always the country of origin. It is not often evident from the documentation whether a vehicle has been used and/or stored in another country prior to shipment.

Table 1. Numbers of vehicles imported into New Zealand from main exporting countries during 2005. Compiled by BNZ Biosecurity Monitoring Group from Customs statistics.

Country of export	New cars	New buses, trucks & commercial vehicles	Total new	Used cars	Used buses, trucks & commercial vehicles	Total used
Japan	38188	8270	46458	155025	12040	167065
Australia	19583	2566	22149	1149	85	1234
Thailand	540	12019	12559	0	0	0
Korea	6965	2	6967	0	0	0
Germany	5241	505	5746	46	0	46
South Africa	2932	170	3102	16	0	16
Great Britain	2808	197	3005	584	76	660
Belgium	2753	77	2830	0	0	0
France	1434	0	1434	0	0	0
Spain	641	636	1277	0	0	0
USA	810	370	1180	1543	127	1670
Singapore	19	0	19	4550	71	4621
Other	2415	3202	5617	340	17	199
Total	84329	28014	112343	163253	12416	175619

Note: the country of export is not necessarily the same country where vehicles are manufactured or sold.

Whilst the risk analysis is not restricted by country of origin, it is assumed that the number of hazards entering New Zealand on used vehicles from Japan will be higher than on vehicles from other countries, simply due to the larger numbers of vehicles involved.

Vehicles and machinery imported into New Zealand arrive either in a dedicated car transporting ship (often described as break-bulk imports), or in containers. Biosecurity inspection statistics are recorded in different databases depending on the method of arrival. Statistics for containerised vehicles and break-bulk machinery are recorded in the Quancargo database, while statistics for break-bulk vehicles are recorded in the Carships database. During 2004-2005, approximately 20 000 vehicles were imported in containers (Quancargo database).

Table 2 presents the types and frequency of used machinery imported over a 21 month period. Accident damaged vehicles are another type of imported vehicle. They are sometimes imported for parts or repair. Numbers vary, but up to 20 vehicles a week are reportedly exported from one facility in Japan (Toy and Glassey, 2006)

Table 2. Types of used machinery imported to New Zealand during period 1 January 2004 to 30 September 2005 (from MAF Quancargo database).

machinery type	total number of type imported and inspected	number and percentage of machines by country of origin				
		Japan	USA	Australia	Pacific	other
excavators & bulldozers	2539	2406	17	48	18	50
boat(s)	1135	163	545	268	26	133
sweepers, graders, scrapers & rollers	495	367	51	51	7	19
loaders	450	403	8	16	5	18
agricultural machinery	420	199	59	17	94	51
cranes	196	119	11	18	5	43
off road dumpers	122	94	6	1	0	21
mobile machines	40	27	7	4	0	2
traction engines	21	12	5	2	0	2
forestry machinery	4	1	2	0	0	1
Total	5422	3791 (70%)	711 (13%)	425 (8%)	155 (3%)	340 (6%)

The age of imported used vehicles is variable, but the age of vehicles arriving break-bulk is reported to be increasing with some 18 percent first registered eight or more years ago in 1998, compared with 60 percent in 2005 (Anonymous, 2006).

3.3 CURRENT RISK MANAGEMENT MEASURES FOR USED VEHICLES AND MACHINERY

The import requirements for used vehicles and equipment are set out in the following MAF Biosecurity New Zealand import health standards (IHSs):

- import health standard for used buses, cars, motor cycles, trucks, utility vehicles and vans from any country, dated 11 September 2001;
- import health standard for treated used vehicles imported into New Zealand, BMG-STD-HTVEH, September 2003;
- import health standard for forestry and agricultural equipment from any country, dated 18 March 1998.

Together these provide four alternative sets of import requirements:

- inspection by MAF staff abroad, followed by decontamination and/or treatment as necessary and clearance on arrival in New Zealand by MAF;
- inspection, followed by decontamination and/or treatment as necessary and clearance on arrival in New Zealand by MAF, or a combination of inspection abroad and in New Zealand;
- inspection and certification abroad by the source country's National Plant Protection Organisation, audit inspection and clearance on arrival in New Zealand by MAF. This option has not been used;
- inspection and treatment to remove any visible contamination followed by heat treatment at 54 °C for 10 minutes at MAF approved facilities on arrival in New Zealand or prior to shipment with audit inspections and clearance by MAF on arrival in New Zealand. Facilities for this option have only been available since December 2006.

The detailed process for undertaking inspections of vehicles and equipment is set out in a single process procedure (MAF Quarantine Service, 2006), which replaces separate procedures for onshore and offshore inspections (MAF Quarantine Service, 2004). The process is summarised below.

Used vehicles imported into New Zealand are inspected either prior to shipment in Japan by MAF Quarantine Service officers or on arrival in New Zealand by MAF Quarantine Service officers at an approved transitional facility or the port of discharge. Whilst the option for offshore inspection is not geographically limited, it is usually only cost-effective when large volumes of vehicles are exported and is currently only routinely applied to vehicles exported from Japan.

Before giving clearance to a vehicle, MAF Quarantine Service officers will visually inspect the interior and exterior, including the underside (usually via a ramp or pit) and engine of the vehicle to ensure that it is free of visible biosecurity contaminants. Components such as air filters that cannot be removed without recourse to tools are not inspected. If contamination is found, the vehicle is directed for decontamination and/or treatment within 12 hours at an approved decontamination facility at the importer's expense. The decontamination/treatment regime depends on the type of contaminant(s) found, and includes water blasting, vacuuming and fumigation. Additionally, decaying wooden decks of vehicles may require incineration. Once a vehicle has been decontaminated, it will be re-inspected, or the fumigation certificate checked. When the inspector is satisfied that the vehicle is free from contamination, it is given biosecurity clearance.

Biosecurity contamination is not consistently defined in the Import health standards and includes animals and animal products, plants and plant products and soil and water. The film of dust that may have settled on a vehicle during storage and shipment and bird droppings or desiccated arthropods found on a vehicle's radiator are given in one IHS as examples of contamination that would not prevent biosecurity clearance being given (New Zealand MAF Biosecurity Authority, 2003). It is not clear what other contamination, if any, would fall within the acceptable level of tolerance. The 2003 import health standard specifies live organisms in the definition of contamination (New Zealand MAF Biosecurity Authority, 2003), whilst the others do not refer to viability.

MAF Quarantine Service Inspectors in Japan have discretion to allow representatives of the vehicle exporting companies who accompany the inspectors to remove small contaminants from vehicles if this is easy and possible (MAF Quarantine Service, 2004). Doing so may allow the vehicle to be signed off for that particular inspection, and facilitate the processing of vehicles and reduce treatment costs. However, it may also result in underestimating the number of contaminated vehicles, as these types of interceptions are not usually recorded by MAF or the operator as treatment is not required. The number of vehicles from which MAF inspectors and/or representatives removed a small amount of contamination and then cleared the vehicle, was recorded for a sample of 751 internally inspected vehicles and 768 externally inspected vehicles in October 2005. Of these 26 percent of all sampled vehicles or 50 percent of contaminated sampled vehicles were cleared in this manner (Fletcher, Y. MQS Japan Programme Manager, pers. comm.). Similarly, 20 percent of vehicles inspected in Japan during the period 12-20 March 2006 were cleared in this way (MAF unpublished data).

The Standards require inspection to the degree necessary for an inspector to be satisfied that the vehicle is free of contamination. In practice the inspection process at the Port of Auckland

takes an average of three minutes per vehicle (excluding the time taken to prepare a vehicle for inspection) by a three person team. This is based on an assessment of the time taken for trained MAF Quarantine Service officers to complete the requisite inspection under normal working conditions (Biosecurity Monitoring Group, 2006). Factors influencing the time for inspection include:

- meeting the requirement for external inspections to occur with 12 hours of arrival;
- working through internal inspections in a timely manner with regard to vehicle flows whilst maintaining inspection efficacy;
- environmental conditions (inspections stop in some weather conditions);
- size and complexity of vehicle or machine: most machinery will take substantially longer to inspect;
- presentation of the vehicle (in Japan, vehicles are presented with mats removed, seats lifted etc);
- pre-cleaning (in Japan a high proportion of vehicles are cleaned prior to inspection).

There are some differences in procedures for inspection in New Zealand and offshore, to accommodate the differences in circumstances. For instance inspections in New Zealand are managed to minimise the likelihood of any contaminants escaping before they can be treated, whereas offshore, the focus is on minimising the likelihood of re-contamination after inspection.

3.3.1 New Zealand inspection

Vehicles must be imported into an approved first port of arrival and if not cleared at the port they must be moved to and be held in an approved transitional facility until clearance is given. The only exception to this is cars shipped as personal effects, which may be inspected at a site other than an approved site subject to certain conditions (Ministry of Agriculture and Forestry, 2003). Uncleared vehicles may be moved only between the port and a transitional facility for treatment with the authorisation of an inspector, to ensure that they are conveyed in such a manner that any organisms, soil, water, etc. can not escape from the consignment before the treatment and/or inspection can be completed (MAF Quarantine Service, 2006). Vehicles are frequently moved from the port at Auckland for decontamination, due to the shortage of facilities on the wharf. The requirements for approved transitional facilities for inspection and decontamination and for the transport of vehicles to such facilities are set out in the import health standard (Ministry of Agriculture and Forestry, 2003). This standard does not specify the properties required for inspection ramps, etc.

External inspections of vehicles must be conducted within 12 hours of discharge at the port of entry into New Zealand or of being de-vanned from a container. This is to minimise the escape of exotic organisms from imported vehicles into the New Zealand environment. Given the large numbers of vehicles discharged from car ships at some ports at one time, meeting this timeframe can be difficult. The place of inspection will depend on the method of arrival. Break-bulk arrivals are usually inspected at the port, whilst containerised vehicles are generally inspected at an approved transitional facility. Unless a non-compliant vehicle is adequately secured to prevent the movement of any regulated pests from the vehicle, decontamination must be conducted within 12 hours of arrival. There can be logistical difficulties in meeting this requirement. Some transitional facilities at which containerised vehicles are de-vanned do not have fumigation facilities. Vehicles found to be contaminated with live organisms at these facilities are moved by approved transport to a site with fumigation facilities (Smith and Toy, 2006). The current decontamination and treatment regimes are outlined in Chapter 4.

3.3.2 Offshore inspection

Inspection in Japan may only take place at a Terminal Receiving Station, a specified area covered by MAF Quarantine Service surveillance, for holding vehicles for inspection prior to loading onto a vessel for shipment to New Zealand. Vehicles are submitted for inspection with a completed Vehicle Condition Report. This report is used to mark the location of any contamination and provides a means of ensuring that identified contaminants are appropriately treated. External inspections must be conducted not more than ten days prior to shipping to minimise the chances of re-contamination. Inspected vehicles must be separated from non-inspected vehicles at all times after inspection by a minimum distance of three metres, or by being loaded on a separate deck during shipment. This is intended to minimise cross-contamination between vehicles. There are no requirements for separation from other cargo on the ship. Any 'passed' vehicles that have not been shipped within the 10 day period must be externally re-inspected prior to loading. During the Asian gypsy moth flight season only (June – September), external re-checks must include an underside inspection.

The offshore inspection process is divided into two parts, two separate sign-offs are required: interior and exterior. A green sticker indicating full biosecurity clearance is given once both sign-offs have been achieved. Some vehicles may have only an external inspection if time constraints do not allow for a full inspection before loading. This allows them to be shipped next to (within three metres of) fully cleared vehicles. The interior inspection is then completed in New Zealand. Where loading is compromised due to lack of space, the fully cleared vehicles immediately next to uncleared vehicles have a red sticker put over the green and these vehicles are re-ramped and inspected on arrival in New Zealand. This separation of pre-shipment inspected vehicles from non-pre-shipment inspected vehicles is a requirement of one of the import health standards (Ministry of Agriculture and Forestry, 2001).

Vehicles that have passed pre-shipment inspection in Japan may be transported by truck to another port or facility in Japan via a pre-arranged MAF approved route. The inspector at the receiving port will conduct an external inspection of all vehicles on arrival to check for recontamination.

A vehicle that fails inspection in Japan due to the presence/signs of live organisms is marked as rejected. All live organisms/signs of live organisms are removed and the vehicle requires either mandatory treatment on arrival in New Zealand, or treatment in Japan at the importers discretion (MAF Quarantine Service, 2006). The majority of vehicles that fail an inspection because of soil, plant or animal debris or seeds are decontaminated, re-inspected and cleared prior to shipment.

3.3.3 Compliance Centres

The Land Transport Rule - Vehicle Standards Compliance 2002 (Rule 35001/1) requires that all unregistered imported vehicles (except new vehicles) be certified before being registered for use on the road. The certification process requires checking of documentation to establish that vehicles were manufactured to safety standards recognised in New Zealand and detailed inspections to confirm the vehicles are still within "safe tolerance" of their manufactured state. The first step is for an inspection to be carried out by MAF on contract to Land Transport New Zealand (LTNZ). This inspection is not part of the biosecurity clearance requirement but has been incorporated into the process. This inspection is to record the odometer reading, confirm the identity of the vehicle by comparing the vehicle identity

number against documentation provided by the importer, and to identify any structural damage present that may preclude the vehicle from being deemed roadworthy.

Prior to registration for use on the road, used vehicles are subsequently subject to a more detailed physical inspection at LTNZ-approved compliance testing centres. These inspections occur after biosecurity clearance and may take place at any time, sometimes many months after importation. There are no restrictions on the conditions under which vehicles are held prior to completion of the compliance check. The inspections involve uncovering of the under-mudguard, door and floor panels and take approximately three hours per car. There is no formal process for dealing with any biosecurity contaminants found during this process. Once a used car has undergone mechanical inspection, it can go anywhere in New Zealand without restriction.

3.3.4 Used machinery and equipment

If safety and access considerations allow, all used machinery arriving in New Zealand as break-bulk (i.e. not in a container) is inspected on the vessel by a MAF quarantine inspector for gross contamination prior to discharge. If the Inspector determines the risk of contamination escaping during transport to a transitional facility to be too high, the goods will not be allowed to be discharged (MAF Quarantine Service, 2006). An estimated 20 machines a year fall into this category (Smith and Toy, 2006). Once discharged, machinery is held on the wharf. Inspection of specialised equipment usually requires removal of cover plates, etc. Guidance on carrying out inspections for such equipment is available (MAF Quarantine Service, 2006). There are additional requirements for inspection and treatment of used machinery over and above those required for other vehicles. Any winches, wires or cables associated with machinery require heat sterilisation at 121 °C for 15 minutes, or removal and destruction. Machinery that is likely to contain or have contained water must be inspected for mosquitoes within 24 hours of discharge. Where the contamination is with animal faeces or similar material, then the equipment will be disinfected after cleaning with a MAF approved disinfectant. The requirement to inspect within 12 hours of discharge from the vessel does not apply for used equipment. This is because the risk of dispersal prior to decontamination is assessed by the inspector at the initial on board inspection and appropriate steps taken to address this risk. If the machine is not inspected on the vessel then an initial inspection on the wharf is completed within 12 hours of discharge.

3.3.5 Decontamination regimes

When a vehicle is found to be contaminated by a MAF quarantine inspector it is sent for treatment, the type of treatment depending on the type of contamination. The number and proportion of vehicles arriving break-bulk and in containers and inspected on arrival into New Zealand which required decontamination are summarised in Table 3. The number of vehicles inspected in Japan requiring decontamination are summarised in Table 4.

Table 3. Used vehicles and machinery imported into New Zealand between 1 January 2004 and 30 September 2005 which were inspected on arrival (from MAF CarShips and Quancargo databases)

Port of entry	Number vehicles imported and inspected on arrival	Number vehicles requiring decontamination	% vehicles arriving at this port requiring decontamination
Auckland	68600	61140	89%
Christchurch	23052	14882	65%
Dunedin	1433	806	56%
Invercargill	131	75	57%
Lyttelton	382	240	63%
Nelson	3160	2102	67%
Napier	3559	2496	70%
Tauranga	1879	1459	78%
Wellington	15183	11411	75%
total vehicles arriving on carships	117379	94611	81%
cars arriving in containers	11299	6394	57%
boats	1135	284	25%
forestry machinery	4	2	50%
harvesters	21	10	48%
agricultural machinery & tractors	420	208	50%
cranes	196	99	51%
graders, scrapers, rollers, sweepers	496	229	46%
off-road dumpers	122	77	63%
bulldozers & excavators	2546	1472	58%
forklift	877	273	31%
motorcycles	5131	452	9%

Note that only the main types of machinery are included in this table.

Table 4. Decontamination of used vehicles inspected in Japan prior to shipment between July 2004 and June 2005 (from MAF CarShips database)

Total number of used vehicles imported into New Zealand	Number vehicles inspected in Japan prior to shipment	% of total number of imported vehicles	Number of vehicles requiring decontamination	% of vehicles inspected in Japan requiring decontamination
177 868	99 343	56%	39 879	40%

These data indicate that:

- fewer vehicles arriving in containers are sent for de-contamination than those arriving in car ships;
- fewer vehicles inspected in Japan are sent for decontamination than vehicles inspected in New Zealand;
- there is considerable variation in required de-contamination rates between ports of arrival;
- there is considerable variation in contamination rates between types of vehicle.

However, the following factors need to be considered in the interpretation of the statistics:

- contamination is only recorded by MAF Quarantine Service officers when follow up treatment is required. Some inspectors will require treatment for, and hence record, every instance of contamination, whilst others will remove contamination such as a single egg mass or a few leaves and not require decontamination treatment. This reduces costs and facilitates speedy clearance of the vehicle. Similarly, in some instances, pre-shipment inspectors are accompanied by cleaners, who will carry out spot decontamination to avoid the need for formal treatment and repeat inspections.
- contamination encompasses a huge range of potential hazards. There is no requirement to record the reason why a specific treatment is required when a vehicle is found to be contaminated. It is, therefore, not possible to determine the profile or relative level of risk associated with the different categories of contaminated vehicle.

3.3.6 Cost of current measures

The costs incurred by the industry in complying with the current import health standards at an industry rather than individual business level are estimated to fall within a low to high range of \$180 to \$400 per used vehicle for vehicles inspected on arrival in New Zealand compared with \$200 per vehicle for those inspected and cleared pre-shipment (Ministry of Agriculture and Forestry, 2005). This is about 1 percent of the total value of used vehicles imported into New Zealand and is at the lower end of the spectrum of biosecurity compliance costs for imported commodities. These figures are based on a high level assessment for the year ending June 2004, rather than a detailed consideration of costs, and exclude MAF inspection fees. (Current inspection fees for vehicles are \$25 or \$50 (depending on size) and \$100 per hour for machinery). They were derived from workshops involving the industry as part of a study undertaken for MAF. The figures are less clear cut for used machinery but were estimated at \$350 per item (Ministry of Agriculture and Forestry, 2005). In both cases, delays were identified as being a particular concern, due to the demurrage charged by ports, additional administration costs, costs of capital being tied up for longer and simple frustration. Although it is not clear from the study, the delay factor may in part explain the reported difference in costs between pre-cleared vehicles and those cleared on arrival.

3.4 CURRENT RISK MANAGEMENT MEASURES FOR IMPORTED NEW VEHICLES

There are no conditions on the importation of a new vehicle into New Zealand, unless, upon arrival an inspector considers that a vehicle or machine has been contaminated. In such circumstances the vehicle will be treated as a used vehicle (Ministry of Agriculture and Forestry, 2001). In practice such contamination is identified only by stevedores reporting it to MAF Quarantine Service inspectors or by inspectors undertaking routine surveillance on the wharf (Smith and Toy, 2006). Note that new vehicles are considered as used vehicles under the import health standard only to enable appropriate biosecurity measures to be taken. They are not recorded as used vehicles in the interception database.

New vehicles may have a small number of kilometres on the clock but have been kept in a wide range of storage conditions. For instance it is reported that new trucks are often imported via Australia, and that new machinery is sometimes field-tested prior to export (Wards, 2006). The storage locations and delivery routes are not usually evident from the import documentation. For example, a number of new Kia cars that were listed as Korean (where they were made) turned out to have been stored in Singapore for about 18 months prior to shipment to New Zealand (A.H. Whitaker, pers. comm.). Even for vehicles exported directly

to New Zealand, the export pathway varies considerably depending on the manufacturer, the model, the market, and shipping schedules (Toy and Glassey, 2006).

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4 Potential Risk management measures

This chapter considers a range of possible risk management measures, discusses generic issues around their feasibility and efficacy and concludes whether they are realistic options for managing risk associated with imported vehicles and machinery. The realistic options will be assessed in relation to each hazard group in the following chapters. The cost and logistical and operational issues of the measures are not considered in this risk analysis. They will be addressed during the development of any revisions to the import health standards. However the logistics of managing a pathway of this size and complexity is an important generic issue. Given the need for rapid application of risk management measures applied on arrival in New Zealand this is a particular issue when several thousand vehicles arrive at one time on a car ship.

The list of possible measures was identified by the project team and includes suggestions stakeholders put forward at a series of workshops (Wards, 2006). The measures are not necessarily exclusive and may be applied either on arrival or offshore or in a combination of both.

A generic issue across the range of measures is a paucity of information on efficacy in managing the range of hazards associated with the vehicle pathway. Much of the literature relates to general pest management treatments, rather than quarantine treatments which demand a higher level of assurance because failure of the measure can result in the establishment of a high consequence exotic pest. In addition, methods for assessing mortality in the literature vary widely. Test insects that have been reared in a laboratory for several generations may differ from wild-type organisms, for instance in losing the ability to diapause, which could have a significant impact on the results of any trials (Mangan and Hallman, 1998). The results of laboratory tests may, therefore, not be applicable to a field situation, but generally give some indication of mortality rates under specific conditions. The biggest issue is the paucity of efficacy data for quarantine treatments against many of the hazards associated with imported vehicles. Organisms such as ants, spiders and moths have not been subject to much research in this area.

4.1 CLOSE THE PATHWAY

The most effective measure for reducing the risk posed by imported used vehicles and machinery would be to ban the import of the assessed commodities into New Zealand. Given the size of the pathway, this would have serious economic consequences, and would constitute a significant trade barrier. It is not considered a feasible option and is not considered further in this analysis, although banning specific high-risk components will be considered where appropriate.

4.2 EXTERNAL AND INTERNAL VISUAL INSPECTION FOLLOWED BY TREATMENT WHERE NECESSARY (CURRENT REGIME)

This can be applied strictly offshore, strictly onshore or in a combination of the two. The regime entails the inspection of vehicles / machinery to determine the presence of quarantine risk material without the aid of specialised optical instruments such as videoscopes.

The IHSs currently provide for pre-shipment inspection arrangements to be put in place by the exporting country's national plant protection organisation (NPPO) and be supported by certification issued by the NPPO. This option has never been taken up. An alternative could

be certification by MAF approved and MAF audited private operators. Whilst risk issues around the motivation of New Zealand MAF quarantine staff in comparison with overseas operators have been raised, there are no data with which to assess their contribution as risk factors. The audit regime and consequences of failure are also important factors. The risk analysis does not address these issues – they are practical considerations to be addressed in the review of the import health standards.

Information on the efficacy of the current risk management regime is available from the following sources:

- MAF Quarantine Service audits;
- MAF Biosecurity Monitoring Group videoscope and vehicle slippage surveys;
- LTNZ compliance checking centres;
- Post-border interceptions and incursions associated with the vehicle pathway.

The objective of the risk management measures is not specified in the import health standards. An inspection efficacy target of 97 percent was set in 2003 against which to assess the effectiveness of the risk management regime. This target was not established on the basis of a risk analysis.

4.2.1 MAF internal audits

Audits are periodically undertaken to determine whether inspection procedures meet the specifications of MAF Quarantine Service process procedures and to identify areas for improvement. The contaminants that were missed during clearance inspections, but found by the audits vary in their level of risk, but were not quantified.

A series of audits of onshore and offshore inspections undertaken in 2003 and 2004 showed an improvement in the effectiveness of inspection over time from relatively low levels to between 94 and 100 percent (MAF Biosecurity Authority, 2004). The audits demonstrated considerable variation in the effectiveness of visual inspection in detecting contaminants in vehicles. Relevant factors affecting efficacy included:

- time spent inspecting each vehicle;
- experience of the quarantine inspector;
- environmental conditions at the time of inspection;
- presentation of the vehicle;
- port-related constraints.

Audits of 77 vehicles at three New Zealand ports in 2005 found 36 percent failed to meet the process procedure requirements. Issues identified by the audits include:

- failure to inspect ‘hidden’ compartments in trucks and specialist vehicles;
- risk items remaining under seats, door hinges, radiators, in cab, and on decks.
- failure to direct risk vehicles for appropriate treatment.

It has been suggested that the requirement to undertake an initial damage inspection for LTNZ at the same time as the biosecurity inspection may result in the focus of attention being diverted from biosecurity. This has not been tested but is considered by MAF Quarantine Service inspectors to be unlikely.

The logistics of managing the biosecurity clearance of vehicles on arrival in New Zealand is particularly complex due to a variety of factors including:

- the requirement for external inspection within 12 hours;
- the arrival of up to a couple of thousand vehicles at one time on a carship and the pressure on wharf storage that this creates;
- the relative shortage of decontamination facilities on the wharf at Auckland;
- the large number of geographically dispersed transitional facilities at which containerised vehicles may be devanned.

These factors mean that there may be delays of several days before internal inspections are undertaken and an imported vehicle is likely to be transported some distance from the wharf to a decontamination facility. There may also be delays in initial external inspections at transitional facilities as well as in repeat inspections following decontamination. Whilst the biosecurity risk associated with these delays and transfers can not be quantified, they are clearly undesirable.

4.2.2 Biosecurity Monitoring Group surveys

Biosecurity New Zealand's Biosecurity Monitoring Group used a videoscope to investigate the occurrence of contaminants in visually inaccessible places of vehicles and machinery in 2005 (Biosecurity Monitoring Group, 2006). A total of 292 vehicles and eight items of machinery were inspected following clearance by MAF Quarantine Service, either at the Ports of Auckland decontamination facilities, off-port cleaning transitional facilities or at a facility where vehicles are checked for compliance with New Zealand structural and equipment specifications.

The number of vehicles surveyed by vehicle type and the number and percentage of each type found to be contaminated in the videoscope survey is shown in Table 1. Many vehicles had multiple contaminants, either of different types or found in different locations.

Table1. Number and percentage of vehicles surveyed post clearance by videoscope and found to be contaminated. Source: Biosecurity Monitoring Group (2006)

Vehicle type	Number of vehicles surveyed	Number of vehicles with contaminants	Percentage vehicles with contaminants	95% confidence limits		Number of instances of contamination
Car	185	107	58%	51%	65%	233
Machinery	8	5	63%	30%	86%	17
4X4	35	19	54%	38%	70%	43
Truck	29	19	66%	47%	80%	26
Utility vehicle	6	5	83%	42%	96%	12
Van	37	18	49%	33%	64%	33
Total	300	173	58%	52%	63%	364

In the case of machinery, the most prevalent contaminant was soil, while in all other vehicle types, the most prevalent contaminant was dried plant material.

Approximately 58 percent of the vehicles and machinery surveyed were found to contain one or more contaminants. These contaminants included dried plant material, seeds, live insects, live spiders / egg sacs, fresh plant material, soil, feathers, and a live lizard. There was a total of 364 instances of contamination. One vehicle from Singapore had a live adult and egg sacs of the brown widow spider, *Latrodectus geometricus*, present.

Of the surveyed vehicles, 154, or 51 percent had contaminants (that would be considered biosecurity contamination under the definitions in the current import health standards) that would not have been detected without the videoscope. The videoscope operators considered it unlikely that every contaminant present in used vehicles and machinery can be seen even with the videoscope, so the percentage with contamination not visible through visual inspection could be an under-estimate.

Most vehicles had more than one instance of contamination. The most prevalent contaminant was dried plant material (199 instances) followed by clay/soil (54 instances), seeds (32 instances), pine needles (19 instances), dried straw/grass (16 instances) and egg sacs (12 instances). Eleven vehicles were found with live organisms excluding egg sacs (8 with spiders, 2 with live insects and 1 with a live lizard). Of these, nine would have been visible with a videoscope only, while two were seen with the naked eye. In addition, there were 12 instances of egg sacs, most of which could not be accessed for identification and viability testing. Three of the four that were retrieved were viable.

The highest incidence of contaminants was found in the wheel area, followed by the engine bay / bonnet, chassis and body panel. The survey did not assess the likelihood of contaminants found in the more enclosed parts of a vehicle being able to reach a vulnerable substrate in New Zealand and establish. The biosecurity risk of these contaminants was not assessed.

Only 24 of the 300 vehicles surveyed were inspected offshore. Of these, 4 (16 percent) had biosecurity risk contaminants compared with 74 (27 percent) of vehicles inspected and cleared on arrival. The numbers of offshore-inspected vehicles surveyed is too small for the difference in contamination rates to be statistically significant.

Twenty vehicles were surveyed at compliance centres, of which eight vehicles had biosecurity contaminants, including soil, plant material, seeds and egg sacs. The survey was concurrent with the partial stripping of the vehicles that is undertaken during the compliance check. The surveyor was present as the compliance centre inspectors removed panels, and was able to video-probe the structure of the vehicles as the inspectors worked (Biosecurity Monitoring Group, 2006).

In addition to the videoscope survey, a survey of 541 randomly selected vehicles that had been given biosecurity clearance for entry into New Zealand was carried out at the ports of Auckland, Wellington and Lyttelton in between September and December 2005. The primary objectives were to determine the nature and quantity of slippage (entry of vehicles carrying undetected contamination) and to estimate the effectiveness of current biosecurity interventions including assessing the appropriateness of visual inspection as a clearance technique. Surveyed vehicles were of three types: offshore-inspected break-bulk, onshore-inspected break-bulk and containerised cargo. Vehicles were searched visually both internally and externally, including inspection of air filters where possible. Machinery was excluded from the survey. The inspection method used by the surveyors was the same as that used by MAF Quarantine Service officers, although more time was spent inspecting each vehicle (approximately four minutes external and 20 minutes internal) (Wedde et al. 2006). Table 2 summarises the sample sizes for the Biosecurity Monitoring Group vehicle surveys.

Table 2. Sample sizes for the Biosecurity Monitoring Group 2005 imported used vehicle surveys, by method of import and location of biosecurity inspection.

Vehicle importation method and location of inspection	Number of vehicles sampled in accessible air filter survey	Number of vehicles sampled in internal and external visual survey	Number of vehicles sampled in videoscope survey*
Containerised imports inspected on onshore	8	14	34
Imported as break-bulk and inspected onshore	182	208	234
Imported as break-bulk and inspected offshore	430	319	24

* Note this Table excludes 8 items of machinery included in the videoscope survey.

The surveys found that the initial inspections undertaken by MAF Quarantine Service officers were more effective than inspections conducted after decontamination. Of the contaminated vehicles, 93 percent were correctly identified as being contaminated at initial inspection and were referred for decontamination. However the re-inspections following decontamination detected only 78 percent of such vehicles and an estimated 2 531 (22 percent) of 11 673 vehicles directed for decontamination by MAF Quarantine Service staff in November 2005 were released with some form of visible contamination still present. Overall, current operations were 73 percent effective at removing visible biosecurity contaminants from used vehicles. This translates into an estimated 3367 vehicles cleared for entry into New Zealand in November 2005 while still contaminated with visible contaminants (Wedde et al. 2006).

Slippage rates (for visible contaminants) were calculated as the number of contaminated vehicles in the survey sample, divided by the total number of vehicles in the survey sample. Containerised vehicles had a higher slippage rate (71 percent) than break-bulk imported vehicles (around 20 percent) but also a large margin of error (95 percent confidence interval of 51-83 percent) since only 14 containerised vehicles were surveyed. Containerised vehicles also had more instances of multiple contamination than vehicles imported as break-bulk, with. There was no difference in overall slippage rates between onshore and offshore inspected break-bulk imported vehicles.

A wide variety of contaminants were found in the surveys. The majority was dry plant material, with seeds being the major type in air filters; 40 percent of imported used vehicles had contaminated air filters. Table 3 summarises the estimated number of vehicles with different types of contaminant that are visible during standard inspection, non visible during standard inspection and located in air filters, entering New Zealand during November 2005. The risk associated with these contaminant types is assessed in the following chapters.

Note that the detection of low frequency contaminants is restricted by sample size. At the sampling rates used in the survey there is a 95 percent chance of detecting visible contamination affecting 1 in 182 imported used vehicles (Wedde et al. 2006). Many of the high consequence organisms assessed in this risk analysis are likely to occur much less frequently than this and were not expected to have been detected in the survey.

Table 3. Estimated number of vehicles with slippage of visible contaminants, non visible contaminants and contaminants in air filters during November 2005, by contaminant type. Source Wedde et al. (2006).

Contaminant type	Visible contaminants		In air filters		Non-visible contaminants excluding air filters**	
	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval
Plant material	2 181 (14%)	1 977-2 840	1 862 (12%)	1 601-2 511	6 081 (40%)	5 384-6 802
Seeds	873 (6%)	205-1471	5 053 (33%)	4 521-5 765	839 (5%)	601-1273
Soil	480 (3%)	494-1 049	33 (0.2%)	125-457	1 562 (10%)	1 211-2 093
Live animals*	591 (4%)	579-1 166	380 (2.5%)	372-900	945 (6%)	692-1387
Animal material	181 (1%)	251-734	294 (2%)	298-811	230 (1.5%)	141-534

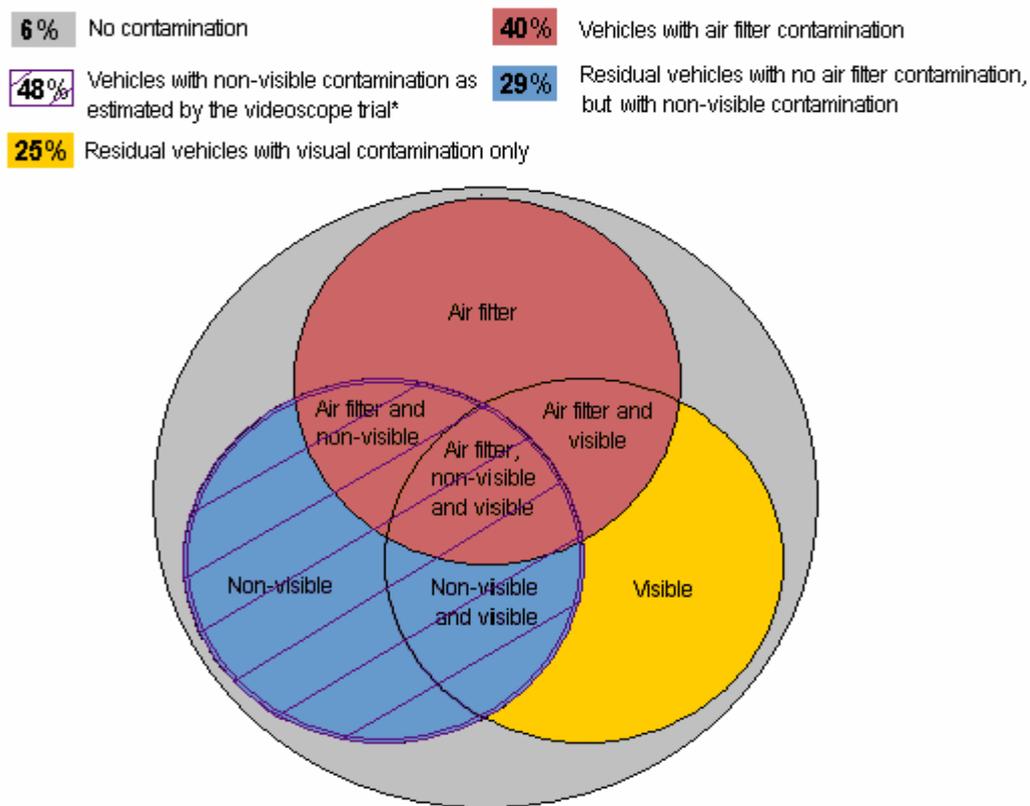
* Live animals include insects, spiders, and reptiles and comprise all viable life stages including egg masses.

**excluding machinery.

Note: Since some vehicles may have more than one contaminant type or the same contaminant in multiple locations, the numbers in individual columns and rows should not be added.

Taking the results of both the videoscope and slippage surveys, the Biosecurity Monitoring Group concluded that the measures specified by the current import health standards which rely on visual inspection are adequate for 31 percent of imported used vehicles. The remainder either have contaminated air filters and/or are carrying contamination that can not be seen with visual inspection, see Figure 1. This translates into an estimated 10 614 vehicles released in November 2005 with contamination present in air filters or in parts of the vehicles not able to be inspected, of which an estimated 7395 vehicles (excluding machinery) had non visible contamination. Note that because the videoscope and slippage and air filter surveys were undertaken independently it is not possible to calculate the overlap between the surveys.

Figure 1. Estimated vehicle contamination on the used vehicle pathway (excluding machinery). Source: Wedde et al. 2006



The Biosecurity Monitoring Group has devised a system of risk units to enable slippage of contaminants to be quantified and compared across pathways. The value of risk exposure (meaning in this case undetected contaminants entering New Zealand) expressed in risk units for a pathway indicates the level of risk posed by the pathway. Note however that the risk unit scale is applied at a very broad level, not at a species specific level and was developed on the basis of expert perceptions of risk rather than detailed risk assessments. It takes no account of the likelihood of establishment via different pathways. When the risk unit model is applied to the slippage survey results, the vehicle pathway was found to result in the highest risk exposure of any of the pathways that have been subject to similar surveys in recent years (air passengers, baggage and international mail pathways) (Wedde et al. 2006).

The Biosecurity Monitoring Group surveys did not look at the rate of re-contamination of vehicles inspected offshore, between inspection and treatment and shipping. This is complex to measure because it is difficult to distinguish between re-contamination and slippage at the original inspection. It is possible that some of the slippage recorded in the survey may be the result of re-contamination after clearance.

Similarly, no information is available to assess the efficacy of current arrangements for transfer of vehicles between the port of entry and treatment facilities, or at treatment facilities prior to treatment. There may be a delay of several days before a vehicle is decontaminated, although vehicles with visible live organisms detected will be fumigated at the port (MAF

Quarantine Service, 2006). The potential for escape of biosecurity contaminants remains a significant area of uncertainty in the current management of the pathway.

4.2.3 Compliance checking centres

There are no published data on the frequency with which biosecurity contamination is found at compliance centres, but information is available from the following sources:

- The managers of the 45 compliance centre members of the Vehicles Services Federation were sent a basic questionnaire in January 2006 seeking information on the frequency with which imported used vehicles were found to be contaminated with various hazard groups. Information on their response to such finds was also requested. Responses were obtained from about 20 of the centres and the results were compiled by the Vehicle Services Federation (N. Boyd, pers.comm.). All centres that responded have found biosecurity risk material on vehicles during the inspection process. Vehicles from Australia are considered to have the greatest volumes of contaminant. Live ants, spiders, cockroaches, beetles and egg masses are reported to be found regularly. Soil and plant material are found on a high proportion of vehicles. In addition, food, dead insects and insect nests are also found from time to time. Contaminants are nearly always disposed of into municipal waste bins. Some compliance centres always inform MAF Quarantine Service of such finds, others never do;
- The Biosecurity Monitoring Group videoscope survey, which included some vehicles surveyed at compliance centres (See 4.2.2);
- Several post-border interception records originate from compliance centres (Biosecurity Monitoring Group interceptions database).

Whilst there are clear limitations to these data, taken together they indicate that a considerable volume of biosecurity contamination is intercepted through the compliance checking process and disposed of through the municipal waste disposal system.

4.2.4 Post-border interceptions and incursions

Post-border interceptions of exotic organisms linked to the vehicle pathway, (Table 4) also indicate that the current risk management regime is not always effective in intercepting live mobile organisms. These records cannot be used to quantify efficacy since there is no consistency of effort. They rely on reporting by the general public and are likely to be biased, with high profile organisms being reported more frequently than inconspicuous ones. Some 88 percent of live post-border vehicle interceptions are of spiders, ants, wasps, reptiles, cockroaches and mantids. Five percent of live records are from new vehicles. Only 19 percent of post-border interceptions from vehicles were from Auckland, the port into which most vehicles are imported.

Table 4. Post-border interception records from vehicles between 2002 and 2005. Source: Biosecurity Monitoring Group interceptions database.

Number of records	Type of organism	Number of live intercepted organisms	Intercepted in Auckland recording district
75	Spiders	55	18
12	Cockroaches	9	2
35	Ants	30	1
16	Other hymenoptera	5	3
12	Mantids	7	1
5	Reptiles	3	2
47	Other	15	11
202	Total	124	38

The number of post-border detections of live organisms on vehicles doubled over the 18 month period from November 2004 to April 2006 (Fernando et al. 2006).

Conclusion

The evidence from monitoring surveys and post-border interception records indicates that the current risk management regime, specified in the import health standards, of 100 percent visual inspection with follow-up decontamination and treatment when contaminants are found, does not meet the current requirement of 97 percent of vehicles being free of biosecurity contamination at the point of clearance into New Zealand. However, it is an available and well-developed risk management measure and will be considered further in the following chapters. One of the inherent difficulties associated with any manual risk management measure, is the reliance on a high standard of training, motivation and skill being applied by all involved. This will be more difficult to achieve under adverse weather conditions or in sites with relatively poor facilities (Toy and Glassey, 2006).

4.3 VARIATIONS ON CURRENT RISK MANAGEMENT REGIME

4.3.1 Improved interception data to target inspection/treatment

The slippage and videoscope surveys have shown that, by increasing the amount of time to inspect a vehicle and using specialised inspection equipment, the ability to detect biosecurity risk material can be improved. If the factors that increase the likelihood of contamination by high-risk organisms could be identified, inspection effort could be focussed on areas where it is most effective. This approach has been used based on country of origin to identify containers at risk of being contaminated with giant African snail (*Achatina fulica*).

The challenge in applying this approach to the vehicle pathway is that the high-risk contaminants are hitchhiker organisms. Risk factors will be identified where possible in this analysis for each hazard group. However, given the range of organisms involved, and the known association of low frequency, high consequence organisms with the pathway, it is unlikely that risk profiles can adequately identify the risk. The information available at the border is generally not useful in identifying contaminated used vehicles. There is very little information available that would indicate use and storage conditions prior to the purchase of a vehicle by the exporter. These factors are likely to be the main risk factors. This means that using interception data to more precisely define the most likely used vehicles to be infested is not expected to work as effectively as with pathways such as containers with a more easily defined history.

However, better information on interceptions and a greater degree of identification and recording will be useful in identifying types of machinery that are a greater risk and for new vehicles which do not have a complex use and storage history. For instance, if live or dead life stages of fall webworm are found on a new vehicle, this indicates that other vehicles from the same source are also likely to be infested. Risk profiles could be developed to identify high-risk new vehicle import systems. Note however, that this system will work less well for species like Asian gypsy moth that are capable of flying long distances. Better interception information would also help in refining treatment regimes and in monitoring the effectiveness of any new risk management measures. It may also help clarify seasonality issues.

4.3.2 Compliance centres part of the formal biosecurity management regime

Currently, LTNZ compliance checking centres (see Section 3.3.3) are not registered as Transitional Facilities. There are no restrictions on the conditions under which vehicles are held pending inspection. There are no obligations on staff to manage any potential biosecurity hazards they may find during the compliance checking process, other than the requirement under the Biosecurity Act 1993 for any New Zealand resident to report to MAF any organism they believe not to be present in New Zealand.

The inspections involve the uncovering of the under-mudguard, door and floor panels and take approximately three hours per car. There is no formal process for dealing with any biosecurity contaminants found during this process. There are no published data on the frequency with which biosecurity contamination is found at compliance centres, but information is available from the following sources:

- The managers of the 45 compliance centre members of the Vehicles Services Federation were sent a basic questionnaire in January 2006 seeking information on the frequency with which imported used vehicles were found to be contaminated with various hazard groups. Information on their response to such finds was also requested. Responses were obtained from about 20 of the centres and the results were compiled by the Vehicle Services Federation.
- All centres have found biosecurity risk material on vehicles during the inspection process. Vehicles from Australia are considered to have the greatest volumes of contaminant. Live ants, spiders, cockroaches, beetles and egg masses are reported to be found regularly. Soil and plant material are found on a high proportion of vehicles. In addition, food, dead insects and insect nests are found from time to time. Contaminants are nearly always disposed of into municipal waste bins. Some compliance centres always inform MAF Quarantine Service of such finds: others never do (N. Boyd, pers.comm.).
- Twenty vehicles were examined by Biosecurity Monitoring Group inspectors at compliance centres using a videoscope in 2005, after vehicles had been compliance checked. Eight vehicles had items classified for the purposes of this survey as biosecurity contaminants (Biosecurity Monitoring Group, 2006).
- Small numbers of post-border interception records regularly originate from compliance centres (see section 4.2.5).

Whilst there are clear limitations to these data, taken together they indicate that biosecurity contamination is regularly intercepted through the compliance checking process and disposed of through the municipal waste disposal system. The videoscope survey discovered that even vehicles that had been subject to limited stripping of panels and covers at centre still harboured multiple contaminants (Biosecurity Monitoring Group, 2006). The compliance centre checks could, however, provide a useful backup biosecurity mitigation measure. Registration of centres as Transitional Facilities would enable risk material to be disposed of

appropriately. However, this would mean that vehicles could not be cleared until the accredited person at the compliance centre has given feedback to Maf Quarantine Service that the vehicle has been checked for biosecurity contamination during the compliance check process and that any contamination found has been appropriately managed. Registration of compliance centres as Transitional Facilities would require a change to the current clearance processes and facilities standard, as well as registration and training of compliance centre staff. Other issues to resolve would include the time between entry into New Zealand and clearance at a compliance centre and measures required to prevent escape of exotic organisms during this period.

Some of these issues could be addressed if the compliance checks are undertaken offshore in conjunction with a pre-MAF inspection vehicle cleaning process. Currently, systems for offshore compliance checks have not been approved by LTNZ and there would need to be an assessment of the extent to which this system would be able to find and remove mobile, cryptic and hidden hazards.

Conclusion: The compliance checking process has the potential to be more closely integrated with the biosecurity clearance process and improve biosecurity risk management, but there are a number of practical issues to overcome. It will be considered as a potential risk management measure in the following chapters.

4.3.3 Improved specification for inspection facilities

The requirements for Transitional Facilities are set out in a facility and operator standard (Ministry of Agriculture and Forestry, 2003). This does not specify the facilities necessary for the inspection and decontamination of vehicles. Facilities vary widely: some have no ramp or pit for underside inspections and these are carried out by the MAF Quarantine Service Officer using a trolley. There are no requirements for facilities used for de-vanning and inspecting vehicles to have appropriate decontamination facilities. Similarly there are no standards specified for Terminal Receiving Facilities in Japan. Nonetheless through experience over a number of years, the quality of offshore facilities and their design to aid inspection have improved. Relevant factors identified by both operators and inspectors include:

- ramp of appropriate height to allow comfortable underside inspection with freedom of movement;
- ramping environment – protection from sun, wind rain, etc. Weather conditions are frequently identified as a factor affecting motivation of both cleaners and inspectors;
- light source;
- presentation of the vehicle with seats, etc. already removed;
- onsite decontamination facilities;
- long-term facility staff with an understanding of the importance of biosecurity (Toy and Glassey, 2006).

Whilst there is insufficient evidence to make a clear link between the standards of facilities and the level of slippage of biosecurity contaminants, there are major differences in standards between facilities and anecdotal evidence from Quarantine staff indicate that this can influence the efficacy of the risk management regime (Toy and Glassey, 2006; Wedde et al. 2006). Some flexibility is likely to be required to take account of the differences in operations between facilities, but strengthening the requirements for inspection facilities is likely to improve biosecurity outcomes.

4.3.4 Inspection using a Videoscope

The videoscope survey effectively trialled this inspection tool (Biosecurity Monitoring Group, 2006). It was found to be a difficult technique to master over a wide range of differently designed vehicles. Inspection using the videoscope took between 45 minutes and an hour per vehicle. On this basis, it is unlikely to be a practical routine measure, but it could be used for inspection of certain classes of machinery considered to be higher risk, or for classes of vehicle that are more difficult to inspect, such as damaged vehicles.

4.3.5 Detector dogs

The mobile and sometimes harmful nature of contaminants, such as snakes, scorpions and spiders, pose a challenge for effective detection in structurally complex vehicles. Some of these groups of organisms are characterised by emission of small amounts of volatile substances which could theoretically be detected electronically or by detector dogs. Dogs could also be useful for rapid checking for re-contamination after inspection or treatment of high-risk contaminants such as Asian gypsy moth egg masses during the flight season (See Chapter 10).

Dogs can be trained to detect a range of non-visible biosecurity contaminants by smell and are an important means of managing biosecurity risk associated with the international mail and passenger pathways particularly in detecting food and plant material. Trials have been conducted by the Biosecurity Detector Dog Programme, which demonstrated that dogs are capable of detecting and indicating the presence of Asian gypsy moth (K. Glassey, pers.comm.; J. Williams pers.comm.). Detector dogs have been trained to detect brown tree snakes in cargo arriving or departing from Guam since 1993 (Engeman et al. 1998). Issues around routine use of dogs for the vehicle pathway include low frequency of some hazards necessitating regular re-training of dogs in the absence of finds. The use of dogs in a wharf environment poses a number of operational issues, including short working periods. These need to be assessed and the feasibility, efficiency and efficacy of using the dogs as a primary risk management measure against the range of hazards associated with the vehicle pathway tested.

Conclusion: Whilst not immediately available as a risk management measure, detector dogs are a potentially effective measure which should be investigated further.

4.4 NON-VISUAL INSPECTION FOLLOWED BY TREATMENT WHERE NECESSARY

4.4.1 Electronic detection.

The possibility of using electronic sensing technology to detect snakes and spiders, and facilitate targeted treatment has been investigated (Braggins and Goldson, 2002). Snakes were found to emit a number of volatile compounds, albeit at very low concentrations. However, the most commonly emitted compounds (acetic acid and phenol) are commonly found in paints and plastics, which are found in vehicles. Spiders generally do not excrete volatile compounds. Social insects are more likely to be detected since due to their gregarious nature, the small amounts of volatile substances produced per individual could build up to detectable concentrations. In addition, some volatiles emitted by the social insects are common across genera, increasing the practicality of rapid assessment (Goldson and Proffitt, 2001). The technology works best in an enclosed space. Whilst container scan work is expanding and

improving detection abilities, the technology has yet to be tested for vehicles and the potential for its use in the short to medium term is limited. This option will not be discussed further.

4.4.2 X-ray screening

X-ray equipment capable of scanning vehicles has been developed by the New Zealand Customs Service. However interpreting the image is likely to be difficult for complex items such as vehicles, particularly if small organisms or quantities of soil occur between layers of metal. There is a lot of organic material in the upholstery etc, which will confuse the image. Being able to differentiate between items of lighter mass in front of, or behind an item of heavier mass such as an egg mass on a wheel rim is also likely to be difficult (H.Webber, pers. comm.).

X-ray screening is used on the international mail and passenger pathways to detect risk material entering New Zealand. Surveys of these pathways have found that some types of risk goods, such as small amounts of plant material and feathers or soil on equipment, are difficult to detect with x-ray technology. Live, mobile organisms are not regularly intercepted on these pathways, and are likely to be difficult to detect. The mail survey highlighted some of the difficulties around screening large parcels and recommended that slower passage of the item and parcels and using x-ray machines that can present numerous images of a parcel from different angles would improve efficacy. The surveys found that the efficacy of detection is also related to the same sort of operator constraints around maintaining concentration as occur with standard visual inspection (Chirnside et al. 2005; Song et al. 2005).

Conclusion: x-ray screening is not considered to be an effective risk management measure for imported vehicles and machinery.

4.5 TREATMENT OF THE CONSIGNMENT

4.5.1 Removal of parts of the commodity

This treatment could involve components that have a particular association with contaminants such as air cleaners (see Chapter 20) and mud guards, or items such as mats that obscure contaminants and the removal of which is likely to make inspection more efficient. It will be considered in more detail for some hazard groups.

4.5.2 Heat treatment

Heat treatment has the advantage of treating both internal and external contaminants and those that are not visible in standard visual inspection procedures. It is also a relatively rapid process and does not involve chemical residues. At temperatures above an organism's thermal limits, denaturing of intracellular proteins and changes in membrane phospholipids occur very rapidly, and the structure of proteins and hence enzymes are adversely affected (Denlinger and Yocum, 1988; Fields, 1992). Death at a high temperature is thought to be due to the failure of cells in a critical tissue, rather than general damage to all cells. Whole organisms are more heat sensitive than are tissues (Fields and White, 2002).

Determining a treatment regime

Developing effective thermal treatment protocols depends upon three components:

- knowledge of the thermal susceptibility of targeted organisms;
- engineering principles that govern thermal energy delivery methods;

- understanding of the thermal effects on the quality of the treated product (Tang et al. 2000).

A heat treatment regime for the vehicle pathway needs to be able to kill the most resistant organisms identified as hazards, in the most insulated parts of the vehicle. There are relatively few studies on the critical thermal maxima of many of the organisms that are hazards on the vehicle pathway. It is, therefore, necessary to extrapolate from species that are taxonomically related or have similar life histories. Such groupings may not be valid, as there is a considerable range of responses to heat amongst arthropod species.

Even closely related species and those that share similar life histories vary considerably in heat tolerance, particularly at lower temperatures. Factors affecting the rate of mortality include:

- **Development stage:** for instance, the eggs of psocid species require treatment at 47°C for 7.4 hours to achieve 99.9 percent mortality, whilst adults require treatment for only 1.7 hours (Beckett, 2002). Diapause status is also important: low metabolic activity makes most diapausing stages quite tolerant of heat (Denlinger and Yocum, 1988).
- **Genetic resistance:** Genetic variation for resistance to short exposures to extreme heat stress has been found in experimental populations of *Drosophila buzzati* which has a relatively immobile larval stage (Loeschcke et al. 1994).
- **Environmental moisture content:** in dry air at high temperatures, evaporation of water can lower the body temperature and this keeps the animal alive at an external temperature higher than it can survive in moist air provided the exposure is short (Gunn and Notley, 1936). For example, the treatment time for the beetle *Rhyzopertha dominica* in grain is 1.5 times greater at 14 percent moisture content than at 9 percent moisture content (Beckett, 2002).
- **Rate of heating:** More rapid rates require shorter treatment times (Hallman and Mangan, 1997). In a review of survival of stored product insects at high temperatures, Fields (1992) found that most insects will not survive more than 12 hours at 45°C, five minutes at 50°C but only one minute at 60°C. The rate of heating to the target temperature ideally, should be specified (Follett and Neven, 2006).
- **Insulation from the heat source:** Substrates that insulate a target organism will require longer overall treatment times (Adler, 2002; Follett and Neven, 2006). Such insulation occurs in vehicles, for instance between carpets and rubber matting.
- **The temperature regime to which insects are exposed before treatment:** The formation of heat-shock proteins following exposure to an intermediately high temperature enables insects to tolerate higher temperatures, or the same high temperature for longer periods (Denlinger and Yocum, 1988; Lester and Greenwood, 1997). Heat pre-treatment is likely to occur in vehicles stored in the sun, for instance internal air temperatures of 60°C have been recorded at ambient temperature of 36°C (Null, 2003; Null, 2006). This may act as informal heat treatment or result in reduced efficacy of heat treatment, although heat-shock proteins are unlikely to be produced at temperatures in excess of 40°C. The protection provided by pre-treatment is short-lived, the period of protection depending on the species and life stage and ranging from several hours in the case of codling moth (Yin et al. 2006) to days in the case of adult *Drosophila* spp. (Dahlgard et al. 1998; Denlinger and Yocum, 1988; Loeschcke et al. 1994). Acclimation to high temperatures appears not to affect survival at temperatures above 55°C (Fields, 1992).
- **Atmospheric composition:** The time taken to achieve mortality of insects treated with a combination of heat and modified atmospheres (generally low oxygen or high carbon

dioxide) has been found to be shorter compared with either treatment alone (Mangan and Hallman, 1998; Neven, 2005) and has been used for treatment of containers (Bergwerff, 2005). Vehicles treated in enclosed containers are likely to be subjected to higher carbon dioxide levels.

Since the specific identity of vehicle contaminants is rarely known, a heat treatment regime must be sufficiently robust to achieve effective mortality of all species and life stages despite the above factors.

There are also difficulties in extrapolating from published data to determine a quarantine treatment. For instance, laboratory testing rarely incorporates realistic pre-treatment heating (Follett and Neven, 2006; Hallman and Mangan, 1997) and to counter this effect the biosecurity treatment regime may need to be more stringent than a regime derived from laboratory data might suggest. Reported arthropod field tolerances also need to be treated with caution. Desert ants for example will use behavioural adaptations to enable them to forage when ambient temperatures exceed 60°C (Denlinger and Yocum, 1988; Marsh, 1985) yet are susceptible to sustained heat treatment at lower temperatures, or when there is no opportunity for thermal refuge.

A review of the heat tolerance of a range of insects concluded that desert ants have the highest critical thermal maximum (CTM) of up to 55°C for active life stages, depending on the species (Sherwood, 1996). In experiments, desert ant species, *Cataglyphis* spp. had (CTM) of up to 55.1°C +/-1.1°C (Gehring and Wehner 1995). The CTM of another desert species, *Ocymyrmex barbiger* is 51.5°C +/-0.7°C, and at treatment temperatures of 62.9°C coordinated ant movement did not occur after treatment of only 11.5 seconds. No ants survived a continuous 30 minute exposure at 51°C but 80 percent of ants that experienced periodic but brief thermal respite of 5 seconds in every 30 seconds, survived 30 minute exposure at 51°C (Marsh, 1985). On this basis, and taking account of the uncertainties outlined above, it is assumed that a vehicle heat treatment regime effective against the active life stages of a range of arthropods found in imported used vehicles, which are expected to be less thermal tolerant than desert ants will require core temperatures throughout the vehicle in the range of 55-60 °C for a sustained period without spatial or temporal thermal refuge. This approach is supported by the reported much lower species diversity in any particular taxonomic group at high temperatures than at lower environmental extremes (Brock, 1969).

The current vehicle Import health standard, BMG- STD-HTVEH, provides for a combination of visual inspection of used vehicles, and removal of any visible contamination, followed by heat treatment to 54°C for not less than 10 consecutive minutes. Since the heat treatment prescribed in this standard has not been used until recently it has not provided us with any further information.

Practicality of heat treatment as a risk management measure for the vehicle and machinery pathway

Live arthropods will seek out any areas of thermal refuge. For heat treatment to be effective it is necessary to ensure that all parts of the vehicle where they may occur are maintained at the specified treatment temperature for the full treatment period. Trials have been undertaken on a Toyota Corolla and a Toyota Hilux, in a solid wood processing plant medium temperature kiln, with temperatures monitored at thirteen sites within the test vehicle, using two different methods (Hosking, 2001). Those sites shielded from air movement, such as the air space inside doors, beneath mats, under seat covers and the spare wheel well, proved most difficult

to heat. Temperatures around areas such as tyres, suspension, sub-frame and engine compartment readily reached target temperatures. Directed air flow was shown to be important in reaching target temperatures at all locations. A prototype facility based on a standard 20ft shipping container has incorporated this (Glassey, pers. comm.).

The time required to achieve a treatment temperature in all parts of the vehicle is an important consideration. In a recent test, with an input temperature of 80°C the treatment temperature of 54 °C was achieved in 12 minutes. Another run with a temperature sensor placed between layers of floor carpet (a common location for dermestid beetles) took 37 minutes to achieve 54°C. A run with a new tractor found that the most difficult spot to heat was next to the gear box, which took 30 minutes to achieve 54°C (Glassey, pers. comm.). These tests highlight the importance of locating temperature sensors in the coldest spots to ensure effective treatment. Within minutes of completion of the heat treatment trials, the car could be accessed and driven away, giving a total treatment time of about an hour.

The more exposed parts of a treated vehicle will be subjected to higher temperatures for longer than the specified core temperature in the most insulated parts. Most vehicle components are designed to operate at high temperatures well in excess of 100°C (Branquart, 2006; Stevenson, 2006) and usual paint bake temperatures of 175°C + are used (Dickie et al. 1997; Miao and Laughlin, 1999), although paint baking occurs before full assembly of the vehicle and addition of the more sensitive components. Spot treatment of blemishes on new vehicles reportedly occurs at 120 °C, but if large areas are damaged the component is replaced (Toy and Glassey, 2006). Nonetheless, since plastics, rubbers and other components reportedly degrade above 70°C (Norstein, 1996) it is assumed that vehicle temperatures sustained above 70°C, may cause damage to a vehicle. During trials with a target kiln temperature between 60 and 70°C, a maximum temperature of 90°C was reached for a brief period. The highest sustained temperature was 85°C for 3 minutes. The variation between the highest and lowest recorded temperatures in the test vehicle was between 10°C and 25°C, the greatest variation occurring in trials with restricted air flow (Hosking, 2001). In a more recent trial, with an input temperature of 80°C, 70°C was the maximum vehicle temperature reached (K. Glassey, pers. comm.). Field trials of steam treatment to decontaminate agricultural equipment from golden nematode, *Globodera rostochiensis* have been undertaken in the USA. These found that to maintain a treatment temperature of 60°C on the equipment surface, the ambient temperature in the treatment chamber reached 71°C. It also resulted in parts of the equipment reaching temperatures of 73°C (Brodie and Norris, 2001). Heat treatment of individual vehicles for black widow and banana spiders, have reportedly been undertaken at a core temperature of about 52°C for 1 hour or 50°C for 2 hours in the UK, with maximum temperatures of up to 60°C, successfully killing the spiders with no reported adverse effects on the vehicles (D. Hammond, pers. comm.).

Taking these factors into account, properly designed and implemented heat treatment is considered a practical risk mitigation measure for vehicles.

Conclusion:

Heat treatment has the advantage of treating both internal and external contaminants and those that are not detectable through standard inspection procedures. Whilst it is desirable to keep treatment costs as low as possible by developing precise treatment regimes, the diversity of arthropod hazards associated with the vehicle pathway and the paucity of information on critical thermal maxima and temperature-time relationships means that this is not possible. Trials have shown that heat treatment at 55-60°C for 30 minutes is likely to be a practical

measure for the treatment of vehicles and evidence from the literature suggests this will kill most arthropods associated with imported vehicles and machinery. Further trials against specified hazard groups and different types of vehicles are recommended. The efficacy of this measure against particular hazard groups is considered in more detail in the following chapters. This regime is consistent with the international guidelines for regulating wood packaging material in international trade. These specify heat treatment at a minimum core temperature of 56°C for 30 minutes on the basis that this combination is documented to be lethal for a wide range of insect pests and pine wood nematode, and is a commercially feasible treatment (IPPC, 2006).

4.5.3 Fumigation

Fumigation, like heat treatment, treats both internal and external contaminants and those that are not visible in standard visual inspection procedures. A regime that will kill the most resistant hazard organisms, in the most remote parts of the vehicle is required.

There are a considerable range of responses to fumigants amongst arthropod species. Factors affecting the rate of mortality and therefore any treatment regime include:

- Temperature: lower dosages are required at higher temperatures due to the organisms' increased metabolic activity. If the specified treatment temperature is not reached in the most insulated parts of the vehicle, the fumigation may not kill all the target pests in the vehicle.
- Developmental stage: the treatment regime must kill the most tolerant stage.
- Resistance within populations: strains resistant to phosphine and, to a lesser extent, methyl bromide have been observed in stored product pests (Bond, 1984). Since the organisms contaminating the vehicle pathway are unlikely to have been exposed to repeated fumigation, it is assumed that resistance will not be a major consideration in determining appropriate treatment regimes.
- Sorption by the treated product and leakage, affecting the concentration of gas free to act against the invertebrates being treated. To ensure appropriate treatment when the sorption and leakage rates are not known, the treatment regime should be specified as a concentration x time product (Bond, 1984).

A number of fumigants are available. Their suitability for managing biosecurity risk associated with the vehicle pathway are briefly reviewed. Health, safety and other issues relating to the use of fumigants are outside the scope of this analysis and are not considered here.

Controlled Atmospheres

Nitrogen, carbon dioxide or a mixture thereof can be added to a sealed space to give a gaseous composition which is insecticidal (Cassells et al. 1994). The technique has been used for stored grain facilities and treatment of fruit for tephritid fruit flies. Regimes vary considerably but are characterised by treatment times running to a number of days (Carpenter and Potter, 1994). It may not be effective against pests that are accustomed to living in a low oxygen environment, but this is unlikely to be an issue in vehicles.

The longer treatment times required in comparison with methyl bromide fumigation mean that it is not likely to be a practical management option and it is not considered further in the following chapters.

Ethanedinitrile

The Australian CSIRO Stored Grain Research Laboratory has developed and patented the chemical (C₂N₂) as a fumigant to replace methyl bromide. Initial work has demonstrated its potential for devitalisation of seed and treatment of fungi as well as insects (Smith et al. 2003). It appears to be effective against both adult and juvenile life stages of timber beetles (Dowsett et al. 2004; Ren et al. 2003). Further verification and development work is required before it can be used as a quarantine treatment. It is, therefore, not considered further in the following chapters, but its' potential to treat a wider range of hazard groups than methyl bromide or heat treatment may mean that this is an appropriate treatment in future. Further research on its use for the vehicle pathway is recommended.

Formalin

Formalin is an aqueous solution containing 37 percent formaldehyde, from which vapour can be released by heating. It is widely used for sterilisation and is effective against a wide range of microbes (Gardner and Peel, 1991). Its main disadvantages as a treatment for the vehicle pathway are that articles must be cleaned prior to fumigation as penetration of soil is poor (De Vos and Turnbull, 2004) and it is not practical for use on a large scale due to the processes required to release vapour (either boiling off water, or mixing with potassium permanganate which results in a heat producing reaction requiring careful management). It is also corrosive, toxic and is not an insecticide. Given these factors it is not considered a practical treatment option for vehicles and machinery and is not considered further in this analysis.

Hydrogen cyanide

Among the commonly used fumigants, HCN is one of the most toxic to insects. It also has a rapid paralyzing effect on most species. This action is an important consideration in dealing with insects, because sub-lethal concentrations may bring about apparent death. After exposure to the fumigant, the reversible action of the poison may permit the insect to recover. It is important from the practical point of view because it means that the maximum recommended concentration should be attained as quickly as possible during the application of the fumigant (Bond, 1984).

Hydrogen cyanide has extremely high mammalian toxicity. It reacts with lubricating oils and fabrics such as rayon and has a risk of explosion. It is therefore not a suitable treatment for vehicles and machinery and is not considered further in this analysis.

Methyl bromide

One of its main advantages is the ability to penetrate quickly and deeply into sorptive materials at normal atmospheric pressure. At the end of a treatment, the vapours dissipate rapidly and make the safe handling of bulk commodities possible, although gas may continue to be released for several days (Toy and Glassey, 2006). High concentrations of methyl bromide may damage rubber, leather and products that may contain reactive sulphur compounds. Aluminium and electronic equipment may be damaged (Bond, 1984). There have been a number of complaints from vehicle dealers in New Zealand over the last year about imported cars that have been fumigated with methyl bromide which are too smelly to sell. It appears that fumigation with methyl bromide sometimes causes a reaction with some vehicle components resulting in offensive odours (K. Glassey, pers.comm.).

The 1987 Montreal Protocol on Substances That Deplete the Ozone Layer is an international agreement designed to protect the stratospheric ozone layer. It stipulates that the production and consumption of compounds that deplete ozone in the stratosphere: chlorofluorocarbons

(CFCs), halons, carbon tetrachloride, and methyl chloroform are to be phased out by 2000 (2005 for methyl chloroform). Scientific theory and evidence suggest that, once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation. The use of methyl bromide as a quarantine treatment to eliminate quarantine pests has been exempt from the phase-out requirements, but as a signatory to the Protocol, New Zealand is committed to reducing its use. The amount of methyl bromide required could be reduced if the treatment is combined with raised temperature. However, more complex treatment facilities would be required and the treatment time would still cause logistical difficulties.

Methyl bromide is currently used for the treatment of vehicles and equipment found to be contaminated with invertebrates (Biosecurity New Zealand, 2006). There is no re-inspection of fumigated vehicles. The specified regimes are assumed to be effective but the evidence to support this is derived from the literature. In Japan, regulations require a fumigated vehicle to be left for four days for the gas to dissipate. This can apparently be reduced to two days through the use of adsorption and gas recovery processes (Toy and Glassey, 2006). Since it is a practical treatment for the vehicle pathway the efficacy of fumigation with methyl bromide against particular hazard groups is considered in more detail in the following chapters, although for the reasons outlined above there are significant disadvantages to its widespread use.

Ozone

Ozone can be generated by electrical discharges in air and has the advantage of not leaving chemical residues. It has been shown to be an effective treatment against stored product insects and to control fungal growth (Kells et al. 2001). In addition to controlling insects, ozone is a good disinfectant. Challenges in developing effective treatment regimes include generating sufficiently large volumes of ozone and the treatment time required to achieve mortality, which in the case of stored product coleopterous and psocid pests is 2-3 days at 120ppm (Zhangui Qin et al. 2003). Treatment with ozone in combination with carbon dioxide may stimulate the opening of the spiracles of the insects and thereby shorten the exposure time (Leesch, 2002). Ozone is a very strong oxidising agent and at high concentrations it is highly corrosive to a number of materials including brass, steel, rubber and iron (Leesch, 2002). Lower concentrations extend the treatment period. Given these limitations it is not currently considered a practical measure for the vehicle pathway. Research to determine whether it is a feasible option for the future is recommended.

Phosphine

Phosphine is widely used as an alternative fumigant to methyl bromide. However, it is corrosive to metals, particularly copper and any copper-containing equipment (especially electrical apparatus) may be severely damaged (Bond, 1984). It also requires long exposure times of days rather than hours especially for immature stages. Phosphine is therefore not a practical option for treatment of vehicles.

Sulfuryl fluoride

Sulfuryl fluoride, is non-flammable, non-corrosive and is an established structural fumigant. It has good dispersion and penetration qualities and is thus useful in treatment of wood contaminants. It is considered highly toxic to all post-embryonic life stages of insects but eggs of most species are less susceptible (Faruki et al. 2005; Kenaga, 1957; Su and Scheffrahn, 1990). For instance at the LD₅₀ level, eggs of the desert locust, *Schistocerca gregaria* require nearly eighty times the dose of sulfuryl fluoride needed to kill other life

stages (Outram, 1967). Control of all life stages of stored product pests in flour mills required concentration x time (CT) products of up to 2255 g.h/m³ at temperatures of 25-30 °C (Reichmuth et al. 2003), whilst in laboratory tests the CT product giving 100 percent of eggs of *Tribolium castaneum*, the most resistant species tested was 1669 g.h/m³ at 25°C (Bell et al. 2003). Computers and copper exposed to sulfuryl fluoride show no ill effect after repeated exposures at 50°C and high concentrations (Bell et al. 2003). It is reported to have little or no effect on the germination of weed and crop seeds (Bond, 1984; Karpati et al. 1983).

The microbial effectiveness of sulfuryl fluoride has not been examined in detail. However, laboratory tests showed potential to control eight forest fungi (Zhang, 2006). A review of published data on the fumigant reports that it results in decreased activity of some bacteria and fungi such as *Aspergillus niger*, *Aspergillus flavus*, *Actinomyces* sp., and *Penicillium* sp., but it does not kill the spores when applied at the concentrations recommended for insects (Derrick et al. 1990).

Given the high concentration time products required to achieve mortality of eggs, sulfuryl fluoride is unlikely to be an attractive risk management measure for the vehicle and machinery pathway. However it is a potential alternative to Methyl Bromide. There is limited published material on its efficacy in the treatment of the hazard groups associated with the vehicle pathway, so it is not considered further in the following chapters. Research to determine whether a practical treatment regime for the hazards associated with the vehicle pathway can be derived is recommended.

Sulphur dioxide

Whilst being reasonably toxic to insects it is rapidly sorbed by any material undergoing treatment and is highly corrosive to metals (Bond, 1984). It is therefore not a practical option for treatment of vehicles.

4.5.4 Residual insecticide application

Residual insecticide application could be a useful mitigation measure in combination with pressure wash and vacuuming (see below). Application of 2 percent permethrin has been used as an effective tool in disinsection of aircraft cabins and holds for many years, with a re-application interval of eight weeks. In these circumstances, frequent cleaning removes the residues, reducing efficacy. This problem could potentially be overcome through the use of new formulations to enable the insecticide application remain effective for an extended period. Such an approach has been tested and found to be effective against gypsy moth, mosquitoes and cockroaches (P. Littlejohn, pers. comm.). However, there are significant uncertainties around the effect of normal vehicle use and whether build up of road film etc would act as a bridge across the insecticide layer. Even if it were not applied in such a way that it effectively treats all parts of a vehicle, hidden arthropods might be killed as they crossed it. It may therefore be an effective way of preventing re-contamination of certain hazard groups such as moths, mosquitoes or ants after inspection and/or treatment and it may be useful in treating internal contaminants. Further research into this potential measure is recommended.

New generation synthetic pyrethroids, such as deltamethrin and bifenthrin, have improved residual life and formulations which withstand ultraviolet degradation are available (S.Ritchie, pers. comm.). A review of the use of pyrethroids (which include a number of broad spectrum synthetic insecticides, such as permethrin) in insect control identifies a

number of issues for consideration depending on the circumstances of use (Elliott et al. 1978). Resistance is a concern in the treatment of pests such as cockroaches.

One of the difficulties associated with the use of insecticides as a risk mitigation measure is the need for contact between the chemical and the pest. An application method that delivers the insecticide to those parts of the vehicle where arthropod contaminants are located is required. Development of technologies that vaporise the chemical so that it diffuses into parts of the vehicle not accessible to direct application, may overcome this problem. It is recommended that the efficacy of this approach in killing hazards on imported vehicles is investigated. Pyrethrins are natural insecticidal compounds, with neurotoxin effect. When present in amounts not fatal to insects, they still appear to have an insect repellent effect. They are non-persistent, and break down easily on exposure to light or oxygen. They have little residual effect, but may be suitable for use in enclosed spaces in this way.

Conclusion: Residual insecticide application will be considered further in relation to relevant hazard groups.

4.5.5 Treatment of pooled water and/or receptacles with chlorine

Pooled water or receptacles that can contain water may hold mosquito eggs. Chlorine is a recognised treatment for mosquito eggs, larvae and pupae. The issues around this treatment are explored further in Chapter 22.

4.5.6 Manual pressure wash

The approved treatment for soil and plant debris on the outside of vehicles and machinery is decontamination by sweeping and/or washing off and collection or destruction of removed material in an approved manner (Biosecurity New Zealand, 2006). There is no specification for the equipment to be used to achieve this decontamination. The requirements for disposal of washings are that they are screened through 2mm sieves to remove any solids, which must be incinerated in an approved facility (Ministry of Agriculture and Forestry, 2003). There are no specifications for disposal or treatment of non-solids. Vehicle treatments are recorded on the MAF database, Quancargo, as steam clean or vacuum, but in practice, 'steam clean' is most likely to comprise pressure wash with cold water. Decontamination regimes range from manual pressure wash to fully automated machines and a combination of the two.

A steam cleaning regime that is able to clean the underside of vehicles at temperatures in excess of 100°C would have the advantage of treating any hazards within soil or plant debris. The practical difficulties associated with treatment at this temperature mean that it is not a feasible option for routine treatment of the pathway. However, if used in conjunction with standard pressure wash to remove the visible contamination, it could be used in short bursts to disinfect small numbers of high-risk vehicles or machinery.

Of the 300 vehicles examined with a videoscope in 2005, 64 or 21 percent had been 'steam cleaned', and 58 of these had residual external contaminants found by the videoscope. Many of the contaminants were found within hollow structural members such as door sills, major chassis members, cross members and inside closed body panels (Biosecurity Monitoring Group, 2006). The survey indicates that water blasting may not be an effective treatment measure against spiders and organic soil and seeds. However, an area of uncertainty is whether soil and seeds from these inaccessible locations are likely to become dislodged at a location where the associated contaminants could become established.

One of the inherent difficulties associated with any manual risk management measures, is the reliance on a high standard of training, motivation and skill being applied by all involved. This will be more difficult to achieve under adverse weather conditions or in sites with relatively poor facilities (Toy and Glassey, 2006).

Whilst the efficacy of pressure wash is uncertain, this measure is considered as a possible measure and assessed in more detail in the following chapters.

4.5.7 Automated wash

An automated washing process has the potential to produce more consistent results more cheaply. Automated washing has been tested for sea containers (Dentener and Bradfield, 2002) and is currently used to pre-clean vehicles prior to MAF Quarantine Service inspection at one facility in Japan (Toy and Glassey, 2006).

The automated container washing test used sterile painted apple moth egg masses laid on cocoons on steel brackets attached on the underside of sea containers. All 17 egg masses attached to large steel brackets were removed by the washing, but only 10 out of 15 of the egg masses on small brackets were removed (Dentener and Bradfield, 2002). It needs to be determined whether there are differences in efficacy in removing painted apple moth egg masses, which are typically laid on the cocoon, and Asian gypsy moth egg masses, which are laid directly onto the container surface.

Of 12 801 vehicles externally cleaned at the Jevic facility in Japan using their automated wash machine in the 13 months period from May 2005-May 2006, 1 709 (13 percent) were subsequently directed for decontamination for external contaminants (Jevic Ltd, unpublished data). This is comparable with the results of a small data recording exercise undertaken by MAF Quarantine Service. During the period 12-20 March 2006, inspectors recorded all contaminants by hazard group on inspected vehicles. During this period 150 vehicles were cleaned with the automated washing machine prior to MAF Quarantine Service inspection and 22 (15 percent) required further decontamination. A total of 2 507 vehicles were subject to external inspection by MAF Quarantine Service officers in Japan over this period. Of these 705 or 28 percent required further decontamination (MAF unpublished data). However, the overall figures include some vehicles that had not been cleaned prior to MAF inspection. Furthermore these data provide a very brief snap shot and are not necessarily representative of the situation over a wider time period. The efficacy of automated decontamination on Asian gypsy moth egg masses is unknown. Of the vehicles directed for treatment following automated washing during the period May 2005 to May 2006, none had life stages of Asian gypsy moth. However it is not known whether any of the treated vehicles had gypsy moth before they were subjected to automated washing and since there is considerable uncertainty around the actual infestation rate this cannot be taken as evidence that this method is effective against Asian gypsy moth. Similarly it is not known whether this method would be effective in treating live organisms not detectable by visual inspection.

Conclusion, whilst there are still uncertainties around the efficacy of automated washing, it is considered an alternative to pressure washing in removing external accessible contaminants.

4.5.8 Vacuuming and air blasting

Vacuuming is used for decontamination of the inside of vehicles. Vacuum treatment is relatively effective in removing visible internal contaminants, but not sufficient treatment by

itself. It is considered as a possible measure in the following chapters. Air blasting is used in Japan at the beginning of the vehicle cleaning process to remove contaminants from more inaccessible locations (Toy and Glassey, 2006). It is not suitable for onshore use, where contaminants need to be removed and disposed of securely rather than being redistributed.

One of the inherent difficulties associated with any manual risk management measures including vacuuming, is the reliance on a high standard of training, motivation and skill being applied by all involved. This will be more difficult to achieve under adverse weather conditions or in sites with relatively poor facilities (Toy and Glassey, 2006).

4.6 CERTIFIED FREEDOM FROM THE HAZARDS

An alternative risk management regime could involve inspection by approved third parties instead of by MAF Quarantine Service. The issues identified by MAF internal audits in relation to implementation of visual inspection procedures will apply equally to any third party inspection or certification arrangements, in addition to operational pressures relating to shipping deadlines. There are a number of logistical issues around this option. Since the effectiveness of this option is not related to the biology of the potential hazards, it will not be considered further in this risk analysis, although it may be an option for consideration in the review of the import health standards.

The option of certification by the exporting country's National Plant Protection Organisation is available in the current import health standard (Ministry of Agriculture and Forestry, 2001). It has not been used and the Japanese NPPO has recently confirmed that it is not interested in certifying vehicles exported from Japan.

4.7 PATHWAY MANAGEMENT CERTIFICATION

The use of officially identified Pest Free Areas (PFA) is applied as a quarantine measure for many plant commodities. PFA status is aimed at designated commodities from specific geographic areas on the basis of the absence of a specific pest or pest complex. It relies on the availability of sensitive surveillance tools for the target species, effective at low population levels, and strong evidence of effective surveillance and exclusion measures to maintain the area pest free. The costs of implementing such systems are often high (Follett and Neven, 2006; Liquido et al. 1996). The approach is not so applicable in cases where a commodity might travel from a certified PFA but the journey involves stops at places that might be high-risk for pests associated with the commodity in question. There are clear limitations of the application of this measure to the used vehicle pathway. It could however be adapted to prevent re-contamination of treated vehicles by some recognised high-risk contaminants such as Asian gypsy moth, and used in conjunction with other measures.

4.8 SYSTEMS APPROACH

The systems approach integrates biological and physical factors with operational procedures to cumulatively provide biosecurity. In general it is more difficult to manage than simple treatment regimes because of the need for compliance monitoring of many of the elements. Conversely, an advantage is the safeguard of having multiple mitigation measures reducing reliance on a single measure, particularly when the efficacy of treatment is uncertain. It works best when there are a small number of pests and the host-pest relationships are well understood (Follett and Neven, 2006) and on high volume pathways (Liquido et al. 1996).

Unfortunately, there a large number of pests on the vehicle and machinery pathway and their relationship with the pathway are not well understood or identified.

Components of a systems management approach for the vehicle pathway could include:

- surveillance for particular high-risk pests such as Lymantriid moths and ants;
- standards for facilities including vegetation free buffer zones, surfacing to prevent puddles forming;
- inspection and/or treatment regimes;
- post-inspection/treatment periods;
- re-contamination prevention, e.g. screening, insecticide spray or targeting particular problem groups through the use of snail pellets or ant baits;
- quarantine periods;
- risk management communication material in vehicles.

This approach is able to deal with a range of risk management objectives for different hazard groups but whilst difficult to apply to the vehicle pathway, is potentially applicable at least to some parts of the pathway.

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The following chapters assess the risks associated with each group of potential hazards identified from the vehicle pathway.

5 Ants (Hymenoptera)

5.1 HAZARD IDENTIFICATION

5.1.1 Identity

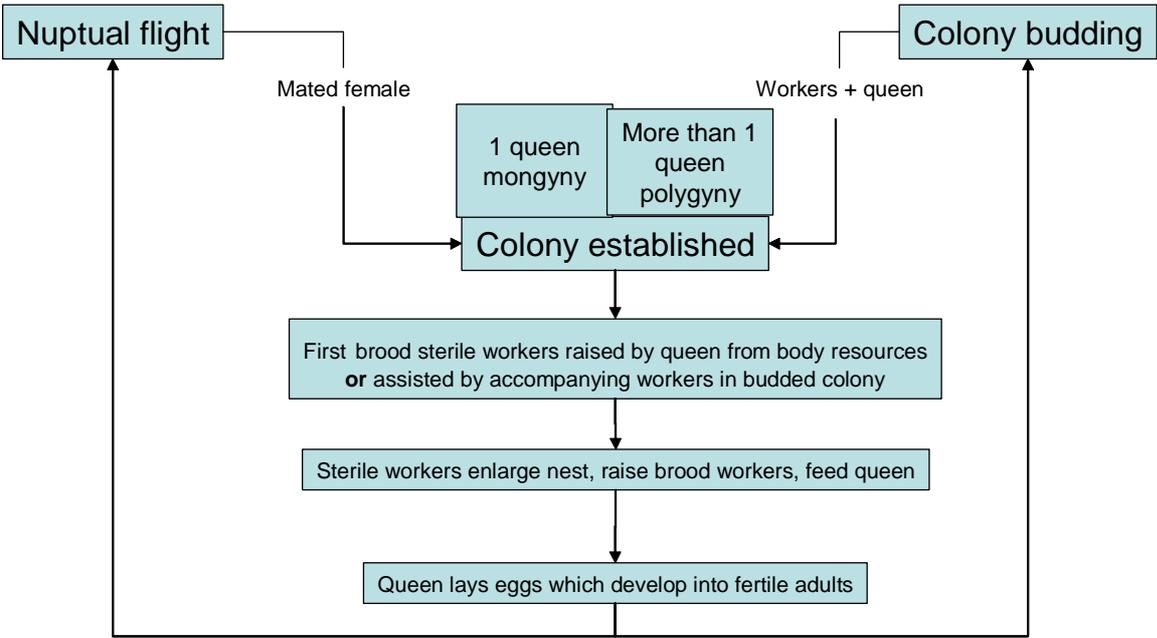
Taxonomic Group: Order: Hymenoptera
 Family: Formicidae

Common name(s): Ants

5.1.2 Introduction

There are approximately 12 000 known species of ants worldwide, many of which are adapted to living in human-modified habitats, often in close association with humans due to abundant food resources. Those ants closely associated with humans and which have been carried around the world by human commerce, are referred to as tramp species (Holldobler and Wilson, 1990). Many of these ants are not yet established in New Zealand. Ants are social insects, whose colonies are dependent on the welfare of a queen. The basic life cycle of ants is illustrated in figure 1. Whilst there are numerous variations on this basic pattern, the key stages from a biosecurity perspective are generally, colonies and mated queens, as entry of these can potentially result in an established population. Note however that for ants in the genus *Diacamma*, which is present in the southern islands of Japan, but not New Zealand, the queen caste has been replaced by reproductives anatomically indistinguishable from the worker caste (Holldobler and Wilson, 1990).

Figure 1 Basic ant life cycle. Adapted from Holldobler and Wilson (1990)



Interceptions of ants recorded during the period 1994–2006 are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Interception records of ants (Hymenoptera: Formicidae) in association with imported vehicles and machinery for the period 1994 to April 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Species	Status in NZ*	Country of Origin	Vehicle type	Interceptions (number & viability)
<i>Amblyopone australis</i>	introduced from Australia	Australia	used machinery	live adults (3) post-border
<i>Anoplolepis gracilipes</i> (yellow crazy ant/long-legged ant)	not present	Singapore	used vehicle	live worker (1)
		Samoa	new machinery	live adult (1)
<i>Camponotus</i> spp. (carpenter ant)	not present	Australia	used vehicle	live worker (1) post-border
		Japan	used vehicle	live workers (16)
			used vehicle	dead queen (1)
		Japan	used vehicle	live queen (1) post-border
		Japan	used truck under wooden deck	viable nest (1) post-border had survived steam cleaning & vacuuming
<i>CreMATogaster</i> sp. (acrobat ant)	not present	unknown	sailing yacht	live unknown stage(1)
		Japan	used vehicle	live workers (1) post-border live larva (1)
<i>Dolichoderus</i> sp.	not present	Japan	used vehicle	live unspecified life form (1)
<i>Hypoponera</i> sp.	unknown (2 species introduced to NZ)	Japan	used vehicle	live worker (1)
<i>Iridomyrmex</i> sp.	unknown, 1 species introduced to NZ	Australia	used vehicle	dead worker (1)
				live worker (1)
		Japan	used vehicle	live adult (1)
<i>Iridomyrmex anceps</i> (meat ant)	present **	unknown	not recorded	live adult (1)
<i>Lasius</i> sp.	not present	Japan	used vehicle	live worker (5)
				10+ female workers (1)
<i>Linepithema</i> sp.	unknown	Japan	used vehicle	live worker (1)
<i>Linepithema humile</i> (Argentine ant)	present	USA	used machinery	worker (1)
			used vehicle	worker (1)
			Japan	used vehicle
<i>Monomorium</i> sp.	unknown	Singapore	used vehicle	worker (1)
		Singapore	new vehicle	live adults (1)
<i>Monomorium destructor</i> (Singapore ant)	not present	Singapore	used boat	live worker (1)
<i>Monomorium antarcticum</i> (southern ant)	endemic to NZ	unknown	used vehicle	live adult (1) post –border (local contaminant)
<i>Monomorium pharaonis</i> (pharaoh ant)	present	Singapore	used vehicle	live worker (2)
		Australia	used vehicle	live queen (1)

Species	Status in NZ*	Country of Origin	Vehicle type	Interceptions (number & viability)
		unknown	used vehicle	live adult (1)
<i>Ochetellus</i> sp.	unknown	Japan	used vehicle	live and dead worker (4)
		Singapore	used vehicle	dead adults (1)
		Australia	used vehicle	live female workers (1)
<i>Ochetellus glaber</i> (black house ant)	present	Australia	used vehicle	worker (1)
		Japan	machinery	worker (1)
			new vehicle	numerous adults (5)
			used vehicle	workers, adults, larvae (56)
				nest and all stages (12)
				18 post-border records, including 2 nests inside door panels
<i>Ochetellus itoi</i>	not present	Japan	used vehicle	live worker (10)
				nest (2)
<i>Pachycondyla</i> sp.	unknown	Japan	used vehicle	live worker (1)
<i>Pachycondyla chinensis</i>	present	Japan	used vehicle	six live workers (1)
<i>Paratrechina</i> sp.	unknown	Japan	used vehicle	live queen (1)
<i>Paratrechina longicornis</i> (crazy ant)	not established (there have been incursions)	Japan	vehicle	live adult (1)
		Singapore	used vehicle	live adult (2)
<i>Paratrechina vaga</i>	present**	Australia	machinery	live adult (1)
		Japan	used vehicle	dead adult (1)
<i>Pheidole</i> sp.	unknown	Japan	used vehicle & machinery	dead adult (2)
<i>Pheidole fervens</i>	not present	Japan	used vehicle	live workers (1)
<i>Polyrhachis</i> sp.	not present	Australia	used vehicle	live workers (1)
<i>Polyrhachis</i> sp. nr. <i>semiaurata</i>	not present	Australia	used vehicle	live worker (1)
<i>Ponera</i> sp.	unknown	Japan	used vehicle	live workers (1)
<i>Prolasius</i> sp.	unknown	Japan	truck	live worker (1)
<i>Solenopsis invicta</i> (red imported fire ant)	not present	USA	yacht (in mast)	live ants and soil (1)
<i>Tapinoma</i> sp.	not present	Japan	used vehicle	live worker (1)
		Singapore	used vehicle	live worker(3)
<i>Tapinoma melanocephalum</i> (ghost ant)	not present	Singapore	used vehicle	live adult (1) post-border many adult females (2) 2 post-border records at compliance centres after vehicle had been vacuumed and pressure washed.
<i>Tapinoma minutum</i>	not present	not recorded	used vehicle	live workers (1)
		Japan	used vehicle	live workers (1)
		not recorded	new vehicle	live workers (1)
<i>Tapinoma sessile</i>	not present	USA	used boat	worker (1)
<i>Technomyrmex</i> sp.	unknown	Australia	used vehicle	workers (1)
			new vehicle	dead workers (1)
<i>Technomyrmex albipes</i> (white footed house ant)	present	Australia	caravan	live worker (1)
		Australia	used vehicle	many live adults (3) 1 post-border record
		Jamaica	not recorded	live adult (1)
		Japan	used vehicle	100s adults (4) 3 post-

Species	Status in NZ*	Country of Origin	Vehicle type	Interceptions (number & viability)
				border records
Unidentified spp.	unknown	Japan	used vehicle	dead worker (5)
				live workers (3)
		Taiwan	used vehicle	dead worker (1)

*<http://www.landcareresearch.co.nz/research/biosecurity/stowaways/Ants/antsinnewzealand.a.sp>, accessed April 2006. Note however that changes in taxonomic consensus may result in changes to the status of some species.

** An *Iridomyrmex* species, established in New Zealand was until recently considered to be *I. anceps*; it is therefore possible that the interception has been misidentified. Similarly *Paratrechina* species are difficult to identify. There is an introduced *Paratrechina* species in New Zealand and it is possible that intercepted specimens might have been misidentified.

The limitations associated with interception records (see section 2.3.1) mean that these records can be used only to demonstrate association with the pathway: they do not provide contamination rates. At least 27 taxa of ants have been intercepted on used vehicles or used machinery, including 15 that are not present in New Zealand. The majority of intercepted ants were alive. There were nine interceptions from new vehicles and four from used machinery. There were several cases in which entire nests and/or live queens were found in imported vehicles and machinery, five of which were of species not present in New Zealand. Whilst the interception of individual worker ants is not of biosecurity concern, since they are incapable of reproduction, the presence of workers may be indicative of a nest hidden within the imported vehicle. Since vehicles found to be contaminated with ants are fumigated without a detailed search for a nest it is not known how many of these vehicles contained nests. Sixty percent of records of species not present in New Zealand, or of genera which include species not present in New Zealand, are from Japan, 16 percent from Singapore and 9 percent from Australia.

Whilst they have not been intercepted from the pathway, it is worth noting that Japan, the main source of imported vehicles, has a number of unusual ant species including a number of species in the genus *Diacamma*, which are queenless. There is a soil-nesting species of *Camponotus*, *Camponotus japonicus* (Abe, 1973) and the Japanese red wood ant *Formica yessensis* that has massive colonies with millions of workers and very large numbers of queens (Higashi and Yamauchi, 1979).

5.1.3 Conclusion

Given that the interceptions of at least 16 ant species that are not present in New Zealand, include pests of economic, environmental and human health significance, and that at least some of the interceptions comprised nests and or queens, ants are considered to be potential hazards associated with the pathway.

This risk assessment focuses on six species with recorded interceptions that are not present in New Zealand, and for which a reasonable amount of information is available. It is based on the information sheets and pest risk assessments for invasive ants undertaken by Landcare Research for Biosecurity New Zealand (Harris et al. 2005). These categorised each species as high, medium or low risk on the basis of assessment against 31 criteria including biological traits, invasive history, pathways, climate match and likely consequences. It is important to

note that the Landcare assessments are of the risk from all pathways and do not relate specifically to the vehicle pathway.

5.2 ENTRY ASSESSMENT

There is increasing evidence that human transportation is the major explanation for the spread of invasive ant species within and between regions (Suarez, 2005).

New Zealand interception records can not be used to quantify the likelihood of entry of ants via the vehicle pathway for the reasons outlined in section 2.3.1. Between December 2004 and June 2005, quarantine staff recorded all ants intercepted at the border on any pathway. The results are summarised in Table 2. Twenty nine out of 361 ant interception records were from vehicles, including new vehicles (unpublished MAF data). The life stage and viability of intercepted ants was not always recorded. The recorded interceptions on inanimate pathways such as vehicles and containers are unlikely to represent the actual rate of arrival of exotic ants, given the difficulty of detecting ants on commodities with multiple hiding places. The rate of detection on fresh produce is likely to be higher than that on inanimate pathways. A study of the United States Department of Agriculture border interception records between 1927 and 1985 found that ants were most commonly intercepted on plants or plant produce (Suarez, 2005).

Table 2 Interceptions between December 2004 & June 2005 of exotic ants, not present in NZ (unpublished MAF data)*

Pathway	Number of ant interceptions	Number of interceptions of species not present in New Zealand and % of all interceptions over period (361)
fresh produce	104	60 (17%)
sea containers	72	54 (15%)
other	50	31 (9%)
baggage	26	14 (4%)
food stuff	40	12 (3%)
personal effects	24	10 (3%)
timber	12	9 (2%)
vehicles (new and used)	29	8 (2%)
flowers & nursery stock	5	5 (1%)

* Note these data have been published in Ward et al. (2006) but the definitions of commodities used in that paper differ from those used in this risk analysis.

A further indication of the likelihood of entry is provided by the vehicle treatment statistics. Of the 2 155 vehicles (3 percent of the total number of imported vehicles) fumigated at Auckland wharf between 01/01/2004 and 30/09/2005 because of the presence of invertebrate contaminants, ants were recorded as the reason for fumigation for 113 vehicles or 0.2 percent of 68 600 used vehicles imported through the port during that time period. On the basis of the interception records, it is assumed that most of these exotic ants will be alive with at least some viable nests. This figure is derived from the inspectors' recorded comments. There is no requirement for inspectors to record the reason for fumigation, so this is likely to underestimate the number of vehicles with ants. Furthermore, given the mobile nature of ants, it is likely that additional vehicles had ants which were not recorded by the inspectors. The videoscope survey found live exotic ants in one of the 300 vehicles surveyed, that had not been found through the visual inspection process (Biosecurity Monitoring Group, 2006). The

post-border records also indicate that not all exotic ants entering via the pathway are intercepted.

Ant colonies can survive reasonably long periods without food and water. For instance Kaspari & Vargo (1995) found that in the laboratory both small and large colonies of *Solenopsis invicta* survived for up to 28 days without food or water, although solitary queens survived these conditions for less than six days. In a different laboratory experiment, colony queens and a reduced cohort of workers survived at least six weeks when fed only water (Porter, 1989). Many ants are omnivorous and could feed on food scraps and dead insects in an imported vehicle. It is assumed that entry is less likely on a clean vehicle without food sources. Some ants may leave the vehicle and forage more widely on the ship. Ants inhabiting ships may be an additional source of contamination of vehicles. There are records of some tramp species including *Tapinoma melanocephalum* and *Paratrechina longicornis* establishing colonies on ships, probably from nests brought on board in cargo (Weber, 1939). Worker ants from a colony on a ship may forage on vehicles and remain on them when they are unloaded in New Zealand. This behaviour does not represent a biosecurity risk, when workers alone are unloaded in the absence of a queen. However given the journey times from most vehicle exporting countries, it is possible for new colonies to be established on a vehicle by budding from a colony in the vessel.

Table 3 summarises the current distribution, likelihood of association with imported vehicles and machinery and likelihood of surviving shipment to New Zealand for six exotic ant taxa intercepted from the pathway.

Table 3. Summary entry assessment for six ant tramp species not present in New Zealand but recorded in association with vehicles/machinery. Information based on (Harris et al. 2005) unless otherwise specified.

Species	Current Distribution	Likelihood of Association with Pathway	Likelihood of Surviving Shipment to NZ
<i>Anoplolepis gracilipes</i> (yellow crazy ant/ long-legged ant)	Most tropical Asian countries, including Japan (southern islands, only) and Singapore, Micronesia, Melanesia and Polynesia; Australia (N.Territory and Brisbane) (Wetterer, 2005)	Associated with a wide range of pathways including soil, packaging, containers and produce as well as vehicles. It has characteristics that lead to greater likelihood of entry of queens with workers in NZ, such as polygyny, budding and mobile colonies and non-specific nesting requirements. Nesting has been reported in urban structures and anthropogenic debris (Lester and Tavite, 2004).	A well-known tramp species with a history of spread well beyond its native range. The interception record for a live worker demonstrates ability to survive shipment from Singapore. Apparently viable colonies and queens have survived shipment from Pacific and Asian countries on other pathways.
<i>Camponotus</i> spp. (carpenter ants) Approximately 600 species in genus	Worldwide, including Australia, Japan, Singapore, UK, USA. (Except polar regions and some oceanic islands, including New Zealand).	Most species nest in wood; some species are associated with human habitation and nest in the structure of buildings. Timber-containing vehicles such as trucks with wooden decks are most likely to be contaminated.	The post-border records of viable nests are indicative of their ability to survive shipment from Japan. Queens can live up to 8 years (Holldobler and Wilson, 1990).
<i>Crematogaster</i> spp. (acrobat ant) Approximately 800	Worldwide (except polar regions, Tasmania and NZ)	Nests occur in a range of sites including soil, cracks in rocks, trunks and twigs (Shattuck, 1999). Some are small enough to be	They are generalised omnivorous feeders, rarely predators of active prey, There have been live interceptions from the pathway.

Species	Current Distribution	Likelihood of Association with Pathway	Likelihood of Surviving Shipment to NZ
species and subspecies		contained within twigs.	
<i>Paratrechina longicornis</i> (crazy ant)	Worldwide distribution, except New Zealand. Restricted distribution in Japan- southern islands and urban pockets.	It is commonly associated with urban areas and buildings. Colonies can occur as temporary nests and are highly mobile. They can nest in a variety of environments from dry to moist including in gaps in walls, in leaf axils, and leaf litter. Dispersal is by colony budding. In more temperate countries of origin, the densities are likely to be low and the distribution restricted, which will reduce the likelihood of transfer to NZ.	It is an opportunistic forager, feeding on live and dead insects and household foods (Smith, 1965) so are more likely to be able to find sufficient food to survive shipment than active predators. There has been a live interception from the pathway.
<i>Solenopsis invicta</i> (red imported fire ant)	Native to South America, introduced to USA, Australia, China, Taiwan, and Singapore (MAF Biosecurity Authority, 2002)	Soil does not appear to be essential for nest formation; although uncommon, queens will nest in moist cracks and crevices of inanimate objects. They are often associated with disturbed habitats such as roadsides, and will infest logs and buildings (MAF Biosecurity Authority, 2002). Following mating, winged queens are attracted to reflective surfaces such as vehicles, with reports of hundreds accumulating in the bed of a truck (Vinson, 1997). Successful colony establishment has been reported in vehicles in the USA (Collins et al. 1993).	A queen could be introduced in a newly-founded nest, before workers are developed and foraging or in an established nest with adult workers present. Once sealed in a newly-founded nest, a queen is able to survive 13 to 95 days on her own body reserves (Markin et al. 1972; Porter and Schinkel, 1986). There is evidence that established nests can survive for at least 42 days at 30°C without food (Porter, 1989). Newly mated queens will produce actively foraging workers within 22 -31 days at temperatures between 24 and 35°C, but cannot survive temperatures as high as 40°C in the laboratory. Moisture availability can also affect successful colony founding (Markin et al. 1972)
<i>Tapinoma melanocephalum</i> (ghost ant)	Worldwide distribution except New Zealand. Introduced to many areas (Harada, 1990). In temperate regions including most of Japan, Europe and USA, it is only associated with greenhouses and heated buildings (Smith, 1965).	A common tramp species widely distributed by commerce and often associated with buildings (Harada, 1990). Often occupies temporary habitats and readily migrates if disturbed (Passera, 1994). Dispersal is by colony budding. Varied nesting habits including in soil, in hollow twigs and plant stems and rotten wood (Harada, 1990, Smith, 1965) The most common entry pathways into NZ appear to be fresh produce and personal effects.	The species is an opportunistic forager (Harada, 1990), and more likely to be able to find sufficient food to survive shipment than active predators. The life span of queens is uncertain but may be only a few weeks (Passera, 1994) which would reduce the likelihood of surviving shipment from the main vehicle exporting countries. A post-border report of 50 live workers is evidence of survival shipment from Singapore, but no search was made for the presence of a queen (Investigation and diagnostic centres, 2006).

5.2.1 Conclusion on entry assessment

Given that:

- several species of exotic ants which occur in countries from which used vehicles and machinery are imported, are urban pests and are thus likely to be in a position to contaminate vehicles;
- several are opportunistic foragers, likely to be able to survive shipment, feeding on other contaminants of vehicles;
- live life stages of exotic ants, including viable nests have been intercepted on imported vehicles at the border and post-border;
- the proportion of cars contaminated with ants is likely to be less than 1%, but the number of imported vehicles is high.

and taking into account the uncertainty around the likelihood of the presence of a nest or a queen for those vehicles on which only workers were intercepted, it is concluded that the likelihood of exotic ants entering New Zealand on the **used vehicle and machinery pathway is non negligible**. Used agricultural machinery and trucks containing significant volumes of soil or timber are more likely to harbour a viable nest.

The likelihood of entry of many species of ants on the vehicle pathway is lower than on some other pathways, but a detailed release assessment for *S. invicta* concluded that the likelihood of introduction by used machinery and motor vehicles is high (MAF Biosecurity Authority, 2002). All of the species assessed here are primarily tropical species, and the likelihood of entry will be relatively low given the lower numbers of vehicles imported from countries where they are established.

Given the records for live ants intercepted on the new vehicle pathway, the likelihood of entry on **new vehicles is also considered to be non negligible**.

5.3 ESTABLISHMENT ASSESSMENT

Many species of ants are extraordinarily invasive, possibly due to the flexibility of having both individual and colony responses that enable them to withstand biotic resistance and to better match conditions in the receiving environment (Moller, 1996). A review of ant colonisation of new areas identified that islands are more at risk from establishment of new species, given their low numbers of indigenous competitors (McGlynn, 1999). Transferred species may merely fill an unoccupied urban niche. They tend to be cryptic, opportunist species. The New Zealand ant fauna is species-poor with current estimates of 11 endemic species, 24 introduced species and a further 15 under incursion response, probably established or doubtfully established (Landcare Research, 2005). On this basis, New Zealand may be susceptible to establishment of new ant species.

Since several ant species have been widely spread around the world, analysis of the traits of previously transferred ant species may provide indications of which species are more likely to establish in a new area. Of 66 species of ants intercepted at the New Zealand border across all pathways, 17 have established and nests of a further six are periodically found on New Zealand soil, but have failed to establish permanently to date (Lester, 2005). The analysis of the factors distinguishing these groups identified mean climatic factors and rate of interception (an indicator of propagule pressure), as the main factors (Lester, 2005). So called 'propagule pressure' or introduction effort is widely thought to increase the likelihood of

establishment (Hee et al. 2000, Memmott et al. 1998, Suarez et al. 2005), although it is recognised ecological traits such as nesting habitat are also influential. For instance, an analysis of the unintentional introduction of non-native ants to the USA found that ground-nesting species were more likely to become established than arboreal species (Suarez et al. 2005). The high rate of entry of ants across pathways (Table 2) is expected to increase the likelihood of establishment of exotic species.

These factors are reflected in the large number of new ant species that have become established in New Zealand in recent years. There were as many endemic ant species as introduced ones in New Zealand 30 years ago, but by 1991 only 28 percent were endemic (Moller, 1996). New species continue to establish and over the last five years six new ants are known to have arrived and become established:

Pheidole proxima

Solenopsis sp

Iridomyrmex sp.

Monomorium sydneyense

Hypoponera punctatissima

Cardiocondyla minutior (M. Sarty pers. comm.)

The size of an introduced nest is expected to influence the likelihood of establishment. Although little information is available on the sizes of propagules transported by human commerce, it seems likely that the likelihood of successful establishment increases steeply with propagule size (Holway et al. 2002). In the case of Argentine ant, (*Linepithema humile*) which is exotic to, but established in New Zealand, one study indicated that queens were unable to survive in the absence of workers, even in laboratory conditions. However, queens with as few as 10 workers experienced high survivorship and rapid colony growth (Hee et al. 2000). For *S. invicta*, the number of workers in a founding colony was experimentally found to be the principal factor influencing brood production and colony success (Porter and Tschinkel, 1986).

The timing of entry may also influence the likelihood of establishment. Entry during the cooler months may increase the stresses on a population with a consequently lower likelihood of establishment.

Once established in an area, human-assisted long distance spread has been documented in species such as Argentine ant. This mechanism has been found to be the primary means of range expansion of this species in New Zealand (Ward et al. 2005). For some species, transfer of whole nests with potted plants is a likely mechanism (Berry et al. 1997). There are limited biosecurity restrictions of movement of commodities within New Zealand. Some species of ants are strong fliers, for instance *Solonopsis saevissima richteri* queens are reported to disperse up to 16 km (Markin et al. 1971), and can spread rapidly without human assistance (Moller, 1996), but species which reproduce by colony budding alone, have limited rates of dispersal in the absence of human-mediated dispersal (Holway et al. 2002).

The so called ‘tramp’ species that have colonised a range of new countries are characterised by an ability to use unstable and perturbed environments with migration when disturbed (Passera, 1994). This trait is likely to result in ready dispersal from vehicles to new habitats. Other characteristics commonly found in invasive species include small size, polygynous social organization, and spread by colony budding (Lester, 2005; Passera, 1994; Fowler et al. 1994; McGlynn, 1999; Rowles and O'Dowd, 2006). Table 4 summarises the assessment of

these factors, and their impact on the likelihood of establishment for some ant species associated with the vehicle and machinery pathway.

Note that a significant uncertainty in predicting the likelihood of establishment of a new species is the impact of predation, parasitism and competition in a new environment. Given New Zealand's depauperate ant fauna, competition with native ant species is unlikely to be a major factor (Harris et al. 2005), but young colonies of *S.invicta* are reported to be highly susceptible to predators (Buren, 1983).

Ward et al. (2006) suggest that exotic ant species from Australia potentially represent a greater ecological risk than species from the tropics. Suggested reasons include its relative proximity, the shared evolutionary history, the large and diverse Australian ant fauna and the fact that 64 percent of exotic ants already established in New Zealand are of Australian origin including two of the ant species that have established most recently (Harris and Berry, 2001).

Table 4. Summary of establishment assessment for several key ant tramp species not present in New Zealand but recorded in association with used vehicles/machinery. Information is based on (Harris et al. 2005) unless otherwise specified.

Species	Environmental Suitability of NZ	Biological Characteristics	Likelihood of Transfer to Suitable Environment
<i>Anoplolepis gracillipes</i> (yellow crazy ant/ long-legged ant)	Primarily a species of moist tropical lowlands, it has not yet established in any temperate areas (Wetterer, 2005). Although winter temperatures are not believed to kill colonies climate modelling indicates that NZ summer temperatures are relatively low and are likely to hinder colony development and foraging except perhaps in Northland. 2 single nests have been found in Auckland during surveillance operations, but were successfully exterminated (Pascoe, 2002) and several more have been found since (M.Sarty pers com.)	Queens accompanied by workers (budding) are required for the successful establishment of a colony. No natural enemies have been recorded. It is a member of the subfamily Formicinae, which spray formic acid, and is unpalatable to most vertebrate predators.	Capable of invading urban areas, plantations and grassland as well as undisturbed habitats. It does not have a close association with buildings and is not likely to establish in heated environments in cities in temperate regions. Dispersal is through colony budding and human mediated movement.
<i>Camponotus</i> spp. (carpenter ant)	Most species have an omnivorous diet, although some species have a mutualistic relationship with aphids and coccids. They are capable of occupying most terrestrial habitats.	Nests are initiated by a single fertilised female. Establishment from relatively few arrival events is therefore more likely.	Members of this genus have only infrequently established outside their native ranges. Nuptial flights do not occur until the colony is several years old. This delay in transfer to the wider environment may increase the likelihood of detection of the colony before it leaves an imported vehicle. However disturbance is likely to result in colony transfer.
<i>Crematogaster</i> spp. (acrobat ant)	Most species are tropical, arboreal dwellers, but some species occur in temperate zones where they more often	Nests are initiated by a single fertilised female. Establishment from relatively few arrival events is	No specific factors

Species	Environmental Suitability of NZ	Biological Characteristics	Likelihood of Transfer to Suitable Environment
	nest in the ground and beneath stones. Only a single species has been recorded outside its native range.	therefore more likely.	
<i>Paratrechina longicornis</i> (crazy ant)	A highly adaptable species with a history of establishment within urban areas in countries with temperate climates. Climate modelling indicates that NZ has low similarity with non-urban sites where it is established. However it could survive in most urban areas in New Zealand, using heated buildings when outside temperatures are too cold. In warm microclimates within urban areas they may persist outdoors throughout the year. There have been incursions in Auckland and Tauranga (Ministry of Agriculture and Forestry, 2004) and a nest found and treated in Wellington.	Queens accompanied by workers (budding) are required for the successful establishment of a colony. It does best in highly disturbed or artificial environments, where it can become numerically dominant. Such habitats in NZ would include gardens, urban areas, coastal dunes, scrub and geothermal areas.	There are suitable habitats for nesting close to sites of arrival or devanning. The species is highly mobile and colonies will move if disturbed (Trager, 1984), so transfer of a colony from a vehicle on arrival is likely.
<i>Solenopsis invicta</i> (red imported fire ant)	Climatic modeling has shown that it could establish over much of the north island and the southern tip of the south island (Morrison et al. 2004). Established colonies are able to move up and down the temperature gradient that develops within the nest, protecting themselves from extreme soil surface and air temperatures. Adequate soil moisture is required prior to mating flights and also appears to be necessary for the successful establishment of a nest. Growth in established colonies is reported to occur only between 24 and 36 °C (Porter, 1988). Established nests have been found in New Zealand on three separate occasions.	There are 2 types of colony, both of which occur in the USA and Australia (Greenberg et al. 1992; MAF Biosecurity Authority, 2002). Monogyne varieties are more invasive, but polygyne colonies reach higher densities and tend to have greater impacts (Greenberg et al. 1992; Holway et al. 2002). The ability to establish a colony from a single newly established nest increases the likelihood of establishment. Mature colonies may produce 4-6000 sexually mature reproductives a year, facilitating rapid establishment and spread, although this life stage is particularly vulnerable to predation (Vinson, 1997). Monogyne populations are lower than polygyne ones.	These ants are omnivorous, opportunistic feeders and will feed on almost any type of animal or plant material. However, their primary diet consists of insects, other small invertebrates, and plant saps (MAF Biosecurity Authority, 2002) The queens of monogyne colonies disperse via nuptial flights, generally of less than 0.6 km, but up to 16 km in the similar species <i>Solenopsis saevissima richteri</i> (Markin et al. 1971). Polygyne colonies have multiple queens and can disperse either by mating flights or through colony budding.
<i>Tapinoma melanocephalum</i> (ghost ant)	Widespread distribution including temperate areas, where it is associated with greenhouses and heated	Their principal means of dispersal is by colony budding, whereby queens walk accompanied by	These ants are opportunistic foragers feeding on many household foods as well as dead and live insects. They often nest in

Species	Environmental Suitability of NZ	Biological Characteristics	Likelihood of Transfer to Suitable Environment
	buildings (Smith, 1965). Climate modeling indicates that NZ is too cold for establishment outside buildings. Mean annual temperatures recorded at the coldest site where it is permanently established outside urban areas are higher than recorded anywhere in NZ. However it could establish anywhere if accidentally transported to suitable buildings.	workers to a new nesting site, or by transportation of nests.	temporary habitats such as plant stems or other debris. Suitably warm habitat occurs in close proximity to the Port of Auckland. They migrate readily if conditions become unsuitable so transfer of a colony from a vehicle on arrival is likely.

5.3.1 Conclusion on establishment assessment

Given that:

- new and used vehicles and machinery can be taken to and used anywhere within New Zealand;
- at least parts of New Zealand and in particular areas around the main entry points for vehicles have a suitable climate and range of habitats for some exotic ants;
- the colonies of some species migrate readily;
- A large number of exotic ant species have already repeatedly established in New Zealand.

And taking account of uncertainty whether there are niches in New Zealand currently unfilled by native ants, it is concluded that **the likelihood of establishment of exotic species of ant in association with the new and used vehicle and machinery pathway is non negligible.**

5.4 CONSEQUENCE ASSESSMENT

Establishment is not always necessary for exotic ants to generate impacts. For instance incursion response costs can occur on arrival. Wood borers, spiders and ants are the most frequent triggers of incursion investigations in New Zealand. In many cases it is not possible to trace the incursion back to a pathway or to determine whether the organisms found are the primary population. It is currently estimated that at least one full time incursion investigator is effectively dedicated to post-border ant incursions. Stopping ants, spiders and wood borers getting across the border has been identified as a priority for more effective incursion response capability (K. Froud pers comm.). Biosecurity New Zealand responded to 19 finds of exotic ants during the 2005-2006 ant surveillance programme (M.Sarty pers. comm.). There are also social and human health impacts associated with contact with exotic ants even when these are from incursions rather than established populations.

There was an incursion of *S. invicta* in Auckland in 2001, one in Napier in 2004 and a further one in Napier in 2006. The 2001 incursion response cost \$1.1 million excluding staff time (K. Froud pers.comm.) and the potential economic impact of the species becoming established has been estimated at \$665million over 23 years (Controller and Auditor General, 2002).

In a review of the impact of exotic ants on native faunas, Fowler et al. (1994) concluded that the impacts are rarely documented or fully understood. The interactions between ants and their prey as well as other predators are complex. Much of the literature relates to Hawaii,

where the primary impact of ants on native fauna is through predation. Native ground nesting bees, beetles, spiders, moth and snail populations were depleted or have been eliminated. The most conspicuous impacts appeared to occur during the initial wave of invasion of ants (Reimer, 1994). Where populations of predated organisms are small and isolated these impacts may be serious and long lasting. There are no native ants in Hawaii, so the consequences might be expected to be more severe than in countries whose native arthropods are adapted to ant predators.

Natural ecosystems vary greatly in the extent to which they are they are affected by invasive ants. The competitive displacement of native ants by invasive ants is the most widely reported effect of ant invasions. The mechanisms involved are reviewed by Holway et al. (2002) for a group of species including *A. gracilipes* and *S. invicta* and include physical aggression, chemical defensive compounds and colony size. There is some evidence that invasive ants are particularly good at tending homoptera and the presence of invasive ants is frequently associated with local increases in homopteran abundance. This may have repercussions such as higher susceptibility and exposure to phytopathogens (Holway et al. 2002).

It is difficult to estimate the consequences of the establishment of an exotic species on the New Zealand fauna, though the best method is via examining the influence of these invasive ants described from the scientific literature elsewhere. The likely direct and indirect consequences of some exotic ant species establishing in New Zealand are summarised in Table 5.

Whilst there may be a greater likelihood of exotic ants entering via the container pathway, vehicles are not restricted in their movement around the country. Ants entering on vehicles are not likely to be picked up by any of the surveillance regimes supporting the container pathway. They are therefore very unlikely to be detected at an early stage.

Table 5. Summary consequence assessment for several key ant tramp species not present in New Zealand but recorded in association with used vehicles/machinery.

Information based on (Harris et al. 2005) unless otherwise specified.

Species	Direct Effects	Indirect Effects
<i>Anoplolepis gracilipes</i> (yellow crazy ant/ long-legged ant)	Colonies in urban areas would be likely to become nuisance pests, as they have in the Seychelles (Haines and Haines, 1978). The ants spray formic acid, and humans may suffer attacks from swarming ants. The species is a major environmental pest as it has a wide diet ranging from insects to molluscs, birds, mammals and reptiles (Wetterer, 2005) and can reach high densities (Haines and Haines, 1978). If able to survive the NZ climate, it would be likely to have significant effects through predation on New Zealand's indigenous fauna, particularly species with restricted northern distributions, such as some land snails. It has invaded native forest habitats in the Seychelles (Haines and Haines, 1978).	The species has the potential to negatively impact on agriculture and horticulture through tending of hemipteran pests for their honeydew (Haines and Haines, 1978; Wetterer, 2005). Such species can transmit plant diseases (Harada, 1990). Additional ecosystem impacts are likely to follow predation led changes. A high consequence pest.
<i>Camponotus</i> spp. (carpenter ant)	Several <i>Camponotus</i> species can cause structural impacts on wooden buildings (Hansen and Akre, 1985). They are also nuisance pests as they forage for food indoors, have a painful	They have an important ecological role in wood decomposition processes, the consequences of this in a new ecosystem are not known.

Species	Direct Effects	Indirect Effects
	bite and spray victims with formic acid. They are large ants and have the potential for impacts on native fauna.	
<i>Crematogaster</i> spp. (acrobat ant)	A nuisance pest when foraging in buildings. They are ecologically dominant and are likely to have an impact on native fauna. They may have economic impacts through predation on the insect fauna of tree crops.	There are reports of impacts involving short circuiting telephone wires by <i>Crematogaster ashmeadi</i> removing insulation (Smith, 1965).
<i>Paratrechina longicornis</i> (crazy ant)	They can serve as mechanical vectors for bacterial infections in hospital environments and commercial food premises (Bueno and Fowler, 1994). Potential impacts are uncertain, since despite widespread occurrence as an urban pest there are few accounts of detrimental impacts in native ecosystems. However it occurs in high densities in the absence of <i>A. gracilipes</i> on Tokelau (Lester and Tavite, 2004). Annual expenditure on treatment of port environs and commercial glasshouses following the spread of crazy ant throughout its potential range is estimated to be low at \$ 18000. Treatment of urban areas and conservation areas are not included (Ministry of Agriculture and Forestry, 2004).	Treatment is likely to be necessary to avoid adverse impacts on commercial glasshouse crops (Ministry of Agriculture and Forestry, 2004)
<i>Solenopsis invicta</i> (red imported fire ant)	This species is a highly invasive insect because of its high reproductive capacity, large colony size (especially polygyne colonies), ability to exploit human disturbances, wide food range, aggressiveness, and ability to sting. Where they establish, they can affect agricultural and horticultural systems, wildlife, natural ecosystems, and people's quality of life; incur medical and pest control costs; and cause damage to roads and electrical equipment (MAF Biosecurity Authority, 2002). Evaluation of selected impacts on households, infrastructure and agriculture suggests that, following range expansion and consolidation, the full annual costs of living with the red imported fire ant would be at least NZ \$318 million . The present value of the total impacts over a 23-year period of range expansion and consolidation from initial establishment is indicated to be at least \$665 million. (MAF Policy, 2001). Around 80 human deaths have been attributed to an allergic reaction to <i>S. invicta</i> in the USA (Taber, 2000) in (Scanlan and Vanderwoude, 2006)	This is a high consequence pest. Predation of seeds of native plants may result in changes in community composition. <i>S. invicta</i> can kill young reptiles and nestlings of ground nesting birds and also prey on snails. The related species, <i>Solonopsis geminata</i> has been reported killing the giant African snail, <i>Achatina fulica</i> on Christmas Island (Lake and O' Dowd, 1991). There are reports of <i>S. invicta</i> affecting the decomposer communities of soils. In the USA, infested sites have an arthropod species richness 40% less than at non-infested sites (Porter and Savignano, 1990). It has been reported to use honeydew as a source of carbohydrate (Teddars et al. 1990) and is likely to invade beech forests.
<i>Tapinoma melanocephalum</i> (ghost ant)	Principally a nuisance pest in urban areas. Also capable of transporting pathogenic microbes in hospitals (Fowler et al. 1993).	Given that it is unlikely to become established outside, impacts will be limited to households and other artificial environments. It could become a glasshouse pest if honey-dew producing insects were to increase in abundance. Environmental impacts are likely to be small.

5.4.1 Conclusion on consequence assessment

There are likely to be significant environmental, economic and social consequences from the entry, establishment and spread of at least some new exotic ant species. The consequences are therefore non negligible.

At least two species intercepted on imported vehicles, *S. invicta* and *A. gracilipes* are considered high consequence pests.

5.5 RISK ESTIMATION

Given that:

- the likelihood of entry into New Zealand and establishment of an exotic species of ant, associated with the used vehicle and machinery pathways is non negligible and the likelihood is expected to be increased when taken in combination with likelihood of entry via other pathways; and
- for a number of the aforementioned species, the environmental, economic and possible human health consequences of establishment would be non negligible.

The risk is considered to be non negligible for used vehicles and machinery and risk management measures are justified.

The likelihood of entry for ants on **new vehicles** and machinery is non negligible and therefore **the overall risk is also non negligible** and mitigation measures are justified.

5.6 RISK MANAGEMENT

Given the risk estimation for this hazard group, the risk management objective is to reduce to a negligible level the likelihood of exotic ants entering via the vehicle pathway and establishing in New Zealand.

5.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

5.7.1 Visual inspection

The effectiveness of detecting ants at the New Zealand border has been estimated at 48 percent for maritime cargo (which includes sea containers and vehicles) using sample based rarefaction procedures, compared with 73 percent for air cargo (Ward et al. 2006).

There are frequent post-border interceptions of exotic ants, many of which are not able to be associated with any particular pathway. This interception rate may reflect their biology and their likelihood of entry, but is also likely to reflect their ability to escape detection at the border. Given their small size, (for instance workers of *T. melanocephalum* are only 1.3-1.5 mm long (Smith, 1965)) and ability to hide in crevices, ants are generally only likely to be found by visual inspection whilst they are actively foraging. MAF Quarantine Service officers report that detection of ants on vehicles is very weather dependent (Toy and Glassey, 2006) and some ants including in the *Paratrechina* genus forage primarily at night (Shattuck,

1999). The likelihood of detecting these species will be lower than those that forage during the day.

It is assumed that visual inspection will be more effective in detecting nests than individual ants, but post-border interceptions of nests indicate that even this is not always achieved. This may be because immature nests of ants can be very small. For instance, immature *S. invicta* nests may be located within 1 cm² of soil or even in a moist crack or crevice and lack active workers (MAF Biosecurity Authority, 2002). Ant nests may also be located in areas not readily visible, for instance *S. invicta* colonies have been reported on at least three occasions in motorised vehicles (Collins et al. 1993).

Live *Tapinoma minutum* specimens (not present in New Zealand) and dead ants (*Ochetellus* sp. of which some species are present in New Zealand) were found during a survey of 300 vehicles using a videoscope to find contamination in parts of the vehicle not visible through routine visible inspections. The numbers involved were not recorded, but reported as ‘many’ (Biosecurity Monitoring Group, 2006). This result indicates that a proportion of ants and ant nests associated with vehicles will not be detected through the current visual inspection process.

In conclusion, the current regime based on visual inspection does not meet the risk management objective for ants.

5.7.2 Vacuuming

Vacuums are unlikely to remove all ants as some are likely to be located in inaccessible locations. This supposition is supported by the interception records for live ants detected after vacuuming and steam cleaning (Investigation and diagnostic centres, 2006). However, pre-shipment removal of all potential ant food sources including food scraps and dead insects by vacuuming and air blasting would reduce the likelihood of survival and, therefore, of entry of any ant colonies. Visual inspection and fumigation where necessary, coupled with mandatory vacuuming offshore to remove all potential food resources including all dead insects from radiator fins and the front of vehicles would reduce the likelihood of entry of ants, but not to a negligible level.

5.7.3 Pressure wash

Pressure washing is unlikely to remove ants/nests in inaccessible parts of a vehicle. The post-border interceptions of ants some time after a vehicle had been steam cleaned support this supposition. However, water-blasting may cause the ants to move to an area where they are more visible and can be found.

5.7.4 Heat treatment

Heat treatment has the advantage of treating both internal and external contaminants and those that are not visible through standard inspection procedures. Desert-dwelling scavenger ants are reportedly amongst the most thermophilic insects identified. For example, *Cataglyphis bombycina* and *C. bicolor* exhibit a critical thermal maximum, CTM, of 53.6 ± 0.8 °C and 55.1 ± 1.1 °C, respectively (Gehring and Wehner, 1995). These ants use physiological and behavioural adaptation to forage at surface temperatures greater than 56°C (Marsh, 1985). The ants forage until their body temperature reaches critical thermal maximum, at which time they seek refuge from the heat (Sherwood, 1996). Without the opportunity for access to thermal refuges the ants become disoriented, incapable of coordination and die (Marsh, 1985). Similarly *S. invicta* worker ants can forage at surface temperatures potentially lethal to them

(i.e. temperatures above 42°C) (Francke et al. 1985) by using extensive tunnel systems to limit their exposure to these temperatures (Porter and Tschinkel, 1987). In the laboratory, coordinated movement of the desert ant, *Ocymyrmex barbiger* did not occur at treatment temperatures of 62.9°C after treatment of only 11.5 seconds. No ants survived a continuous 30 minute exposure at 51°C but 80 percent of ants that experienced periodic but brief thermal respite of 5 seconds in every 30 seconds, survived 30 minute exposure at 51°C (Marsh, 1985). This illustrates the importance of ensuring that treatment temperatures are sustained without temporal or spatial thermal refuges.

Unpublished results of small scale laboratory thermal death tests, using *Iridomyrmex glaber* (now known as *Ochotellus glaber*) workers and pupae of *Chelaner antarctica* (also known as *Monomorium antarctica*) established 100 percent mortality following treatment at 50°C for 5 minutes (Crabtree, 2002).

In conclusion, while not found on vehicles, or established in Japan, desert ants are a worst case example for heat treatment. It is assumed that treatment at 55°C for 30 minutes will be effective against all other ant species, including those recorded in association with the pathway.

5.7.5 Fumigation

There is little information available on the efficacy of fumigants against ants. Most data relate to field control of ant nests (e.g. Amante, 1961; Little, 1950), rather than use for biosecurity treatment, and predates the development of more effective baiting technology. The available information suggests that fumigation with methyl bromide is a moderately successful nest control tool, but this can not be translated into biosecurity treatment specifications.

Unpublished experimental data show that methyl bromide will kill *S. invicta* worker ants when used at a dose rate of 32 g/m² for a period of 24 hours (Hargreaves, 2001). Efficacy against queens was not tested. The effectiveness of the current border vehicle fumigation regime (48 g/m² for a period of 24 hours) against ants is not verified but is assumed to be effective against all life stages.

5.7.6 Surveillance

A national ant surveillance programme was established in 2001, following an incursion of *S. invicta*. Surveillance is targeted on sites where incursions are likely to be initiated particularly airports and seaports. Bait trapping and visual surveillance are undertaken from December to March each year when air and soil temperatures are optimal for ant activity and thus there is the greatest likelihood of detection. Surveillance focuses on species considered to be high-risk invasives including the following that have been recorded in association with the vehicle pathway: *S. invicta*, *P. longicornis*, *A. gracilipes*, *T. melanocephalum*, *Camponotus spp.* and *M. destructor* (Anonymous, 2005). Whilst the programme has been successful in intercepting a number of these species it is not comprehensive. Specifically, the surveillance programme focuses on ports and areas of importation. Given that imported vehicles can move away from targeted areas within a few days, surveillance, whilst being a useful supplementary measure will not by itself provide an appropriate level of protection for this hazard group.

5.7.7 Treatment during shipment

Ants can inhabit ships and potentially infest vehicles in transit. Treatment on the ship would have the advantage of preventing contamination by ants living on the vessel. Broadcast application of toxic bait is generally considered the most effective and efficient method of control for ant colonies. Ants actively collect and take bait back to the nest, where through

food exchange processes insecticide impregnated food is transferred to colony members including the queen, (Stanley, 2004; Williams, 1994). However there are difficulties to such an approach. The bait has several components, including an attractant, a carrier matrix, and a toxicant which is non-repellent and delayed in action. Baits are often developed for single species, so several different baits are likely to be required. Treatment on a vessel has not been attempted so it is not known what treatment regime would be required to effectively kill hitchhiking ants throughout the vessel.

5.7.8 Offshore versus onshore risk management

Whilst there are no data on recontamination rates, recontamination of vehicles treated offshore prior to shipment could occur in ant infested areas. The likelihood of recontamination could be established through a surveillance regime around vehicle storage facilities. In the event that species identified in this assessment are detected the following treatment would be required:

- maintaining a sealed surface on the storage area and treating both it and a 10-20 m buffer zone with suitable ant baits (both protein and lipid based are likely to be required (Stanley, 2004)) at an appropriate density;
- one week following application of the bait, spreading an ant deterrent such as products containing chlorpyrifos throughout the baited area;
- where any localized ant activity is found treat with ant bait;
- spray vehicles with a barrier insecticidal spray.

Note that this is a generic regime developed for container yards in the Pacific Islands (Nendick and Sarty, 2006). A detailed site specific surveillance and treatment programme would need to be designed by an ant control specialist with knowledge of the local area and fauna. Mated queens can either move the whole or part of a nest over-ground, or fly in by themselves on a nuptial flight. This programme is intended to prevent contamination by both means.

Many invasive ant species are highly mobile and tend to relocate when disturbed. Such relocation might be triggered by steam cleaning increasing the likelihood of early establishment in New Zealand. Offshore risk management measures are therefore preferred for this hazard group.

5.8 RECOMMENDED MEASURES

1. Mandatory heat treatment of imported used vehicles and used machinery at a core temperature of at least 55°C for 30 minutes **or** fumigation with methyl bromide at 48 g/m² for 24 hours. If treatment occurs offshore, an ant surveillance and treatment programme at the exporting facility as identified above would help prevent recontamination. Continued targeted surveillance at high-risk sites within New Zealand is recommended **and**
2. A systems approach to the management of imported new vehicles incorporating surveillance and appropriate storage yard maintenance measures should be investigated.

An alternative package of measures comprising:

- visual inspection and fumigation/heat treatment where necessary; **and**

- mandatory vacuuming **offshore** to remove all potential food resources including all dead insects from radiator fins and front of vehicles; **and**
- bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4);

would reduce the risk to a lower level than that associated with the current risk management regime but would not meet the risk management objective.

5.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- the frequency of entry of exotic ants via the vehicle pathway is unknown –the data for this group of hazards are limited, the estimate of <1 percent vehicles contaminated with ants entering a year is assumed to be an underestimate.
- It is not known what proportion of vehicles on which worker ants are found also contain a nest or viable queen not detectable through visual inspection. It is assumed that at least some of them do.
- The rate of contamination of vehicles from ant populations established on ships is unknown.
- The likelihood of contamination of new vehicles is uncertain. It is the conditions in which the vehicles are stored rather than their age which is likely to determine whether or not they are contaminated.
- The ability of single queens to survive transport to New Zealand is not known.
- it is assumed that removal of all potential ant food sources including food scraps and dead insects from a vehicle prior to export would reduce the likelihood of survival and therefore of entry of any ant colonies;
- It is assumed that the high rate of entry of ants into New Zealand across all pathways will increase the likelihood of establishment of exotic species.
- It is assumed that environmental conditions in New Zealand will enable exotic ants to establish over sufficiently large areas to have significant consequences.
- The consequences of the establishment and spread of several exotic ant species for native flora and fauna and ecosystem processes are unknown.

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6 Bees, wasps and sawflies (Hymenoptera)

6.1 HAZARD IDENTIFICATION

6.1.1 Identity

Category: Insects

Taxonomic Group: Order: Hymenoptera,

Name: wasps, bees and sawflies

The Hymenoptera comprises 60 families and about 100,000 species. Many groups exhibit complex social behaviour (Hill, 1994). The risks associated with the Formicidae family are assessed in the previous chapter. This section addresses interception records for other families in the order.

6.1.2 Association with pathway

Hymenopteran interception records (other than those in the Formicidae family) for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Interception records of Hymenoptera, other than ants in association with imported vehicles and machinery over the period 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand *	Country of origin	Vehicle type	Interceptions (number & viability)
<i>Apis mellifera</i> honeybee	Apidae	yes	Japan	used vehicle	live adult (1) dead adult (1)
<i>Bombus terrestris</i> large earth bumblebee	Apidae	yes	Japan	used vehicle	post-border live adult (1)
<i>Xylocopa pubescens</i>	Apidae	no	Japan	used vehicle	dead adult (1)
unidentified	Apidae	unknown	Japan Australia	used vehicle	dead adult (2) dead adult (6)
<i>Apanteles</i> sp.	Braconidae	no	Japan	used vehicle	dead adult (2) live adult (1) egg, unknown viability (1) live pupae (5)
unidentified	Chalcidoidae	unknown	Japan	used vehicle	live adult (1)
unidentified	Eulophidae	unknown	Japan Australia	used vehicle new vehicle used machinery new machinery	galls on foliage (1) galls on foliage (1) galls on foliage (1) galls on foliage (1)
<i>Eumenes pomiformis</i>	Eumenidae	no	Italy	new machinery	Post-border, mud nests and dead pupae & adults

Organism	Family	Present in New Zealand *	Country of origin	Vehicle type	Interceptions (number & viability) (14)
<i>Odynerus quadrifasciatus</i>	Eumenidae	no	Japan	new vehicle	live adult (1)
<i>Ancistrocerus gazella</i>	Eumenidae	yes	unknown	used machinery	live adult (1)
unidentified	Eumenidae	unknown	Japan Australia	used vehicle	dead (1) dead (1)
<i>Lasioglossum sp.</i>	Halictidae	yes	Japan	used vehicle	Post-border, live adult (1)
unidentified	Halictidae	unknown	Japan	used vehicle	life stage & viability not recorded (1)
<i>Ctenochares bicolorus</i>	Ichneumonidae	yes	unknown	used vehicle	live adult (1)
<i>Mesochorus sp.**</i>	Ichneumonidae	unknown	unknown	used vehicle	life stage not recorded (1)
unidentified	Ichneumonidae	unknown	Japan	used vehicle new machinery	dead adult (1) pupa (1) live adult (1)
<i>Sphaerophthalma pensylvanica pensylvanica</i>	Mutillidae	no	USA	used vehicle	post-border live adult (2) + nest Vehicle had been steam cleaned & vacuumed.
<i>Sphaerophthalma pensylvanica</i>	Mutillidae	no	USA	used vehicle	live adult male(1)
unidentified	Pompilidae	unknown	Japan	used machinery new machinery	dead larva (1) dead pupa (1)
unidentified	Proctotrupeoidea	unknown	Japan	used vehicle	dead adult (1)
unidentified	Scoliidae	unknown	Japan	used vehicle	dead adult (1)
<i>Sirex noctilio</i>	Siricidae	yes, introduced from Europe	Japan	used vehicle	live adult (1)
<i>Euodynerus sp.</i>	Vespidae	no	Japan	used vehicle	worker (1)
<i>Polistes chinensis</i> (Asian paper wasp)	Vespidae	present in north island since 1979	Japan Thailand	used vehicle new vehicle	live adult (6) dead life stages (10) Post-border live adults & nest
<i>Polistes jadvigae</i>	Vespidae	no	Japan	used vehicle	Post –border live adult & nest (3) Border dead adult (1) live adult (1)
<i>Polistes rothneyi</i>	Vespidae	no	Japan	used vehicle	live female worker (1)
<i>Polistes sp.</i>	Vespidae	unknown, 2 species in genus present in NZ	Japan	used vehicle	post-border live individuals of all life stages (15) plus nest
<i>Polistes sp.</i>	Vespidae	unknown, 2	USA	used	unviable nest (1)

Organism	Family	Present in New Zealand *	Country of origin	Vehicle type	Interceptions (number & viability)
		species in genus present in NZ	Brazil	machinery used	unviable nest (1)
			Japan	machinery used vehicle	nest (1) viability not recorded
<i>Vespula lewisii</i>	Vespidae	no	Japan	used vehicle	dead adult (1) live female adult (1)
<i>Vespula vulgaris</i>	Vespidae	yes established in 1970s	UK	vehicle	dead adult (1) live adult (1)
			unknown	used vehicle	live queen (1)
<i>Sceliphron sp.</i>	Sphecidae	no	USA	machinery	pupa (1)
			Australia	used vehicle	dead adult (2)
<i>Sceliphron madraspatanum</i>	Sphecidae	no	Japan	used bus	dead adult (1)
unidentified	Sphecidae	unknown	Australia	used vehicle	dead adult/larvae(4)
			Australia	used machinery	nest (1) Postborder (compliance centre) live larvae +nest (1)
unidentified	Sphecidae	unknown	USA	used vehicle	dead adult (2) live pupa (1)
			Japan		dead adults (6)
			Japan	new vehicle	live adults (3) post-border larvae in mud nest (1)
unidentified	Tiphiidae	unknown	Australia	used vehicle	dead adult (1)
<i>Xylocopa sp.</i>	Xylocopidae	no	UK	used boat	live adult female(1)

*(www.landcareresearch.co.nz/research/biodiversity/invertebratesprog/hymenoptera/checklist_index.asp, 2006)

** Recorded during Biosecurity Monitoring group used vehicle survey (Wedde et al. 2006).

The limitations associated with interception records (see section 2.3.1) mean that these records can only be used to demonstrate association with the pathway. They do not provide contamination rates. There are interception records for 22 genera/species of Hymenoptera in 16 families. The majority were intercepted on vehicles imported from Japan, but the other major vehicle exporting countries also feature prominently. The number of recorded interceptions containing live individuals and nests is noteworthy. 64 percent of interceptions identified at least to genus level were of species or genera not present in New Zealand.

There have been six instances of post-border interceptions with nests, of taxa either not present in New Zealand or of organisms identified only to genus and therefore of unknown status. Two of these were on new vehicles or machinery. These interceptions indicate the limitations of visual inspection, and in at least one instance of pressure wash, in mitigating the likelihood of entry of this hazard group, even when nests which would be expected to be more visible are involved.

The Hymenoptera have a diverse range of life cycles and strategies, and importation of a nest is not necessarily required for establishment. Brief summaries of distribution, biology and pest potential of each intercepted family are set out below. Information is derived from (Hill, 1994) unless otherwise specified.

Apidae (honey bees, bumble bees etc): 1 000 species. Includes all the genera that were previously classified in the families Anthophoridae and Ctenoplectridae. Both species recorded from the vehicle pathway are present in New Zealand. Hitchhikers in this family are nonetheless of concern because they vector a number of parasites and diseases. *Apis* nests are perennial. Colony fission is the method of spread and annually the old queen leaves the colony with a swarm of workers to found new colonies. In contrast, *Bombus* colonies are annual. Young fertilised queens over-winter and construct a small underground nest in the spring. *Bombus terrestris* is believed to have been introduced to Tasmania, where it is now widespread including in areas of native forest, through the accidental introduction of a single fertilised female, possibly an over-wintering queen (Maynard et al. 2004).

Braconidae: 40 000 species. Small parasitoid wasps with a wide range of hosts, notably lepidopteran caterpillars and aphids. They have an almost worldwide distribution. Members of the family have been used for biological control; however there could be adverse consequences for native invertebrates from accidental introductions.

Chalcidoidea: A large superfamily, showing considerable adaptive radiation and diversity of life strategies. Most of the species are parasites or hyperparasites of other insects. The egg parasites are among the smallest of insects. There are 14 major families recognised.

Eulophidae: 3 000 species. The family has many small genera with relatively distinct geographical distribution. Generalisation about the biology is difficult.

Eumenidae (Potter wasps): 3 000 species. A family of solitary and predacious wasps. Mud nests are stuck onto a solid substrate or twig and provisioned with paralysed caterpillars. A single egg is laid inside the cell. Some species tunnel into soil and wood.

Halictidae (mining bees, sweat bees): The family is widespread and common in most parts of the world, but is particularly abundant in Australia. Nests are underground and vary in size; some species are solitary but others social and form small colonies.

Ichneumonidae: 60 000 species. The majority are parasites or hyperparasites. Some species are host specific, but many more appear to be habitat specific. Few species occur in hot dry conditions. The adults are diurnal or nocturnal and often feed on flowers. Some species are solitary while others are gregarious with several developing in the same host. In cooler regions the adult females of many species hibernate over winter.

Mutillidae (velvet ‘ants’): 5 000 species. The males are winged, the females are ant-like in appearance. They parasitize other hymenoptera, especially *Bombus* spp. and Sphecidae.

Pompilidae (spider-hunting wasps): 4 000 species. These wasps have very long hind legs. All are predatory and provision their nests with paralysed spiders. Eleven species of Pompilidae are recognised from New Zealand, of which ten are endemic.

Proctotrupoidea: The group has recently been redefined into three separate small superfamilies. Most of the species parasitise beetles.

Vespidae (true wasps, social wasps): 800 species. They are mostly social and construct 'paper' nests, either above or underground. They mainly have a holarctic distribution but extend throughout Asia and India. They are similar to *Bombus* species in generally having an annual life cycle, but some overwinter. *Polistes* is a tropical genus with aerial nests. *Polistes chinensis* was first found in Auckland in 1979 and has since spread through the North Island and top of the South Island after a failed eradication attempt (Barlow and Goldson, 2002). It reaches densities of more than 200 nests per hectare, and removes up to 957 grammes invertebrate biomass per hectare from shrublands in Northland. On the basis of these abundances and prey consumption rates it may have a significant impact on the fauna of native ecosystems. It preys on invertebrates, primarily Lepidoptera and competes with native species for nectar and honeydew resources (Clapperton, 1999). Two species of *Vespula* wasp (*V. germanica* and *V. vulgaris*) have also become established in New Zealand with significant consequences. They compete with native birds and invertebrates for food, notably honeydew, and it is estimated that wasps remove 90 percent of the standing crop of honeydew from beech forests for five months of the year (Beggs, 2001). This also affects nutrient cycling. Wasps also prey on native invertebrates with impacts on local populations as well as on insectivorous native birds (Barlow and Goldson, 2002). Despite more than a decade of research on the impact of introduced wasps in beech forest communities, the complexity of the ecosystem means that it is still not known whether wasps have an effect on any native species at the population level. Nonetheless, there are a number of other social wasp species that have not yet established in New Zealand but which are considered to be pests in other countries. They are excellent invaders and are more likely than solitary wasps to have adverse impacts in a new country (Beggs, 2001).

Scoliidae: Scoliid wasps are external parasites of scarabaeid larvae. There are no endemic scoliids in NZ but *Radumeris tasmaniensis* (yellow flower wasp) has recently become established in Northland.

Siricidae (wood wasps/horntails): Large insects whose abdomen terminates in a spine. The female has a stout ovipositor used for boring and drilling into the sapwood of trees. The larvae hatch in the tree and burrow deep into the sapwood and may cause significant damage in addition to vectoring fungal pathogens. *Sirex noctilio* was introduced into New Zealand from Europe and is now established across the country.

Sphecidae (sand wasps, mud-daubers etc): 7 700 species. Most species provision mud cells with paralysed arthropods. Nests and adults of several species of *Sceliphron* spp. are repeatedly encountered in New Zealand (Harris, 1994) but have not established (Berry, 2005). On at least three occasions the interceptions have been from imported vehicles (Harris, 1992).

Tiphiidae: 1 500 species. Most species parasitise ground nesting hymenoptera.

Xylocopidae (carpenter bees): Mostly large hairy bees which excavate long tunnels in dead tree trunks or branches as well as structural timbers. They are mainly tropical although some smaller species occur in the USA.

Social insects have a well-recognised invasive potential, and at least 4 species of wasp have established in New Zealand during the last 60 years. Contributing factors include the tendency

of queens to seek hibernation refuges in places that may be associated with transported goods; the increase in global movement of such goods; the ability of the queen to produce thousands of workers in the absence of males (once fertilised in the autumn); short generation time; high dispersive ability; wide environmental plasticity; a broad diet and opportunistic feeding behaviour (Moller 1991). In practice there appears to be a high likelihood of early nest failure, perhaps due to the combined energetic demands of nest-building, foraging and raising the initial brood and vulnerability to catastrophic failure. Nonetheless, in comparison with most other invertebrates the likelihood of establishment of social wasps is high (Barlow and Goldson, 2002).

New Zealand has no native social wasps or bees. Communities with a near absence of a taxonomic or functional group may be comparatively vulnerable to invasion by species of those groups see Ward et al. (2006).

6.2 CONCLUSION

Given that:

- a large number of Hymenoptera species could be associated with the vehicle pathway, most of which will not be possible to identify at the border;
- many of the genera intercepted from the vehicle pathway occur in vehicle exporting countries, but not in New Zealand.

and taking into account, interceptions of some live insects as well as nests, and the acknowledged invasive potential of social insects, it is concluded that **Hymenoptera are potential hazards on the used vehicle pathway.**

The number of post-border interceptions of nests is noteworthy in indicating the limitations of visual inspection in mitigating the likelihood of entry of this hazard group.

It is also noteworthy that there is no surveillance for this group of potential hazards, so early detection of any exotic species that establish is very unlikely.

The interception record of live adults and nests in imported new vehicles indicate that **bees and wasps are also potential hazards on the new vehicle pathway.**

Since most of the intercepted Hymenoptera are either social, or are solitary and have a life cycle centred around mud nests provisioned with paralysed arthropods, and since many of these Hymenoptera are likely to establish nests in colonies like the Formicidae, it is assumed that any Hymenopteran contaminants on the pathway will be managed by the measures that are recommended for the treatment of Formicidae or spider hazards. This hazard group is therefore not assessed further.

6.3 REFERENCES

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7 Beetles (Coleoptera) except Dermestidae

7.1 HAZARD IDENTIFICATION

7.1.1 Identity

Category: Insects

Taxonomic Group: Order: Coleoptera,

Name: Beetles

7.1.2 Introduction

The coleoptera is the largest order of insects with 95 families and about 330 000 species, with many new species being described annually (Hill, 1994). The risks associated with the Dermestidae on the vehicle pathway are assessed in Chapter 14. This section addresses interceptions of all other families.

The beetle interception records (other than those in the Dermestidae) for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Beetle interception records (other than dermestids) between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Pathway	Interceptions (number of records & viability)
<i>Gibbium psylloides</i> , smooth spider beetle	Anobiidae	no	Japan	used vehicle	3 live adults (1)
<i>Lasioderma serricorne</i> , tobacco beetle	Anobiidae	yes	Japan	used vehicle	live adults (4) live larvae (9)
<i>Stegobium paniceum</i> drugstore beetle	Anobiidae	yes	Japan	used car used van	live adult & larva (2) live adult (1)
<i>Theca hilleri</i>	Anobiidae	no	Japan	used vehicle	live adult (1)
unidentified	Anobiidae	unknown	Japan	used vehicle	unrecorded life form & viability (2)
<i>Lyctus brunneus</i> , Powderpost beetle	Bostrichidae	yes	Australia	machinery	live adult(1)
<i>Rhyzopertha dominica</i>	Bostrichidae	yes	USA	used agricultural machinery	Viability not recorded (1)
unidentified	Bostrichidae	unknown	Japan	used vehicle	Viability not recorded (2)
<i>Anisodactylus</i> sp.	Carabidae	genus not present in NZ	Japan	used vehicle	dead adult (1)
<i>Pterostichus</i> sp	Carabidae	genus not present in NZ	Japan	used vehicle	dead adults (3)
unidentified	Carabidae	unknown	Japan	used vehicle	dead adults (4)

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Pathway	Interceptions (number of records & viability)
<i>Anoplophora chinensis</i> , citrus longhorn	Cerambycidae	no	Japan	used vehicle	adult (1)
<i>Anoplophora malasiaca</i> , white-spotted longicorn beetle	Cerambycidae	no	Japan	used vehicle	adult (1)
<i>Anoplophora succedanea</i>	Cerambycidae	no	Japan	used vehicle	adult (1)
<i>Chlorophorus annularis</i>	Cerambycidae	no	Japan	used vehicle	adult (1)
<i>Oemona hirta</i> , lemon tree borer	Cerambycidae	yes, NZ native	Japan	used utility vehicle	live adult (1)
<i>Purpuricenus</i> sp. nr <i>temminckii</i>	Cerambycidae	no	Japan	used vehicle	dead adult (1)
<i>Zorion</i> sp.	Cerambycidae	genus present in NZ	Japan	used vehicle	adult (1)
<i>Zorion castum</i> , flower longhorn beetle	Cerambycidae	yes endemic to NZ	Netherlands	machinery	live adult (1 post-border)
unidentified	Cerambycidae	unknown	Japan	used vehicle	on plant material(2)
			Australia	used vehicle	on plant material (2)
			USA	used machinery	live adult (1)
			USA	new machinery used truck	adult (1)
			Japan	new motorcycle	live adult in bark on tray (1) dead adult (1)
<i>Aulacophora</i> sp.	Chrysomelidae	genus not present in NZ	Japan	used vehicle	dead adult (1)
<i>Paropsis charybdis</i> , eucalyptus tortoise beetle	Chrysomelidae	yes	unknown country	used vehicle	live adult (1)
unidentified	Chrysomelidae	unknown	Japan	used vehicle	dead adults (3) live pupae (2)
<i>Chilocorus</i> sp.	Coccinellidae	no	UK	used vehicle	live adult (1)
<i>Coccinella septempunctata</i> , seven spotted ladybird	Coccinellidae	yes	Japan	used vehicle	live adults (2)
unidentified	Coccinellidae	unknown	Japan	used vehicle	dead adults (2), 1 on plant debris.
<i>Cryptolestes ferrugineus</i> , rusty grain beetle	Cucujidae	no	USA	agricultural machinery	live adult (1)
unidentified	Curculionidae	unknown	Japan	used vehicle	dead larvae on plant debris (3) live adults (3)

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Pathway	Interceptions (number of records & viability)
			USA	used machinery	dead larvae (5) live adult (1)
			USA	new machinery	
<i>Derelomus bicarinatus</i>	Curculionidae	no	Japan	used vehicle	live adult (1)
<i>Hypera</i> sp.	Curculionidae	genus not present in NZ	Japan	used vehicle	live adults (2)
<i>Mitrastethus baridioides</i> , long nosed Kauri weevil	Curculionidae	yes	Australia	used machinery	live adult (1 post-border)
<i>Sitophilus oryzae</i> , rice weevil	Curculionidae	yes	USA	used machinery	live adult (1)
unidentified	Dytiscidae	unknown	Japan	used vehicle	dead adults (2)
<i>Agrypnus</i> sp.	Elateridae	genus present in NZ	Japan	used vehicle	dead adult (1)
			South Korea	used machinery	adult (1)
<i>Adelocera fuliginosus</i>	Elateridae	no	Japan	used vehicle	dead adult (1)
unidentified	Elateridae	unknown	Japan	used vehicle	dead adult (1)
<i>Cercyon</i> sp.	Hydrophilidae	no	Japan	used vehicle	dead adult (1)
<i>Syndesus cornutus</i>	Lucanidae	no	Japan	used vehicle	dead adult (1)
unidentified	Lucanidae	unknown	Japan	used vehicle	dead adult (1)
<i>Carpophilus marginellus</i>	Nitidulidae	yes	Japan	used vehicle	dead adult (1)
<i>Parissopalpus nigronotatus</i>	Oedemeridae	no	Japan	used vehicle	live adult (1)
<i>Copidita</i> sp.	Oedemeridae	no	Japan	used vehicle	live adult (1)
unidentified	Platypodidae	family not present in NZ.	Japan	used vehicle	adult (1)
<i>Allomyrina dichotoma</i>	Scarabaeidae	no	Japan	used vehicle	post-border record of >50 dead adults dead adult (1 border)
<i>Anomala albopilosum</i>	Scarabaeidae	no	Japan	used vehicle	dead adults (2)
<i>Anomala cuprea</i>	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Anomala rufocuprea</i> , soybean beetle	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Aphodius</i> sp.	Scarabaeidae	genus present in NZ	Japan	used vehicle	dead adult (1)
<i>Eucetomia</i> sp.	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Hoplia</i> sp.	Scarabaeidae	no	Japan	used vehicle	dead adult (1)

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Pathway	Interceptions (number of records & viability)
<i>Heteronychus arator</i>	Scarabaeidae	yes	Japan	used vehicle	live adult (1)
<i>Maladera</i> sp.	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Melolontha</i> sp.	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Pericoptus</i> sp.	Scarabaeidae	genus present in NZ	Japan	used vehicle	live adult (1)
<i>Phyllophaga rugosa</i>	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Polyphylla laticollis</i>	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
<i>Protaetia orientalis</i>	Scarabaeidae	no	Japan	used vehicle	dead adult (11)
<i>Stethaspis</i> sp.	Scarabaeidae	genus present in NZ	Japan	used vehicle	dead adult (1)
<i>Xylotrupes</i> sp.	Scarabaeidae	no	Japan	used vehicle	dead adult (1)
unidentified	Scarabaeidae	unknown	Japan	used vehicle	dead adult (28) live adult (1)
unidentified	Scolytidae	unknown	Japan	used vehicle	dead adult (1)
<i>Cryptamorpha desjardinsi</i>	Silvanidae	yes	Japan	used vehicle	dead adult (1)
<i>Atheta</i> sp. vexing rove beetles	Staphylinidae	genus present in NZ	Japan	used vehicle	live adult (1)
<i>Copraporus</i> sp.	Staphylinidae	no	Japan	used vehicle	live adult (1)
unidentified	Staphylinidae	unknown	Japan	used vehicle	dead adult (3)
<i>Alphitobius diaperinus</i> , lesser mealworm	Tenebrionidae	yes	USA	used agricultural equipment	live adult (1)
<i>Tribolium castaneum</i> , red flour beetle	Tenebrionidae	yes	Japan	used vehicle	live adults (5) larva (1)
<i>Tribolium confusum</i> , confused flour beetle	Tenebrionidae	yes	Japan	used vehicle	live adult (1)
				used truck	live adult & larva (1)
unidentified	Tenebrionidae	unknown	Japan Australia	used vehicle new machinery	dead adult (1) live adult (1)
unidentified	Throscidae	no	Japan	used vehicle	live adult (1)

There are more interception records for this group of potential hazards than any other, but, as discussed in Chapter 2, this does not necessarily reflect the relative frequency of contamination. The records comprise 48 genera in 21 families. The majority were intercepted on vehicles imported from Japan. 60 percent of intercepts were dead adults, 33 percent were alive adults or larvae and 7 percent had no record of viability and/or life stage. The high proportion of dead interceptions is not surprising, since most adult beetles are unlikely to survive shipment without a supply of food. However, the dead adults may indicate contamination by less visible life forms such as eggs, larvae or pupae, probably associated

with soil or plant debris contamination of the vehicle. Since soil and plant material is not routinely inspected for secondary contamination, eggs and larvae would not be intercepted and recorded. Half of the interceptions are of species or genera not present in New Zealand, although there were only 4 instances of more than 1 adult of a species not present in New Zealand.

Brief summaries of distribution, biology and pest potential of each family are set out below. Information is derived from (Hill, 1994) unless otherwise specified.

Anobiidae (furniture/timber beetles): 11 000 species. It is difficult to make general statements about such a large family. Many species are destructive timber beetles and a few are stored product pests. Several of the main pest species are already present in New Zealand. *Gibbium psylloides*, the smooth spider beetle, is a pan-tropical food product pest, not established in New Zealand. Spider beetles are mainly scavengers on plant and animal substances and are usually seen in grains infested by some other stored product beetle. They often feed on parts of dead insects within the food product. Spider beetles contaminate food products with body parts, faeces and pupal cases. They prefer the dark, are most active at night and hide during daylight hours inside crevices, and in other darkened areas. Contamination of the vehicle pathway with Anobiidae is likely to be via contaminated food. As a group, their biology is similar to that of the dermestid beetles.

Bostrichidae (black beetles, auger beetles etc): 430 species. The adults bore galleries in branches or trunks of trees, particularly those that are sick or moribund, some are stored product pests. The interception records for this family from the vehicle pathway are of species already present in New Zealand. Contamination of the vehicle pathway with this family of beetles is likely to be via secondary twigs and wood products.

Carabidae (ground beetles): 25 000 species. In temperate regions all species live on the ground in leaf litter, under bark and in soil. In the tropics many species are arboreal and are good fliers. Both adults and larvae are predacious of other insects and small invertebrates. They play an important role as natural predators of pest species but also have the potential to become environmental pests. Some species are secondarily vegetarian and feed mostly on seeds. They can be minor agricultural pests. Eggs and pupae occur in soil. Entry of this family of beetle is therefore most likely to be via contamination of imported vehicles or machinery with soil.

Cerambycidae (Longhorn beetles): 20 000 species. A worldwide family, most abundant in tropical rain forests. The host plants are typically trees, but sometimes woody shrubs and a few herbaceous plants. Large numbers of eggs, up to 200 in the case of *Anoplophora chinensis*, are laid on or into the bark or exposed roots and the larvae bore into the wood. Pupation also takes place under the bark. Adults emerge from the tree and live for 1-3 months. Heavy infestations can result in the death of the tree and longhorn beetles can be pests in timber and fruit plantations as well as environmental pests. *Anoplophora malasiaca* and *A. chinensis* are borers of citrus that are not found in New Zealand but are recognised pests in Japan (Lingafelter and Hoebeke, 2002). Entry on the vehicle pathway is likely to be via plant material containing eggs, larvae or pupae. Felled timber and nursery stock are likely to be more significant entry pathways.

Chrysomelidae (leaf beetles): 20 000 species. A diverse group of beetles, containing many recorded agricultural pest species. Larval habitats are varied including both soil dwellers,

feeding on roots, and leaf feeders. Adults generally feed on leaves. Many species are disease vectors. The most likely means of entry via the vehicle pathway is in association with soil or plant debris. *Aulacophora* sp., the only genus in this family recorded from the vehicle pathway, contains many pests of the Cucurbitaceae, cucumber family in Africa, India, S.E. Asia, Australia and Japan.

Coccinellidae (ladybird beetles): 5 000 species. Both adults and larvae are carnivorous and prey on aphids, scale insects, small caterpillars etc, although some species are phytophagous. A few species are regarded as agricultural pests, but most are considered beneficial as natural predators of insect pests. The eggs are laid in batches of 200-800 on plant foliage and plant debris is the most likely means of entry via the vehicle pathway.

Cucujidae (flat bark beetles): 500 species. Often found under bark on trees, but a few, especially in the genus *Cryptolestes* and including *Cryptolestes ferrugineus*, which has been recorded from an imported vehicle are adapted to feed on stored products and can be damaging pests.

Curculionidae (weevils): 60 000 species. A very large group including many agricultural pests with varied biology and habits, distributed worldwide. Both adults and larvae are phytophagous and can be damaging. All parts of a plant can be affected. *Hypera* spp., clover leaf weevils, which have been recorded from the vehicle pathway, are pests in Europe, Asia, USA and Canada, but not present in New Zealand. Plant debris is the most likely means of entry via the vehicle pathway for this group of beetles.

Dytiscidae (true water beetles): 4 000 species. A predominantly Palaearctic family of fiercely predacious water beetles. Both larvae and adults are aquatic and are therefore unlikely to enter via the vehicle pathway.

Elateridae (click beetles, wireworms): 7,000 species. A worldwide group. The larvae occur in the soil, feeding on plant roots. Most countries have a wireworm problem, but the pest species complex is composed of different species in different regions. Few species are widely distributed. Larval development is slow, sometimes taking a number of years to complete. Adults tend not to feed much but may eat some leaf material or pollen. Entry of elaterid beetles on the vehicle pathway is likely to be of larvae via fresh root material. This is unlikely except perhaps on used agricultural or forestry machinery.

Hydrophilidae (scavenging water beetles): 2 000 species. Most species are aquatic feeding on decaying vegetable matter, but some are terrestrial, found in rotting vegetable material. There are some minor crop pests in temperate areas mainly in the genus *Helphorus*.

Lucanidae (stag beetles): 750 species. Larvae and pupae develop in rotting wood. The life cycle is generally extended and takes several years. Some adults are nectar feeders.

Nitidulidae (sap beetles): 2 200 species. A family with varying life histories, although most are very small. Some species are found on flowers, feeding on nectar and pollen, some being quite host specific. Others occur on decaying animal matter or fungi, on sap or fermenting fluids. Some are insect predators and a few are pests of stored products. Sap feeding species can be disease vectors. It is not possible to generalise about the entry of such a diverse group.

Oedemeridae (False blister beetles): 1 000 species, of which all the adults are obligate pollen feeders. Many species cause blisters when pinched or squashed against the skin, and the larvae of some are wood borers. Generally, eggs are laid under bark of trees. Larvae hatch, and either bore into the wood or drop to the ground and bore into damp soil where they probably feed on rootlets and fungal rhizomes. Pupation takes place in the soil (Arnett, 2005). Wood and soil contamination are the most likely means of entry via the vehicle pathway.

Platypodidae (Ambrosia beetles): 1 000 species of mostly tropical beetles, closely related to the Scolytidae and sometimes included within that family. The larvae are wood borers and can be pest species (Atkinson 2004). Wood is the most likely means of entry via the vehicle pathway.

Scarabaeidae (chafers; cockchafers; June beetles etc): 17 000 species. The family is composed of six large and well-defined subfamilies. Of the Scarabaeids intercepted from the vehicle pathway, *Anomala* is a widespread genus attacking many different plants both as adults and larvae. The genus occurs throughout Africa, Asia and the USA in both tropical and temperate regions. 16 pest species have been recorded from Japan alone. *Melolontha*, *Pericoptus*, *Polyphylla*, *Stethaspis* and *Hoplia* species are cockchafers. The larvae are polyphagous root eaters and the adults bite pieces from leaves and young apples. They have a palaeartic distribution, but individual species are not widespread, partly because adults are poor fliers. Larval development is slow and can take a number of years. *Eucetomia* sp. and *Protaetia orientalis*, which originates in India and Japan are in the Cetoniinae (rose chafers) which feed on nectar, pollen and overripe fruit. Larvae mostly develop under grassland feeding on roots and decaying vegetable matter.

Allomyrina dichotoma is in the Dynastinae (rhinoceros beetles), an entirely tropical group. The adults have well-developed mouthparts and the larvae live in soil and rotting vegetation. They are pests of sugarcane, coconut and oil palms. Contamination of imported vehicles and machinery with soil or root material is the most likely means of entry of this group via the vehicle pathway.

Scolytidae (bark beetles & ambrosia beetles): A principally tropical group of wood borers in which the adults rather than the larvae are the primary tunnelers. They are important forestry pests and are characterised by very effective dispersal and host-finding mechanisms. Several species are known to be associated with plant pathogens such as *Leptographium* spp. e.g. (Jacobs et al. 2000). Some species are twig borers and could be transported in relatively small volumes of plant material, although it is unlikely they would survive once the cambium dried out.

Staphylinidae (rove beetles): 27 000 species. Most species are predacious ground beetles, capable of flying well. The larvae feed in soil and leaf litter which is the most likely route of entry via the vehicle pathway. Staphylinids are generally considered to be important natural enemies of agricultural pests and establishment of an exotic species would be likely to have adverse impacts through predation on New Zealand's rare native insect fauna. Some species in this family contain a blistering agent that will causing blistering of human skin following direct contact with the beetle (Goddard, 2003).

Tenebrionidae (darkling beetles etc): 15,000 species. A variable group, with a range of habits. The genus *Tribolium* is an important group of stored product pests. They are long lived prolific breeders with a life cycle of about 5 weeks. They are most abundant in processed products.

Throscidae: Sometimes included within Elateridae. Throscidae occur in most parts of the world, but have not been reported from New Zealand. The larvae often occur in the soil, where they feed on ectomycorrhizal fungi on the roots of trees; however some have been collected in rotten conifer wood and grass tufts (Lawrence et al. 2005).

7.2 CONCLUSION

Given that:

- there are a very large number of species of beetle that could potentially be associated with imported vehicles and equipment, most of which will not be possible to identify at the border;
- viable life-forms of the families of beetles intercepted from the vehicle pathway are most likely to be found in association with other contaminants – soil, wood, plant material or food which are commonly found in imported vehicles but not inspected for associated pests;
- many of the genera intercepted from the vehicle pathway occur in vehicle exporting countries, but not in New Zealand;
- at least some of the families and genera intercepted include significant agricultural and forestry pests or vectors of pathogens.

and taking into account, that most of the interception records are for adults who are generally unlikely to survive shipment to New Zealand, but may indicate the presence of other less visible life forms, it is concluded that **beetles are potential hazards on the used vehicle pathway**. Agricultural and forestry machinery are more likely to be contaminated with significant quantities of soil and plant material than passenger vehicles. Given the association of beetles with other contaminants, it is assumed that the measures recommended for the management of dermestid beetles, soil, plant and animal material and food debris will adequately mitigate the risk associated with other beetles. This hazard group is therefore not assessed further.

It is assumed that the majority of new vehicles will only be contaminated with inorganic road film and the dust that accumulates on vehicles during storage and shipping. **Beetles are therefore not considered to be potential hazards on the new vehicle pathway.**

7.3 REFERENCES

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8 Booklice (Psocoptera)

8.1 HAZARD IDENTIFICATION

8.1.1 Identity

Taxonomic Group: Class: Insecta; Order: Psocoptera

Name: Booklice or barklice

8.1.2 Association with pathway

There are 22 families of Psocoptera and some 2 000 species. They are small to minute insects, primarily found in tree foliage, bird nests, domestic premises or warehouses. They feed on fungi, algae and organic debris. They can cause significant damage to museum specimens and are a nuisance pest of stored products (Hill, 1994).

The booklice interception records for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand. The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates.

Table 1. Booklice interception records between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status (Scott and Emberson, 1999)	Country of origin	Vehicle type	Records
<i>Ectopsocopsis cryptomeriae</i>	Ectopsocidae	not present in NZ, occurs in Japan & USA	USA	new machinery	post-border record of >10 live adults of both sexes
<i>Liposcelis</i> sp. *	Liposcelidae	1 species in genus present in NZ	Japan	used vehicle	6-10 live adults and eggs on debris
unidentified	Psocidae	unknown	Australia	used caravan	1 record of live adult
unidentified	Trogiidae	unknown	Australia	used caravan	1 record of adult of uncertain viability
unidentified	unidentified	unknown	Japan Tonga	used vehicle new vehicle	1 record of live adult 1 record of live adult

*Intercepted during Biosecurity Monitoring Group slippage survey in the air filter (Wedde et al. 2006).

Since booklice are very small and are often found on plant material which is not routinely inspected for associated species, it is likely that they are under-recorded on the vehicle and machinery pathway.

8.2 CONCLUSION

Given that booklice:

- are very small and likely to be an under-recorded contaminant on the vehicle and machinery pathway;
- tend to be associated with plant contamination;
- can in some cases cause damage to museum specimens and stored products.

they are considered a **potential hazard on the used vehicle and machinery pathway**.

However, given the paucity of species level identification, it is not possible to generalise about the likelihood of entry and establishment or of the consequences of establishment and spread of exotic species in this group. Since risk management measures are proposed for soil, plant and animal debris contamination associated with the vehicle and machinery pathway no further analysis is undertaken for booklice as a potential hazard group.

Issues around the biosecurity risk of contaminants in air filters are considered further in Chapter 23.

It is assumed that the majority of new vehicles will not be contaminated with significant quantities of plant debris. **Booklice are therefore not considered potential hazards on the new vehicle pathway.**

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9 Bugs (Hemiptera)

9.1 HAZARD IDENTIFICATION

9.1.1 Identity

Category: Insecta

Taxonomic Group: Order: Hemiptera

Common name(s): Bugs

9.1.2 Introduction

The order Hemiptera is very large comprising some 38 families and 56 000 species, many being agricultural pests (Hill, 1994). The order is characterised by mouthparts adapted for piercing and sucking juices from plant or animal tissues. Many Hemiptera are vectors of plant viruses. Traditionally there have been considered to be two sub-orders, the Homoptera and the Heteroptera, both of which have been recorded in association with the vehicle pathway.

The hemipteran interception records for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus or family and some but not all the species in that genus/family are present in New Zealand.

Table 1. Hemipteran interception records associated with the vehicle and machinery pathway over the period 1994-2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Scott and Emberson, 1999) & *	Country of origin	Vehicle type	Life stage (number of records & viability)
unidentified	Belostomatidae (giant water bugs)	no	Japan	used vehicle	live adult (1)
unidentified	Coreidae (brown bugs)	unknown	Japan	used vehicle	live adults (1 post-border) dead adult (1)
<i>Sigara</i> sp.	Corixidae (water boatmen)	unknown	Japan	used vehicle	dead adults (2)
<i>Gerris</i> sp.	Gerridae (pond skaters)	no	Japan	used vehicle	dead adults (5)
<i>Largus</i> sp.	Largidae (pyrrhocorid bugs)	no	Japan	used vehicle	dead adult (1)
unidentified	Lygaeidae (seed bugs)	unknown	Japan	used vehicle	dead adults (4)
unidentified	Miridae (capsid bugs)	unknown	Japan	used vehicle	dead adult (1)
unidentified	Nabidae (damselfly bugs)	unknown	Japan	used vehicle	1 viability uncertain
<i>Ranatra chinensis</i>	Nepidae (water scorpions)	no	Japan	used vehicle	dead adults (9)
unidentified	Ochteridae (velvety shore bugs)	no	Japan	used vehicle	dead adult (1)
unidentified specimens	Pentatomidae (stink bugs)	unknown	Japan	used vehicle	dead adults (9)
<i>Erthesino fullo</i> tallow	Pentatomidae	no	Japan	used vehicle	live adults (3 post-

Organism	Family	Present in New Zealand (Scott and Emberson, 1999) & *	Country of origin	Vehicle type	Life stage (number of records & viability)
stink bug					border) live adult (1) dead adults (2)
<i>Glaucias subpunctatus</i>	Pentatomidae	no	Japan	used vehicle	dead adult (1)
<i>Halyomorpha</i> sp. nr <i>brevis</i>	Pentatomidae	no	Japan	used vehicle	live adult (1)
<i>Nezara viridula</i>	Pentatomidae	yes	Japan Italy	used vehicle new tractor	dead adult (1) live adult (2)
<i>Coptosoma punctissimum</i>	Plataspidae (helmet bugs)	no	Japan	used vehicle	dead adult (1)
<i>Isyndus obscurus</i>	Reduviidae (assassin bugs)	no	Japan	used vehicle	live adults (1)
unidentified	Reduviidae	unknown	Japan	used vehicle	dead adults (28)
unidentified	Aphididae (aphids)	unknown	Japan USA	used vehicle machinery	dead adult on vehicle (1) on plant debris (1)
<i>Aulacorthum solani</i> (Foxglove aphid)	Aphididae	no	Japan	used vehicle	live adult (1)
unidentified	Cicadidae (cicadas)	unknown	Japan Australia	used vehicle machinery	dead adults (27) dead adult (1)
<i>Graptosaltria nigrofusca</i>	Cicadidae	no	Japan	machinery	1 post-border plus note of past dead interceptions of this species.
<i>Graptosaltria bimaculata</i>	Cicadidae	no	Japan	used vehicle	dead adults (2)
<i>Cryptotympana okinawana</i>	Cicadidae	no	Japan	used vehicle	dead adult (1)
unidentified	Coccidae (soft scales)	unknown	Japan	used vehicle	dead adult & eggs (1)
<i>Pseudaulacaspis</i> sp.	Diaspididae (hard scales)	unknown	unknown	agriculture equipment	live adult (1)
<i>Scolypopa australis</i>	Ricaniidae (Ricaniid planthoppers)	yes	unknown	unknown	live adult (1 post-border)
unidentified	scale insects	unknown	Japan	used vehicle	plant debris (15)

*<http://www.landcareresearch.co.nz/research/biodiversity/invertebratesprog/hemwsite/nzhemlist/>

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Several interceptions were only identified to family level. There are records from 15 genera and 18 families. All but three were from vehicles imported from Japan. 79 percent of interceptions identified to species or genus level are organisms not present in New Zealand. 89 percent of interceptions were dead suggesting most adult bugs are unlikely to survive

shipment without a supply of fresh food. However, the dead adults may indicate contamination by less visible life forms such as eggs or immatures associated with plant debris contamination of the vehicle. Since plant material is not routinely inspected for associated species, eggs and immatures would not be intercepted and recorded.

Brief summaries of distribution, biology and pest potential of each family are set out below. Information is derived from (Hill, 1994) unless otherwise specified.

Belostomatidae, giant water bugs: 100+ species. Fiercely predacious, aquatic insects. Adults fly strongly at night and are attracted to lights, so may become trapped in a vehicle.

Coreidae, brown bugs: 2000 species. A group of strong flying phytophagous bugs with phytotoxic saliva causing necrosis of host plant tissues. There have one or two generations a year, depending on the local climate.

Corixidae, water boatmen: 200 species. Another group of aquatic insects which can be very numerous around paddy fields, ponds etc. The adults fly freely and may become trapped in used vehicles. It is very unlikely that they would survive shipment to New Zealand.

Gerridae, pond skaters: 200 species. Large aquatic insects with long middle and hind legs fringed with bristles, with which the insects skate or run over the water surface. Adults occasionally fly at night. *Gerris* is a common genus in Europe.

Lygaeidae, seed bugs: 2000 species. Small dark or brightly coloured bugs. Most are phytophagous but a few are predatory.

Miridae, capsid bugs: 6000 species. A group of important agricultural pests. The majority are phytophagous but a few are predacious or omnivorous. They inject toxic enzymes in their saliva into plant tissues, resulting in a necrotic spot around the feeding puncture. Some species feed almost continuously and thus cause extensive plant damage. Eggs are laid into plant tissues. There are 5 nymphal instars and the nymphs are as damaging as the adults.

Nabidae, damsel bugs: 300 species. A mostly tropical group found primarily in herbage where they hunt small phytophagous insects. Eggs are inserted into plant stems.

Nepidae, water scorpions: 3 000 species. These insects have aquatic larvae but do not generally breed in small water-holding containers. They are therefore unlikely to be associated with the vehicle pathway or survive shipment to New Zealand.

Pentatomidae, stink bugs: are a diverse group of some 2 500 species comprising plant feeders, predators and omnivores. The family is most abundant in neo-tropical, Ethiopian and Indo-Malayan regions. Eight species of Pentatomidae occur in New Zealand. Two are endemic, and two others are native to New Zealand but occur also elsewhere in Australasia and parts of the South Pacific. The remaining four have been introduced (Larivière, 1995). Most Pentatomidae feed on plant juices, and live above ground on their host plants. Some species are destructive to cultivated plants. The phytophagous species are most likely to be associated with plant debris contamination of vehicles.

Plataspidae, dwarf shield bugs, helmet bugs: 500 species. Small, shiny round phytophagous insects found throughout the old world tropics.

Ochteridae, velvety shore bugs: 60 species predominantly in the old world tropics. A predacious group feeding mainly on fly larvae, springtails and aphids. They usually inhabit the shore line of quiet waters and are found on sand and mud banks. Given their habitat and food requirements it is considered unlikely that ochterid species will be commonly associated with either the new or used vehicle or equipment pathways or survive shipment to New Zealand.

Reduviidae, assassin bugs, contains only species that are either predacious or parasitic in invertebrate and vertebrate tissue and blood (Carver et al. 1991). Reduviids in the subfamily Triatominae are obligate blood-feeders of birds or mammals (Carver et al. 1991; Schuh and Slater, 1995). Some members of this family are vectors of *Trypanosoma cruzi*, a blood parasite causing trypanosomiasis or Chagas' disease, which is frequently fatal. Most species hunt on the ground, in low herbage, bushes and sometimes trees, but some species are urban dwellers. The genus *Isyndus*, intercepted on the vehicle pathway does not appear to be a significant pest group.

Aphididae, aphids: 3 500 species. One of the dominant insect groups in the northern hemisphere, feeding on a range of plant material including woody plants, herbaceous plants, cereals and grasses. Most species are host specific but many of the most serious pests are polyphagous. Aphid life cycles usually consist of parthenogenetic generations that exploit rapidly growing herbaceous plants in the summer, and a sexual generation that results in diapausing eggs that over-winter on a primary host, which is often a 'permanent' woody shrub or tree. Host alternation often occurs as a regular seasonal migration between two host plants. Viviparous parthenogenesis results in high fecundity of aphids. With 9-12 generations a year it is estimated that a single female aphid could give rise to 600 000 million offspring a year, in the absence of predation. Most aphids are phloem feeders, but some can also use the xylem. Honeydew excretion is general, often resulting in associations with sooty moulds and ants. Many aphids act as virus vectors with some species transmitting more than 100 different virus diseases in plants. Aphids are very small and it is likely that they would not be detected by visual inspection of vehicles. The number associated with the vehicle pathway is likely to be much greater than the two interception records would imply. However, being small, they are subject to desiccation and require a continuous food supply. The nymphs of some aphid species are dispersed by air currents and could be blown into vehicles. The survival time of unfed crawlers is affected by temperature and humidity, and is generally less than 24 hours (Greathead, 1990). It is therefore unlikely, with the possible exception of diapausing eggs, that aphids would survive transport to New Zealand on plant debris associated with used vehicles and equipment. The only record of a live aphid intercepted on a vehicle is of a species already present in New Zealand and could have contaminated the vehicle locally.

Cicadidae, cicadas: 4 000 species. A family of mainly tropical insects, unusual among the Homoptera in that they feed from the xylem vessels of the plant and have a special alimentary mechanism for short-circuiting excess water straight to the hind gut for prompt excretion. The larger species are tree feeders, whilst some small species feed on the stems of large grasses and sugarcane. Generally the female lays eggs into twigs or grass stems that have been split by her ovipositor. Considerable damage can be done by oviposition as the foliage distal to the oviposition site often withers and dies. The eggs hatch into tiny nymphs which fall to the ground and burrow into the soil using their stout, modified forelegs for digging. Nymphal life is spent underground where they pierce plant roots as a source of sap. Development is a lengthy process taking several years in larger species. When the nymphs are fully grown they

emerge from the soil at night and crawl up vegetation where metamorphosis is completed. The genus *Cryptotympana* occurs throughout south-east Asia, including Japan, and can be a pest of *Citrus* trees. Given their life cycle, it is unlikely that cicadas will survive shipment to New Zealand in vehicles. This is supported by the absence of recorded interceptions of live cicadas.

Coccoidea, scale insects: A super-family characterised by apterous (without wings), degenerate, larviform females and nymphs which are scale-like or covered with a waxy exudate. Males, when they occur, have a single pair of wings and vestigial mouthparts. Since the females are immobile, dispersion is via the first instar nymphs, which crawl or are dispersed by the wind. The group contains many crop pests which, being small and sessile, are readily transported around the world. It is likely that they are under-recorded as contaminants on the vehicle pathway, since they are most likely to be associated with plant debris, which is generally not checked for further contamination by associated organisms. Given the large number of species involved it is difficult to generalise about the group.

Diaspididae, hard or armoured scales. The female is covered by a hard scale not attached to the insect body and usually firmly fixed to the plant surface. The eggs or nymphs are laid under the protection of the scale and the female's body shrinks progressively until she is dead and the entire space under the scale is occupied by the eggs or nymphs. In Japan, 101 species of Diaspididae are recorded as agricultural pests. It is likely that they are under-recorded as contaminants on the vehicle pathway, since they are most likely to be associated with plant debris, which is generally not checked for further contamination by associated organisms. Burger and Ulenberg (1990) conducted a comparison of the relative likelihood of introduction of armoured scale insects to a new geographic area in association with different plant parts and stages of growth, concluded that the earliest stages of growth such as seeds and leafless twigs or cuttings are least likely to be infested and whole plants are most likely.

Ricaniidae, Ricaniid planthoppers: 350 species. A largely tropical group of phytophagous bugs of moth-like appearance. *Scolypopa australis* is a minor pest of passion vine in Australia and is now established in New Zealand.

9.1.3 Conclusion

Given the biology and ecology of the **Nepidae, Coroxidae, Belostomatidae, Gerridae, Nabidae, Ochteridae, and Cicadidae**, these families **are not considered to be hazards on the vehicle and machinery pathway**. Given the biology of the **Pentatomidae, Coreidae, Lygaeidae, Miridae, Plataspididae, the Reduviidae, the Aphidae, the Coccoidea, and the Diaspididae**, the interception records for these families, the impracticality of identifying individual species at the border and the number of pest species that are not present in New Zealand, these families **are considered potential hazards on the vehicle and machinery pathway**.

Given the sap/blood feeding requirements of most Hemiptera, they would need to be associated with fresh plant/animal material of sufficient size not to desiccate during shipment. There is little evidence of contamination of the pathway with fresh plant or animal material and the likelihood of adults and nymphs surviving shipment to New Zealand on the relatively small quantities of plant debris generally contaminating vehicles and equipment is low, unless there are diapausing life stages. Entry is more likely on vehicles imported from Australia for which the journey time is much shorter.

The likelihood of new vehicles being contaminated with fresh plant material is considered to be negligible and **Hemiptera are not considered potential hazards on the new vehicle pathway.**

In the absence of recorded interceptions of live individuals of significant pest species in this hazard group, and the diversity of organisms and biology within the group, a detailed risk assessment has not been undertaken. Since risk management measures are proposed for plant debris contamination associated with the vehicle and machinery pathway (Chapter 20), it is assumed that these measures will adequately mitigate any risk associated with phytophagous Hemiptera.

As a result of the large diversity of Reduviidae species and habitats, there is a large variation in the likelihood of association with the pathway among the different groups. Many species feed on other arthropods and dwell on soil or on plant material. The risk from these species would likely be mitigated by the measures recommended for the management of soil, plant and animal material and food debris. Other reduviids have become adapted to anthropic habitats, which can be found in domestic and peri-domestic environments (Schuh and Slater, 1995) and some species of human health significance can be abundant in urban areas. Triatomines living in association with humans for example, are likely to live in nearly any dark place where they are able to hide (Schuh and Slater, 1995). Nonetheless it is considered unlikely that any reduviids would be more resistant to treatment than spiders or cockroaches and it is assumed that measures for these hazard groups will adequately mitigate any risk from Reduviidae associated with the vehicle pathway.

Other pathways, particularly nursery stock and fresh produce are likely to be more important pathways for entry of the families in this order identified as potential hazards.

Two new species of Hemiptera (*Creiis liturata* and *Anoeconeossa communis*) have been found in Auckland on *Eucalyptus* spp. in recent years. Although the pathway of introduction for these species is not known, their presence provides evidence that members of this group can enter and become established in New Zealand.

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10 Butterflies and moths (Lepidoptera)

10.1 HAZARD IDENTIFICATION

10.1.1 Identity

Category: Insecta

Taxonomic Group: Order: Lepidoptera

Name: Butterflies and moths

10.1.2 Introduction

The order Lepidoptera comprises 97 genera and some 120,000 species (Hill, 1994). Butterflies and moths have two pairs of membranous wings and wings and body clothed in broad scales. The order is characterised by a large number of pest species with a wide diversity of habits.

The lepidopteran interception records for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus or family when some but not all the species in that genus/family are present in New Zealand.

Table 1. Lepidopteran interception records between 1994 and April 2006 associated with imported vehicles and machinery. Primary source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Dugdale, 1988; Hoare, 2001)	Country of origin & pathway	Life stage (number of records) & viability
unidentified	Arctiidae	unknown	Japan used vehicle	live larvae (2) dead pupae (3, 1 record post-border) dead adult (1) dead larvae (8)
<i>Hyphantria cunea</i> , fall webworm*	Arctiidae	incursion in NZ, eradicated (Bennett and Bullians, 2003)	Japan used vehicle, egg mass on tyre wall	dead larvae (2) egg mass- viability unknown (1)
<i>Spilosoma</i> sp.*	Arctiidae	no	Japan used vehicle	dead pupa (1)
unidentified	Cosmopterigidae	unknown	Japan used vehicle	live pupa (1)
<i>Sitotroga cerealella</i>	Gelechiidae	yes	Ireland used vehicle	dead adult (1)
unidentified	Gelechiidae	unknown	Japan used vehicle	live larva (1)
<i>Asthena pulcharia</i>	Geometridae	no	Japan used vehicle	live adult female (1)
unidentified	Geometridae	unknown	Japan used vehicle	dead adults (4)
<i>Wiseana cervinata</i>	Hepialidae	yes	Australia new vehicle	dead adults (10, 1 post- border)
<i>Pamara guttata</i>	Hesperiidae	no	Japan	dead adult (1)

Organism	Family	Present in New Zealand (Dugdale, 1988; Hoare, 2001)	Country of origin & pathway	Life stage (number of records) & viability
unidentified	Hesperiidae	unknown	Japan used vehicle	dead adult (1)
<i>Euthrix potatoria</i>	Lasiocampidae	no	UK used vehicle	dead adult (1)
unidentified	Lasiocampidae	unknown	Japan used vehicle	dead adult (1) dead pupa (1)
unidentified	Limacodidae	unknown	Japan used vehicle	live pupa (1) live larvae (1) dead adult (1)
unidentified	Lycaenidae	unknown	Japan used vehicle	dead adults (2)
<i>Dasychira</i> sp.??*	Lymantriidae	unknown	Japan used vehicle	dead pupa (1)
<i>Lymantria dispar</i> , Asian Gypsy Moth	Lymantriidae	formerly present in NZ, now eradicated (Ross, 2004)	Japan used vehicle used truck used ute	239 records total*** live egg mass (92) dead egg mass (50) unsure/unreported viability egg mass (38) live larvae (3) dead larvae (17) dead pupae (15) unsure /unreported viability pupae (2) dead adult (3) unsure/unreported viability adult (2) multiple life stages unsure/unreported viability (16) dead unreported life stage (1) 2 post-border records
<i>Lymantria mathura</i>	Lymantriidae	no	Japan used vehicle	live eggs & larvae (1)
<i>Lymantria monacha</i> , Nun moth	Lymantriidae	no	Japan used vehicle	larva (1) viability not recorded **
<i>Orgyia thyellina</i> , white spotted tussock moth	Lymantriidae	incursion in NZ, now eradicated (Hoare, 2001, Hosking et al. 2002)	Japan used vehicle	dead larva (2) flive eggs (1) 2 egg masses**
unidentified	Lymantriidae	unknown	Japan used vehicle USA used vehicle	dead life stages (30) live egg mass (1) dead pupa (1)
<i>Achaea janata</i> , Castor oil looper	Noctuidae	no	Japan used vehicle	adult (1)
<i>Agrotis ipsilon ipsilon</i> , Greasy cutworm	Noctuidae	no	Japan used vehicle	live adults (5)
<i>Agrotis ipsilon aneituma</i> ,	Noctuidae	yes	Japan used vehicle	live adults (2) dead adults (2, 1 post-border)
<i>Arccte coerela</i>	Noctuidae	no	Japan used vehicle	dead adult (1 post-border)

Organism	Family	Present in New Zealand (Dugdale, 1988; Hoare, 2001)	Country of origin & pathway	Life stage (number of records) & viability
<i>Catocala</i> sp.	Noctuidae	no	USA new vehicle	dead adult (1 post-border)
<i>Chasmina</i> sp.	Noctuidae	1 species detected once	Australia used vehicle	live adult (1)
<i>Chrysodeixis argentifera</i>	Noctuidae	no	Australia used vehicle Japan used vehicle	live adult (1) pupa (1) live adult (1)
<i>Dasypodia selenophora</i>	Noctuidae	no	USA used vehicle	live adult (1)
<i>Dermaleipa juno</i>	Noctuidae	no	Japan used vehicle	live adult female (1 post-border)
<i>Diarsia</i> sp.	Noctuidae	unknown	Japan used vehicle	live adult (1)
<i>Eudesmeola lawsoni</i>	Noctuidae	no	Japan used vehicle	live adult (1)
<i>Eudocima materna</i>	Noctuidae	no	Australia forklift	adult (1)
<i>Grammodes</i> sp.	Noctuidae	no	Sweden truck	recently dead adult (1 post-border)
<i>Graphania lignana</i>	Noctuidae	no	unknown	unrecorded life stage, dead (1)
<i>Graphania mutans</i> , grey brown cutworm	Noctuidae	no	Australia used vehicle	live adult (1)
<i>Graphania plena</i>	Noctuidae	no	Japan used vehicle	live adult (1)
<i>Helicoverpa armigera</i>	Noctuidae	yes	Japan used vehicle	live adults (4)
<i>Helicoverpa punctigera</i> , native budworm	Noctuidae	no	Australia used vehicle	live adult (1)
<i>Idia</i> sp.	Noctuidae	no	USA new machinery	live pupa (1 post-border)
<i>Maurilia iconica</i>	Noctuidae	no	Australia used vehicle	live adult (1)
<i>Mythimna separata</i>	Noctuidae	yes	Japan used vehicle	live adult (1)
<i>Mythimna stenographa</i>	Noctuidae	no	Japan used vehicle	live adults (3)
<i>Oxyodes tricolor</i> , Conspicuous looper	Noctuidae	no	Australia used vehicles	live adult (1)
<i>Persectania aversa</i>	Noctuidae	no	Japan used vehicle	live adult (1)
<i>Simplicia</i> sp.	Noctuidae	unknown	Japan used vehicle	dead adult (1)
<i>Spodoptera litura</i> , cluster caterpillar	Noctuidae	yes	Australia used vehicle Japan used vehicle	live adult (1) live adult (1)
<i>Spodoptera</i> sp.*	Noctuidae	unknown	Japan used vehicle	egg (1) viability not recorded
<i>Thysanoplusia orichalcea</i> , flax	Noctuidae	yes	thought to be contaminated	3 records of live larvae and adults

Organism	Family	Present in New Zealand (Dugdale, 1988; Hoare, 2001)	Country of origin & pathway	Life stage (number of records) & viability
caterpillar			locally	
<i>Tmetolophota unica</i>	Noctuidae	yes	Japan used vehicle	live adult (1)
unidentified	Noctuidae	unknown	Japan used vehicle	dead life forms (22) live adult (7)
<i>Uraba lugens</i> , gum leaf skeletoniser	Nolidae	yes	Australia machinery	dead larva (1) live larva post-border (1)
<i>Clostera</i> sp. *	Notodontidae	unknown	Japan used vehicle	pupa (1) viability not recorded
<i>Cynthia cardini</i>	Nymphalidae	no	UK used vehicle	dead adult (1)
unidentified	Nymphalidae	unknown	Japan used vehicle	dead pupae (3, 1 post- border)
<i>Hofmannophila pseudospretella</i> , brown house moth	Oecophoridae	yes	Japan used vehicle	larvae (2)
unidentified	Oecophoridae	unknown	Japan used vehicle	live larvae (2) live pupae (1)
			Singapore used vehicle	live larva (1)
<i>Graphium sarpedon</i> , blue triangle	Papilionidae	no	Japan used vehicle	dead adult (1 post- border)
<i>Papilio</i> sp.	Papilionidae	no	Japan used vehicle	dead adult (1)
<i>Pieris napi</i>	Pieridae	no	Japan used vehicle	dead adult (1)
<i>Pieris rapae</i> , white butterfly	Pieridae	yes	Japan used vehicle	live pupae (4)
unidentified	Pieridae	unknown	Japan used vehicle	live pupae (4)
<i>Nipponopsyche</i> sp.	Psychidae	no	Japan used vehicle	dead pupa (1)
unidentified	Psychidae	unknown	Japan used vehicle	dead life forms (21, 1 post-border) live larva(1) dead pupa & larva (1)
			Japan new vehicle	
<i>Pterophorus monospilalis</i>	Pterophoridae	yes	Japan used vehicle	live adult (1)
<i>Aglossa caprealis</i> , murky meal moth	Pyralidae	yes	Japan used vehicle	live larva (1)
<i>Gauna aegusalis</i>	Pyralidae	no	Japan used vehicle	live adult (1)
<i>Hymenia recurvalis</i> Hawaiian beet webworm	Pyralidae	no	Japan used vehicle	live adult (1) dead larva (1)
<i>Plodia interpunctella</i> , Indian meal moth	Pyralidae,	yes	Japan used vehicle	live adults (3)
<i>Pyrausta</i> sp.	Pyralidae	unknown	Japan used vehicle	live pupa & larva (1)
unidentified	Pyralidae	unknown	Japan used vehicle	3 records of live & 9 of dead life stages
<i>Caligula japonica</i> ,	Saturnidae	no	Japan	pupa (1)

Organism	Family	Present in New Zealand (Dugdale, 1988; Hoare, 2001)	Country of origin & pathway	Life stage (number of records) & viability
Japanese giant silkworm			used vehicle	
<i>Antheraea eucalypti</i> gum emperor moth	Saturnidae	yes	unknown machinery	live adult (1)
<i>Hippotion celerio</i> , grapevine hawk moth	Sphingidae	no	Australia used vehicle	live adult (2)
<i>Hippotion scrofa</i> , scrofa hawk moth	Sphingidae	no	Australia used vehicle	live adult (2)
<i>Hippotion</i> sp.	Sphingidae	no	Japan used vehicle	live adults (7)
<i>Theretra pinastrina</i>	Sphingidae	no	Japan used vehicle	dead adult (1)
unidentified	Tineidae	unknown	UK agricultural equipment	live larva (1)
<i>Grapholita molesta</i>	Tortricidae	yes	USA new vehicle	live larva (1 post-border)
unidentified leaf roller	Tortricidae	unknown, 12 species in family present in NZ.	Japan used vehicle	adult/larvae/pupae (5) live larva & pupa (2)
<i>Artona</i> sp., bamboo moth	Zygaenidae	unknown	Japan used vehicle	live adults (6)
<i>Harrisina</i> sp.	Zygaenidae	no	Japan used vehicle	dead pupa (1)
<i>Pryeria sinica</i> , burnet moth	Zygaenidae	no	Japan motorcycle Japan used vehicle	recently hatched live adult (1 post-border) live pupa (3)
unidentified	Zygaenidae	unknown	Japan used vehicle	live larvae & pupa (5)
unidentified	unidentified	unknown	UK new agricultural machinery Japan used vehicle Jamaica used vehicle	live larva (1) live pupae (2) dead pupae or adults (7) dead pupa (1)
unidentified	unidentified	unknown	Japan used vehicle	live larva (1) dead larva (1) pupa (1) uncertain viability

* identified through DNA analysis of specimens submitted as “Asian gypsy moth” (Karen Armstrong, pers.comm. to Melanie Newfield, February 2006)

** identified through DNA analysis (Armstrong et al. 2003)

*** *Lymantria dispar* records are for period 1998-2001 only. After 2001 changes in recording mean that interception records of Lymantriidae from 2002-2005 were less commonly recorded to species level and are therefore difficult to compare with records from 1998-2001 (Biosecurity New Zealand 2007).

58 Lepidoptera taxa in 24 families have been identified from imported vehicles and machinery. 93 percent of interceptions were on vehicles from Japan. The majority were intercepted alive. 41(71 percent) of organisms identified to species or genus level are not currently found in New Zealand, but for 14 of these there were no live interceptions. There

have been 13 post-border interception records of which half were of live life stages and 66 percent of these were of organisms not present in New Zealand and included hatching Asian gypsy moth egg masses. Interception records cannot be used to quantify likelihood of entry, see Chapter 2. There are a large number of lymantriid interception records in part because MAF Quarantine Service staff are trained to look for lymantriid egg masses and there have been periods over which all lymantriid interceptions have been recorded and sent for identification. However there are important caveats with these data even for more intensively reported species such as *L. dispar*. In particular it is not reported who undertook the identifications and how these were done, so the reliability of the identifications is uncertain (Biosecurity New Zealand 2007). In addition, to the records in table 1, *Papilio xuthus* has been recorded from an imported Japanese vehicle (Hoare, 2001).

Brief summaries of distribution, biology and pest potential of each family intercepted are set out below. Information is derived from (Hill, 1994) unless otherwise specified.

Arctiidae (tiger moths, woolly bears): 10 000 species. A mostly nocturnal group of moths, some of which are attracted to lights. Many species are polyphagous. Eggs are generally laid on host plant foliage and the larvae are densely hairy. In temperate regions many species over-winter as larvae. They pupate on the host plant, in leaf litter, in the soil or in some cases on inanimate objects. Several species, including fall webworm, *Hyphantria cunea*, are serious agricultural pests. Only about 9 species occur in New Zealand (Dugdale, 1988). Larvae of several species cause caterpillar hair dermatitis in humans (Southcott, 1978).

Cosmopterigidae (fringe moths): 1 200 species. A widely distributed family of small moths. Larval habits range from leaf miners to predators of scale insects.

Gelechiidae: 4 000 species. A widely distributed family of small moths with a wide range of larval habits. *Sitotroga cerealella*, angoumois grain moth, is a major pest of stored grains and dried fruit.

Geometridae (carpet moths, pugs & loopers): 12 000 species. An ecologically dominant group of moths worldwide. They are essentially a forest group with relatively few crop pests. Eggs are laid in bark crevices or on plant foliage. The larvae are looper caterpillars and many can disperse using silk threads over considerable distances in the wind. Adult moths of some species feed upon mammalian tears, sweat and serum exuding from wounds (Southcott, 1978). Eight species in this family are present in New Zealand.

Hepialidae (swift moths): 300 species. A widely distributed family, best developed in Australia and New Zealand. The larvae live in the soil and bore into roots and can be agricultural and forestry pests.

Hesperiidae (skippers): Stout-bodied butterflies that fly fast and erratically. Many are diurnal. The family occurs worldwide but the predominance of species is in the tropics. The larvae feed on monocotyledonous plants.

Lasiocampidae (eggars, lappets & tent caterpillars): 1 000 species. A widespread group of large moths, absent from New Zealand and most abundant in the tropics. Eggs are laid in a band around a twig. The caterpillars live gregariously inside a 'tent' of silk on the host plant. Whilst not recorded from imported vehicles, the genus *Dendrolimus* has a number of significant defoliating pests including *D. punctatus* which damages pines in Japan, China,

Korea and Taiwan. Defoliation is usually extensive with damage occurring over thousands of hectares. Additionally larvae of a number of genera possess urticating hairs that pose a human health hazard (Wallner and Radnor, 1996).

Limacodidae (stinging & slug caterpillars): 1 000 species. A widespread family of forest moths, best represented in the tropics. Eggs are laid on the underside of leaves. The larvae often have urticating spines, are polyphagous and tend to be associated with monocotyledonous plants. The larvae and pupae are often heavily parasitised. A number of genera are of human health significance as the larvae have urticating hairs or spines (Southcott, 1978).

Lycaenidae (blues, coppers, hairstreaks): A large group of small butterflies well represented in all regions of the world. Most larvae are phytophagous, but some are predatory. They are principally pests of citrus and Leguminosae.

Lymantriidae (tussock moths etc): 2 500 species. A worldwide family with representatives on all continents except Antarctica, but absent from a number of oceanic islands. The adults do not have a proboscis and do not feed. No species in this family are present in NZ. Seven northern hemisphere species, including gypsy moth, nun moth and white spotted tussock moth have been identified as a high-risk to New Zealand forestry based on their pest status and polyphagous nature (Armstrong et al. 2003). Nun moth, *Lymantria monacha* is a significant pest of European forests where it defoliates both conifers and deciduous trees. It has periodic outbreaks. Adults are attracted to lights and eggs are laid in bark crevices or on inanimate objects such as containers (Wallner and Radnor, 1996). It is noteworthy that 1 percent of intercepted specimens assumed by MAF Quarantine Service officers to be Asian gypsy moth and sent for identification by DNA analysis turned out to be nun moth and a further 1 percent were white spotted tussock moth (Armstrong et al. 2003). At least 7 genera of Lymantriidae are native to Australia (Riotte, 1979). Lymantriid caterpillars are covered by long tufts of hair which are urticating in most species. Since larval hair may be incorporated into other life stages, such as egg masses, all life stages may be of human health significance (Southcott, 1978).

Noctuidae: 25 000 species. The largest family of Lepidoptera and the most significant in terms of the number of agricultural pests. Twelve species in this family are present in NZ. There is considerable confusion regarding the taxonomy of Noctuidae with long lists of synonyms for many species and lack of agreement over generic definitions. The family has the full range of larval and adult feeding behaviours including leafworms, stem borers, budworms, bollworms, fruitworms, armyworms, cutworms, rootworms, coccid predators, fruit piercers and blood sucking moths. Some noctuids such as *Calyptra* spp. take blood meals from a variety of mammals including humans and have been suggested as potential vectors of parasites (Southcott, 1978). Several species recorded from the vehicle pathway, notably *Achaea janata*, *Helicoverpa punctigera*, *Mythimna* sp., and *Spodoptera litura*, are important agricultural pest species.

Nolidae: 100 species. A small family of worldwide distribution found primarily in the Old World tropics, sometimes regarded as a subfamily of the Noctuidae. Until recently, no species in this family occurred in New Zealand but *Uraba lugens*, gum leaf skeletoniser, has become widespread in Auckland over the last 5 years. This species is a significant defoliator of eucalyptus in Australia (Bain et al. 1997). Some species including *Uraba lugens* are of human health significance, as the larvae have venomous spines (Derraik, 2006).

Nymphalidae (four-footed butterflies): 5 000 species. Both sexes have the anterior legs reduced and useless for walking. All adults are diurnal and feed either on flowers, animal urine, dung, rotten fruits or sap exuding from trees.

Oecophoridae: 3 000 species. A large, ecologically important family, particularly well developed in Australia. Nine species in this family occur in New Zealand. There are few agricultural pests but there are a number of cosmopolitan domestic pests whose larvae feed on carpets, fabrics etc.

Papilionidae (swallowtails): 600 species. A tropical group of colourful butterflies, many with distinctive trailing 'swallowtails' on the hind wings. Some are *Citrus* pests. No species in this family occur in New Zealand.

Pieridae (whites, yellows and orange-tip butterflies): A largely temperate family some of which are extremely abundant. Only one species occurs in New Zealand. Some species are strongly migratory.

Psychidae (bag moths): 800 species. A widespread family, most abundant in the tropics and sub-tropics. Australia has a particularly rich Psychidae fauna. Two species in the family are present in NZ. They are unusual in that the males are strong fliers but the females generally have no wings, legs, antennae or functional mouthparts. Females wait for males in their larval 'bag' and after mating the eggs are laid in the bag. There are some important pests of plantation crops.

Pterophoridae (plume moths): A widespread family whose larvae attack the Compositae more than any other plant group. The larvae either feed externally on leaves and flowers or internally in stems or fruit.

Pyralidae (snout moths): A very large group of moths, widely distributed throughout the world, but most abundant in the tropics. In the past, this family was often regarded as being composed of five separate families. Consequently the taxonomy is somewhat confused. Some species are adapted to aquatic habitats. Others are important pests of stored products. Adult moths of some species feed upon mammalian tears, sweat and serum exuding from wounds (Southcott, 1978). Ten species in the family are present in New Zealand.

Saturniidae (emperor moths): A predominantly tropical family whose larvae generally produce silk. Only one species in the family is present in New Zealand. Several genera have larvae with urticating spines, which may cause lesions in humans, and adult moths of some species are reported to cause dermatitis (Southcott, 1978).

Sphingidae (hawk moths): 1 000 species. Large conspicuous moths found worldwide, but predominantly in tropical regions. The majority are nocturnal. There are some important pests of cultivated plants. Only one species in the family occurs in New Zealand.

Tineidae (clothes moths): 2 400 species. The family has been subject to taxonomic review, resulting in fewer species. The larvae of one sub-family feed on dried animal material and in an urban situation can be significant domestic pests.

Tortricidae: 4 000 species with a worldwide distribution. They are basically insects of deciduous forests, most abundant in warm temperate regions. The larvae are often difficult to distinguish and the pests of fruit trees are often collectively known as fruit tortricids. They are an important group economically, with for instance, some 25 species recorded feeding on apple. Twelve species in the family are present in New Zealand.

Zygaenidae (burnets or foresters): 400 species, occurring worldwide except for New Zealand (Dugdale, 1988). They are sometimes called day-flying moths. *Artona martini*, the most common bamboo feeding zygaenid species in eastern China and Japan became established in Northland in the 1990s and became the first New Zealand record of the family. The method of arrival of *A. martini* is unknown, but a cocoon was found in an imported Japanese vehicle, suggesting that the vehicle pathway was a possible mode of entry. Other possible pathways include visiting yachts and forest produce. The moth is expected to spread throughout New Zealand wherever the host plant is grown (Gill, 2000). The larvae possess urticating hairs, a trait, unknown in larvae of indigenous New Zealand Lepidoptera (Gill, 2000).

10.1.3 Conclusion

Given that the Lepidopteran families associated with the vehicle pathway have:

- a wide diversity of biology and ecology;
- been regularly intercepted, mostly as live life-stages of organisms that are not present in New Zealand;
- a large number of members known to be of high consequence.

Lepidoptera are considered to be potential hazards on the vehicle and machinery pathway.

A detailed pest risk analysis has been undertaken for some high impact moths most of which have recently been the subject of incursion responses in New Zealand. Imported vehicles and machinery is an entry pathway for four out of the six species assessed: Asian gypsy moth, *Lymantria dispar*, Lymantriidae, white spotted tussock moth, *Orygia thyellina* Lymantriidae, painted apple moth *Teia anartoides*, Lymantriidae, and fall webworm, *Hyphantria cunea*, Arctiidae (Biosecurity New Zealand 2007). These species are used as examples to assess the risk from Lepidoptera on the vehicle pathway and the detailed risk assessments for them (Biosecurity New Zealand 2007) are summarised here. The current risk analysis for *L. dispar* differs from an earlier assessment of the used vehicle pathway as a means by which gypsy moth may enter New Zealand (MAF Biosecurity Authority, 2000) in that it covers all the pathways that are now known or suspected for Asian gypsy moth and incorporates new information on the life cycle, host range, pathways and the incursion in Hamilton.

10.2 ENTRY ASSESSMENT

Table 2. Summary entry assessment for four moth species not present in New Zealand but recorded in association with vehicles/machinery. Based on Biosecurity New Zealand (2007).

	Asian gypsy moth	Fall webworm	Painted apple moth	White spotted tussock moth
Distribution (in main vehicle exporting countries)	Gypsy moth is native to Eurasia, its range extending into North Africa and Japan. It has been introduced to North America. A number of geographical variants are recognised, in particular a distinction is commonly made between gypsy moth from Asia and gypsy moth from Europe and North America.	Native to North America and introduced to parts of Europe, Japan, Korea and China (European and Mediterranean Plant Protection Organization, 1979). Only the black-headed strain occurs in Asia and Europe, but both the black headed and red headed strains occur in the United States (Zhang, 1998).	Native to Australia (Riotte, 1979). The most common ports listed in freight schedules between Australia and New Zealand are ports in areas where it occurs.	Native to Japan, Korea, Taiwan, Russian Far East (Hoare, 2001; Hosking at al. 2002).
Association with the pathway	<p>-Populations occur in the vicinity of some exporting ports in Japan (R.Kleinpaste, pers.comm.);</p> <p>-females are strong fliers and can disperse up to 100km (Baranchikov and Sukachev, 1989; Savotikov et al. 1995) and are attracted to light (Savotikov et al. 1995);</p> <p>-eggs are laid on a variety of objects that are not host plants, including vehicles;</p> <p>-viable egg masses are intercepted on imported vehicles</p>	<p>-Vehicles are recorded in the overseas literature as a pathway for spread (Warren and Tadic, 1970);</p> <p>-DNA identification of 2 larvae and 1 egg mass from imported vehicles from Japan (K. Armstrong pers.comm. to Melanie Newfield, 2006);</p> <p>-later instar larvae can disperse up to 33 m (Warren, 1970). It is assumed that larvae could contaminate and pupate on vehicles used or stored within 40m of host</p>	<p>-There have been no interceptions on the vehicle pathway. However despite 6 post-border interceptions there have only been 2 border interceptions, one on a container and one on container packaging. It is clear that the species is getting through the border undetected, albeit infrequently;</p> <p>-there is evidence that late instar larvae can pupate on inanimate objects (Flynn, 1999; Harris, 1988). Imported vehicles have therefore been identified as a pathway for entry into New Zealand;</p>	<p>-There have been interception records of viable eggs from vehicles, the only commodity on which the species has been intercepted;</p> <p>-oviposition sites are limited by the immobility of the adult female and therefore depend on the site selected for pupation by the female larvae. The maximum crawling distance of larvae is not known;</p> <p>-there is seasonal dimorphism in pupation sites. Larvae that develop during short day conditions pupate on inanimate objects</p>

	Asian gypsy moth	Fall webworm	Painted apple moth	White spotted tussock moth
	each year.	plants.	-just under 9% total vehicle imports are from Australia.	and develop into flightless females which lay diapausing eggs (Kimura, 1977).
Likelihood of surviving shipment	<p>- Reported tolerances, survival times (up to 2 years) and interceptions of live egg masses indicate ability of eggs masses to survive transit conditions; (Sullivan and Wallace, 1972; Yocum et al. 1991).</p> <p>-direct sea transit times from AGM supporting export countries to NZ exceed maximum survival times for neonate larvae (Stockhoff, 1991);</p> <p>- only pupae that infest a vehicle just prior to shipping are likely to arrive in NZ.</p> <p>-transit times are close to the maximum survival times of adult moths.</p>	<p>- Eggs hatch in 5 to 23 days (Warren and Tadic, 1970). Larvae feed within the nest in the early instars (Warren and Tadic, 1970) so it is assumed that recent contamination by fresh foliage is necessary for their survival;</p> <p>-Pupation can occur on inanimate objects (Warren and Tadic, 1970) and pupae can be diapausing or non-diapausing. Diapausing pupae persist for several months.</p> <p>-ability to survive transit conditions is uncertain, but there are indications that temperatures outside the range 10°C to 35°C are unfavourable to development (Warren and Tadic, 1970);</p> <p>-Known to have arrived in NZ, so can survive some transit conditions but unclear on which pathway</p>	<p>-Pupal duration ranges from 6 to 19 days depending on sex and temperature (Charles et al. submitted; Gellatley, 1983; Phillips, 1992), This exceeds the shipment time from Australia.</p>	<p>-Diapausing eggs can persist for many months and are capable of surviving transit conditions.</p>
Risk factors	-A univoltine species, so contamination with egg masses occurs	-A multivoltine species with overlapping life stages and no	-Pupae are the most likely life stage to enter New Zealand (or immobile females	-Vehicles being used/stored outside close to host vegetation are most

	Asian gypsy moth	Fall webworm	Painted apple moth	White spotted tussock moth
	<p>only during the flight season (mid June to mid September in Japan depending on latitude), but a vehicle can arrive at the port with a viable egg mass at any time of year. Note: Most European gypsy moth females do not fly and are less likely to lay eggs on inanimate objects than Asian forms (Humble and Stewart, 1994; Roy et al. 1995). Contamination by these forms is likely to be late instar larvae crawling on to a vehicle and pupating and emerging females laying eggs;</p> <p>-contamination with egg masses depends on the storage location. There is a greater likelihood if a vehicle is stored outside under lighting than in a garage.</p> <p>- there are periodic outbreaks where population levels become very high (Savotikov et al. 1995). During such times there is a greater likelihood of introduction from the areas experiencing the outbreak.</p>	<p>clear risk period for contamination</p> <p>- larvae can crawl onto a vehicle stored within 40 metres of host foliage, and pupate (Warren and Tadic, 1970). Pupae occur in protected locations on a wide range of objects that are not host plants. They are camouflaged and are small (less than 1.5cm long). Use and storage conditions prior to export are a key risk factor;</p> <p>-diapausing pupae considered most likely life stage to arrive in NZ in a viable condition. This is expected to occur during the Northern Hemisphere autumn-spring</p> <p>-outbreaks have occurred. The likelihood of entry during such periods is increased</p> <p>- it has crossed the border (post-border interceptions) more frequently than it has been intercepted at the border.</p>	<p>sitting on the pupae they emerged from, or egg masses laid on pupae);</p> <p>- Larvae use a wide range of objects as pupation sites including sea containers, wooden fences and metal packaging;</p> <p>- vehicles only expected to be infested if stored close to host foliage. The exact distance that late instar larvae can crawl to pupate is not known but field observations suggest travel up to 70 metres is possible (Ian Gear, Pers. Comm. to Melanie Newfield, June 2006).</p>	<p>likely to be contaminated;</p> <p>-diapausing eggs are most likely to infest a vehicle in the northern hemisphere autumn, but could arrive in New Zealand any time between September to May.</p>
New vehicle pathway factors	contamination levels could be comparable to those of used vehicles if new	contamination possible if new vehicles stored within larval	contamination possible if new vehicles stored within larval crawling	contamination possible if new vehicles stored within larval crawling

	Asian gypsy moth	Fall webworm	Painted apple moth	White spotted tussock moth
	vehicles are stored outside during the flight season in an area with lights and host vegetation – but we don't know how frequently this would occur.	crawling distance of host foliage with moth populations.	distance of host foliage with moth populations.	distance of host foliage with moth populations.
Summary likelihood of entry	non negligible for entry of any life stage (larvae from hatching egg masses and adults emerging from pupae in transit) via both new and used vehicles and machinery. Highest for used vehicles and for egg masses.	non negligible for pupae on new and used vehicles and machinery.	non negligible for pupae/adult females/ egg masses on new and used vehicles and machinery.	non negligible for diapausing eggs masses on new and used vehicles and machinery.

Note that interception data suggest that used vehicles are the most likely of all the pathways investigated in the moth pest risk analysis for gypsy moth egg masses to arrive in New Zealand. The way that vehicles are stored combined with the volume of trade also supports this. Vehicles are also the only commodity on which fall webworm and white-spotted tussock moth have been intercepted. Imported used vehicles are likely to be one of the more important entry pathways for fall webworm, but there is insufficient data to make precise comparative statements. The likelihood of entry of painted apple moth is considered less likely on vehicles than on other pathways due to lower volumes on this pathway from Australia.

It is noteworthy that painted apple moth, fall webworm and white-spotted tussock moth all have similar modes of introduction, via late instar larvae crawling on to a vehicle looking for pupation sites. The life-stage that is transported is either the pupa or eggs laid by a female on emerging from the pupa. For these species, the critical factor in determining infestation is whether the vehicle is close enough to a population of larvae for them to crawl on to it and pupate.

It is not possible to estimate the frequency of contamination of imported vehicles with moths. Interception records are not routinely recorded (see Chapter 2 for limitations of these data). A maximum of 147 Asian gypsy moth interceptions were recorded on imported vehicles in 1999. There are more interception records for Asian gypsy moth on vehicles than of any other moth species, the maximum contamination level indicated by these figures is 0.11% or one vehicle out of 900 (Biosecurity New Zealand 2007). Since these figures include all Asian gypsy moth interceptions (live and dead and all life stages) the numbers of recorded viable gypsy moth egg masses arriving is less than this. The contamination rates for the other moth species assessed are likely to be considerably

lower than those for Asian gypsy moth (based on both the interceptions records and biology of the species – i.e. how it gets on to the vehicles). Actual levels of contamination for viable life stages for any one species are expected to fall in the range of 1 in 1 000 to 1 in 100 000 (Biosecurity New Zealand 2007).

Vehicle fumigation records do not routinely record the reason for fumigation and moths are virtually never mentioned. Fumigation records cannot therefore be used to give an indication of relative contamination rates for this hazard group.

The likelihood of exotic moths being transported to New Zealand from any particular country is dependent on a number of factors. The greater volume of imported vehicles (both new and used) from Japan will increase the likelihood of entry of species that occur in Japan. However there are high-consequence species in each of the main exporting countries. The likelihood of entry will also depend on the population levels of the species in the exporting country and whether there are high levels in areas used for vehicle storage.

10.2.1 Conclusion on entry assessment

Given that:

- several species of exotic Lepidoptera which occur in countries from which used vehicles and equipment are imported, occur in areas in which they are likely to be able to contaminate used vehicles and machinery;
- the species assessed above are able to survive shipment in at least some life stages;
- live life stages of three of the species assessed have been found on imported vehicles at the border and/or post-border;
- the proportion of cars contaminated with individual moth species is likely to be less than 1 percent but the number of imported vehicles is high;

it is concluded that **the likelihood of exotic moths entering New Zealand on the used vehicle and machinery pathway is non negligible.**

Contamination of new vehicles is possible if the vehicle is stored within larval crawling distance of host foliage supporting moth populations of *O. thyellina*, *T. anartoides*, and *H. cunea* and if are stored outside during the flight season in an area with lights and host vegetation for *L. dispar*. The **likelihood of entry via new vehicles is also considered to be non negligible.**

10.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

Table 3. Summary establishment assessment for four moth species not present in New Zealand but recorded in association with used vehicles/machinery. Based on Biosecurity New Zealand (2007).

	Asian gypsy moth	Fall web worm	Painted apple moth	White spotted tussock moth
Environmental suitability in New Zealand	<p>-A polyphagous species with multiple hosts (Humble and Stewart, 1994; Baranchikov and Sukachev, 1989). Gypsy moth from Japan is reported to have a more restricted host range, but does feed on conifers (Higashiura et al. 1999);</p> <p>-preferred hosts such as <i>Prunus</i>, <i>Quercus</i> and <i>Betula</i> species are common in both urban and rural environments, including close to major ports of entry. However hosts are patchily distributed and would not be in a suitable condition for feeding larvae all year round;</p> <p>-most regions of NZ are regarded as suitable, except the South Island west coast (Kay et al. 2002);</p> <p>-there was an incursion in Hamilton in 2003.</p>	<p>- has a very wide host range comprising hundreds of species in a wide range of families (Greenblatt et al. 1978; Warren and Tadic, 1970; Worth, 1994);</p> <p>-host species include New Zealand horticultural crops such as apple and genera widely used in amenity planting such as <i>Fraxinus</i> and <i>Acer</i>;</p> <p>-no distribution modelling available but geographic distribution overseas indicates a species with broad ecological tolerances;</p> <p>-there have been incursions in west Auckland in 2003 and 2005.</p>	<p>-a polyphagous species with a very broad host range. In New Zealand it is reported feeding on a number of species not previously recorded as hosts including native species (Flynn, 1999; Burnip et al. 2003);</p> <p>-on the basis of thermal requirements, it is considered capable of establishing throughout coastal areas of NZ. (Charles et al. submitted)</p> <p>-a population established in NZ in 1999 (Flynn, 1999);</p> <p>-there are no seasonal barriers to establishment.</p>	<p>- a polyphagous species with a wide host range including fruit trees, elm trees and willow (Hoare, 2001; Hosking et al. 2002). In the laboratory it has been reported feeding on radiata pine, larch and native beech (Ministry of Forestry unpublished reports).</p> <p>-there is limited information on the environmental tolerances, but it has a broad native distribution.</p> <p>-A population established in Auckland in 1996.</p>
Biological characteristics	<p>-More than 1000 eggs per egg mass (Humble and Stewart, 1994; Savotikov et al. 1995);</p> <p>- the proportion of eggs that hatch and synchronicity of hatching depends on a range of factors e.g.</p>	<p>- A bivoltine species, so there is likely to be more flexibility in the lifecycle to adjust to the season shift between hemispheres than for a univoltine species;</p>	<p>- Multiple pupae are necessary for a population to become established;</p> <p>-females are flightless (Gellatley, 1983;) so adults are more likely to find a mate if several individuals arrive at once as opposed to a</p>	<p>-Egg masses are reported to contain 400-600 eggs (Yokoyama and Kurosawa, 1933);</p> <p>-the trigger for breaking diapause is not understood, humidity may be important (Kimura</p>

	Asian gypsy moth	Fall web worm	Painted apple moth	White spotted tussock moth
	<p>chilling (Keena, 1996). Multiple egg masses have been intercepted on imported vehicles;</p> <p>- larvae disperse largely passively over distances of a few hundred metres or more rarely, to more than 1km (Conrad and McManus, 1981);</p> <p>-The combination of the way eggs respond to temperature inversion when transported to New Zealand and host availability may limit the ability to establish. Arrival too early in the NZ spring may mean eggs have had inadequate chilling to develop properly, whilst arrival late in the NZ autumn may mean that there is limited host material available;</p> <p>-the threshold population size for 50% establishment for European gypsy moth is reported to be 107 adult males (Liebhold and Bascompte, 2003) suggesting that it is a species which typically requires a large founder population;</p> <p>- the cumulative effect of repeated introductions of single life stages via a range of pathways is expected to increase the likelihood of establishment</p>	<p>-multiple pupae are necessary for a population to become established. Clumped arrivals will increase the likelihood of establishment;</p> <p>-has successfully colonised over a dozen new countries since 1940, but NZ is the first reported from the Southern Hemisphere.</p>	<p>number of introductions of single individuals.</p>	<p>and Masaki, 1977);</p> <p>-it is a bivoltine species and consequently there is likely to be more flexibility in the lifecycle to adjust to the season shift between hemispheres than with a univoltine species;</p>
Likelihood of transfer to a suitable	-once the eggs hatch on an imported vehicle, host species	-adults fly only a few hundred metres, but given	- host species are common and within the range that a larva can	-following hatching the larvae will need to disperse in order

	Asian gypsy moth	Fall web worm	Painted apple moth	White spotted tussock moth
environment	are highly likely to be within larval dispersal distance; establishing from other pathways.	the abundance of host species this may not be limiting.	balloon.	to locate a food plant. Although uncertain, it is assumed that 1 st instar larvae balloon and this would enable it to transfer from a vehicle to suitable habitat. Host species are likely to occur nearby.
Likelihood of establishment	non negligible has been able to establish	non negligible has been able to establish	non negligible has been able to establish	non negligible has been able to establish

Note that each of the species assessed above has established, albeit temporarily in New Zealand in recent years and been the subject of an incursion response. Prior to 1996, no species in the family Lymantriidae had established in New Zealand. These establishments cannot be linked definitively to the vehicle pathway, although it is one of the most likely pathways for entry and establishment (Biosecurity New Zealand 2007). In addition the bamboo moth *Artona marini* has become permanently established in New Zealand. The imported vehicle and machinery pathway has been identified as one of the most likely entry routes (Gill, 2000).

The likelihood of Asian gypsy moth establishment is lower than that for the other species because it typically only has one generation per year and its life cycle is strongly linked to seasonal changes.

While as a general rule it is considered that the larger the founder population size, the greater the likelihood of establishment, there is unlikely to be a precise threshold above which establishment is certain (Simberloff, 1989). Successful establishment of arthropods (from studies on the release of biocontrol agents) has been recorded from introduction of fewer than 20 individuals e.g. (Berggren, 2001; Hee et al. 2000; Simberloff, 1989). In terms of optimising gorse thrips (a biological control agent) releases, Memmott et al. (1998) suggested that a number of smaller introductions would be more likely to lead to successful establishment than a smaller number of larger introductions.

The rate at which exotic moth species would spread in New Zealand is uncertain as there is little information on even the main pest species outside their native range. However the human assisted means by which the species arrive in New Zealand are also pathways for domestic spread. None of these internal pathways have any biosecurity measures or restrictions on them.

A range of pathways have been identified for all the species assessed in MAF's moth pest risk analysis (Biosecurity New Zealand 2007); vehicles and machinery is not the only one. An important difference between the pathways is that following biosecurity clearance, vehicles can be sent anywhere in New Zealand. The likelihood of a population of moths that establishes from an imported vehicle/ machine becoming established in an area covered by an active surveillance programme is low. The chances of detecting a population while it is still eradicable are therefore reduced.

10.3.1 Conclusion on establishment assessment

Given that:

- imported vehicles and machinery can be taken to and used anywhere within New Zealand;
- all four species assessed, have a wide host range and New Zealand has a suitable climate for them;
- repeated arrivals of viable moth life-stages is expected to increase the likelihood of establishment;

it is concluded that the **likelihood of establishment of exotic species of moth and of Asian gypsy moth, fall webworm, painted apple moth and white spotted tussock moth in particular, in association with new and used imported vehicles and machinery is non negligible.**

10.4 CONSEQUENCE ASSESSMENT

Table 4. Summary consequence assessment for four moth species not present in New Zealand but recorded in association with used vehicles/machinery. Based on Biosecurity New Zealand (2007).

	Asian gypsy moth	fall webworm	Painted apple moth	white spotted tussock moth
Economic	- Present value costs estimate to range from \$62 million to \$393 million, in 2003 figures based on a non-eradicable population establishing (Harris Consulting, 2003).	-The economic costs of establishment are estimated to be in the range between \$29 million and \$127 million, with a midrange of \$55 million present value. Damage to horticultural crops (pipfruit, stonefruit, berryfruit) and amenity/garden plantings being the main cost. (Harris Consulting, 2003).	-The economic costs of establishment were estimated to be in the range of \$58 million to \$356 million over a 20 year period, present value in 2001/02 (Ministry of Agriculture and Forestry, 2002).	-The 1996 eradication programme was estimated to have a benefit of \$23.4 million based on impact on commercial forestry and amenity and ornamental trees (New Zealand Institute of Economic Research (Inc), 1997).
Direct	-Impacts most likely on urban gardens & amenity plantings; -some impacts on horticulture e.g. apple, peach, pear and berries, requiring a change in pest management regimes; -impacts on native beeches, <i>Nothofagus</i> spp. are considered unlikely-uncertain impact on other native species;	-Considered a pest species throughout its range, although in most cases it is considered more "locally damaging" than a major widespread pest; -impacts most likely on urban gardens & amenity plantings; -impacts on native flora are uncertain but in laboratory trials, larvae fed on a number of native	-The extent to which painted apple moth would feed on and become a pest of indigenous and commercially important species remains uncertain; -the hairs of painted apple moth are urticacious and cause skin irritation in sensitive individuals (Common, 1990)	- Impacts on commercial horticultural species such as apple, cherry, plum, pear and persimmon, requiring pest management programmes; -garden and amenity species are also likely to be affected, as a wide range of amenity species, including oak, elm, box elder and willow are known hosts.

	Asian gypsy moth	fall webworm	Painted apple moth	white spotted tussock moth
	<p>-defoliation of some minor forestry species such as larch, <i>Larix</i> spp.</p> <p>-caterpillars cause dermatitis in humans (Southcott, 1978).</p>	<p>species including <i>Nothofagus menziesii</i> and <i>Leptospermum scoparium</i> (Kay, 2004, Sept);</p> <p>-caterpillar hairs may cause dermatitis in humans.</p>		<p>Impacts may include control costs and replacement costs for damaged plants (New Zealand Institute of Economic Research (Inc), 1997);</p> <p>-caterpillar hairs may cause dermatitis in humans (Southcott, 1978).</p>
Indirect	<p>-Lymantriid moths are known to be significant pests and it is expected that some countries would impose market access restrictions if it were to be detected on exported NZ goods;</p> <p>-shelter belts being defoliated or acting as a reservoir for re-invasion of orchards;</p> <p>- human health and social impacts of control programmes</p>	<p>human health and social impacts of control programmes;</p> <p>-market access impacts are uncertain;</p>	<p>-Lymantriid moths are known to be significant pests and it is expected that some countries would impose market access restrictions if it were to be detected on exported NZ goods;</p> <p>- human health and social impacts of control programmes ;</p>	<p>- human health and social impacts of control programmes ;</p> <p>-market access impacts are uncertain.</p>
Consequence summary	<p>-A high consequence pest;</p> <p>- non negligible;</p> <p>- an incursion followed by successful eradication would also have significant consequences for NZ.</p>	<p>-A high consequence pest;</p> <p>- non negligible;</p> <p>- an incursion followed by successful eradication would also have significant consequences for NZ.</p>	<p>-A high consequence pest;</p> <p>- non negligible;</p> <p>- an incursion followed by successful eradication would also have significant consequences for NZ</p>	<p>-A little known species not reported anywhere outside its native range except NZ, so consequences are difficult to predict, but impacts on a wide range of economic, environmental, cultural and social values cannot be ruled out;</p> <p>-non negligible.</p>

Note: Impacts on native ecosystems and forestry, human health and market access were difficult to assign monetary values to and were excluded from the economic assessments.

Note that painted apple moth and white spotted tussock moth are poorly known species, so there is significant uncertainty about the consequences of establishment. Other than New Zealand these species have not been reported anywhere outside their native range. This

highlights the difficulty in predicting which other species associated with the vehicle pathway will become a pest if introduced to New Zealand.

There have been a number of exotic moth eradication programmes involving widespread aerial spraying in the Auckland area. Aside from the direct economic costs of these programmes, there have been associated human health and social concerns (Glare and Hoare, 2003). The public tolerance for further programmes of this nature in the future is likely to be limited.

10.4.1 Conclusion of consequence assessment

There are likely to be significant economic, environmental, human health and social consequences from the entry and establishment of a new species of Lepidoptera and of *L. dispar*, *O. thyellina*, *T. anartoides*, and *H. cunea* in particular in New Zealand. **The consequences are therefore non negligible.** Three of these species are considered high consequence hazards. White-spotted tussock moth is likely to be classified as a high consequence hazard although there is more uncertainty about this species when compared to the others in this analysis.

10.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of a new species of Lepidoptera and of *L. dispar*, *O. thyellina*, *T. anartoides*, and *H. cunea* in particular, associated with the used vehicle and equipment pathway is non negligible;
- at least 3 high consequence pest species in this hazard group with a strong association to the vehicle pathway have established and been eradicated from New Zealand in the recent past;
- the economic and social, human health and environmental consequences of establishment would be non negligible.

The risk is considered to be **non negligible** for **used** vehicles and machinery and risk management measures are justified.

The risk of entry for *L. dispar*, *O. thyellina*, *T. anartoides*, and *H. cunea* on **new** vehicles and machinery is **non negligible** and therefore the overall risk is considered non negligible and mitigation measures are justified.

Gum leaf skeletoniser, *Uraba lugens*, Nolidae, is another high consequence hazard that has been recorded from the pathway. Although this Australian species was not assessed in detail in the moth risk analysis, it appears to be similar to painted apple moth and fall webworm in that it infests items by late instar larvae crawling onto a commodity and pupating. Furthermore it has established twice in New Zealand, so is known to have crossed the border undetected more frequently than it has been detected at the border (Biosecurity New Zealand 2007). Furthermore, Lepidoptera in at least 36 additional taxa which are not present in New Zealand have been recorded from the vehicle pathway. Whilst they have not been subject to risk analysis, it can not be assumed that the risk associated with them is negligible. The nun moth, *Lymantria monacha*, Lymantriidae for example is known to be of high consequence. It is capable of feeding on both radiata pine and Douglas fir and is considered to be a serious threat to plantation forestry in New Zealand (Withers and Keena, 2001). *Lymantria monacha* has only once been intercepted at the border- a larva on a used vehicle from Japan which had

been collected as part of the Asian gypsy moth recording programme (Armstrong et al. 2003). Whether the paucity of interceptions means that nun moth seldom occurs on imported items or whether it reflects the fact that egg masses are smaller and less conspicuous and therefore less likely to be detected than gypsy moth egg masses is uncertain (Biosecurity New Zealand 2007).

10.6 RISK MANAGEMENT

Given the risk estimation for this hazard group, the risk management objective is to reduce to a negligible level the likelihood of exotic moths entering via the vehicle pathway and establishing in New Zealand.

10.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

10.7.1 Visual inspection:

A survey of 300 vehicles and machinery, using a videoscope to find contamination in parts of the vehicle not visible through routine visible inspections found that 51 percent of vehicles surveyed had contaminants that would not be visible during routine visual inspection (Biosecurity Monitoring Group, 2006). No moths were found, but this would not be expected given the low frequency of contamination of this hazard group and the small sample size. However the survey indicates that live organisms can enter New Zealand in parts of a vehicle not accessible to visual inspection. The used vehicle slippage survey of 541 vehicles found ten instances of Lepidoptera. Most could not be identified and were dead or of unrecorded viability, although one live specimen was of a species present in New Zealand (*Orocrambus flexuosellus*) (Wedde et al. 2006). This survey was not designed to detect low frequency contaminants such as those assessed above. Based on this sample size there is a 95 percent chance of detecting visible contamination affecting 1 in 182 used vehicles. Contaminants occurring less frequently than this in the general population of imported vehicles are less to have been detected (Wedde et al. 2006).

Whilst Asian gypsy moth egg masses are commonly found in locations such as tyre walls which can be readily inspected, they may also be deposited in more inaccessible locations. There have been at least two post-border records of egg masses being found at compliance checking centres, including one inside a bumper. The U.S. Army Environmental Hygiene Agency Entomological Sciences Division produces a regular Pest Management Bulletin. A 1994 Bulletin, explains that gypsy moth eggs masses and larvae are very difficult to find through visual inspection of privately owned vehicles and military trucks returning from Germany, because of the many hiding places associated with vehicles. Intensive inspections have generally not revealed gypsy moth egg masses, yet larvae have been found emerging from the cargo. The Bulletin recommends that high-risk gypsy moth cargo should be held for 10 days from the date of arrival or until the last date of expected local egg hatch, to mitigate the limitations of visual inspection (U.S. Army Environmental Hygiene Agency, 1994).

Several other high-risk moth species are likely to enter New Zealand as pupae. These are much less obvious than Asian gypsy moth egg masses and are more likely to be missed by visual inspection. The fact that there have been post-border interceptions but virtually no border interceptions highlights the limitations of visual inspection for species such as fall

webworm, which actively seeks out protected hidden sites. The single interception record (along with the assessment in Biosecurity New Zealand (2007)) suggests that fall webworm pupae are occurring on vehicles but are not being detected or recorded. This may be because pupae are more effectively camouflaged or in locations that cannot be visually inspected.

In conclusion, the current regime of visual inspection does not meet the risk management objective for moths.

10.7.2 Vacuuming

Since moths are predominantly external contaminants of vehicles, vacuuming is not considered an effective risk management measure.

10.7.3 Pressure wash

The efficacy of external cleaning against hidden moth eggs and pupae is unknown. In a trial of an automated container wash system, all 17 sterile painted apple moth egg masses attached to large steel brackets on the underside of a container were removed by the washing, but only 10 out of 15 of the egg masses on small brackets were removed (Dentener and Bradfield, 2002). It needs to be determined whether there are differences in efficacy in removing painted apple moth egg masses, which are typically laid on the cocoon, and Asian gypsy moth egg masses, which are laid directly onto the container surface. It is likely that provided a stream of water can be directed onto an egg mass it would be effectively removed. The uncertainty lies in the extent to which the more inaccessible parts of a vehicle are treated in this way.

An automated washing process has the potential to produce more consistent results more cheaply and is currently used to pre-clean vehicles prior to MAF Quarantine Service inspection at one facility in Japan (Toy and Glassey, 2006). Of 12 801 vehicles externally cleaned at this facility in Japan in the 13 months period from May 2005-May 2006, 1 709 (13 percent) were subsequently directed for decontamination for external contaminants (Jevic Ltd, unpublished data). None of these had life stages of Asian gypsy moth. However it is not known whether any of the treated vehicles had gypsy moth before they were subjected to automated washing and since there is considerable uncertainty around the actual infestation rate this cannot be taken as evidence that this method is effective against Asian gypsy moth.

10.7.4 Heat treatment

The unpublished results of small-scale laboratory trials indicate that diapausing eggs of both Asian and European gypsy moths were killed when exposed for as little as five minutes at 55°C. Temperatures lower than this were not tested (Hosking, 2001). Since diapausing life stages are typically the most resistant to adverse conditions, it is assumed that larvae and adults will also be killed by this regime.

Heat is used as a quarantine treatment against codling moth, *Cydia pomonella*. Even after exposure to thermal conditioning, 100 percent kill of 5th instar larvae (the most heat resistant life stage) was obtained after three minutes at 52°C (Yin et al. 2006). Both diapausing and non-diapausing larvae are killed by treatment at 50°C for five minutes or 52°C for two minutes (Wang et al. 2004), while treatment at 45°C for 45 minutes without thermal conditioning results in kill of all life stages (Neven, 2005). There is no reason to assume that other moth species will be significantly more heat tolerant than these species.

Heat treatment at a minimum core temperature of 55°C for 5 minutes is therefore considered likely to achieve the risk management objective for Lepidoptera.

10.7.5 Fumigation:

There is limited literature on the efficacy of structural fumigation against Lepidoptera. However, considerable work has been done on the efficacy of methyl bromide fumigation as a quarantine treatment on codling moth, *Cydia pomonella* life-stages on fruit. For example a concentration-time treatment of between 25 and 52 g.h/m³ at 21°C has been found to effect 100 percent mortality on 1 day old eggs (the most resistant life stage) on various fruit, and a quarantine treatment of 68+/- 3 g.h/m³ proposed (Yokoyama et al. 1990).

Methyl bromide is reported to kill fall webworm adults, larvae and pupae (Forestry Compendia, 2005), although treatment regimes are not specified.

The US army recommended fumigation treatment for gypsy moth on vehicles and other cargo is 40g/ m³ for 6 hours at 16-21°C, equivalent to 240 g.h/m³ (U.S. Army Environmental Hygiene Agency, 1994). The recommended rate for fumigation of commodities contaminated with *L. dispar* in Canada is 40g/ m³ for 4 hours (160 g.h/m³) at 16°C (Canadian Food Inspection Agency, 2000).

In conclusion, it is assumed that mandatory fumigation at the current vehicle fumigation rate of 48g/ m³ for 24 hours at 21°C is more than is required to kill even the most resistant moth life stages and would achieve the risk management objective.

MAF Quarantine Service procedures require a vehicle on which an Asian gypsy moth egg mass has been detected to be fumigated (MAF Quarantine Service, 2006). This is a recent requirement, but an appropriate one since the presence of an egg mass indicates that the vehicle has been stored in conditions suitable for egg laying. If one mass is found it is likely that others will also have been laid.

10.7.6 Targeted surveillance onshore:

A pheromone trapping surveillance system for *L. dispar* was established in 1993 in response to ships and cargo entering New Zealand from the Russian Far East, and expanded as a result of the increase in imported Japanese used cars, increase in the use of transitional facilities for containers and high number of *L. dispar* interceptions. The trap network is focussed around ports and specified high-risk sites such as de-vanning sites, container yards and imported car storage yards. In March 2003 a live male gypsy moth was caught in one of these traps in Hamilton (Ross, 2004). Whilst this programme is a valuable back-up measure and triggers an eradication response, it is not sufficient in itself to mitigate the risk associated with the vehicle pathway particularly since egg masses may be transported around the country beyond the limited range of the surveillance network. Furthermore the control programmes resulting from surveillance detections have significant costs.

10.7.7 Targeted information gathering

Apart from the country of origin, available information does not suggest that it is possible to narrow down which used vehicles are most likely to be infested. In the case of Asian gypsy moth, interception data cannot rule out any particular vehicle types particularly as it is use and storage conditions that affect the likelihood of infestation. For the other species, there are too few interceptions to draw any conclusions at all. However the biology indicates again that use and storage conditions are particularly important for species such as fall webworm and white-spotted tussock moth, which are only likely to infest vehicles stored within a comparatively short distance of a population. Use and storage information is not available for imported used

vehicles and is unlikely to become available. However an approach based around identifying which new vehicles are most likely to be infested and then either treating those or requiring system improvements that would reduce the likelihood of infestation is a feasible way to substantially lower the risk from new vehicles, since the storage conditions are more readily identified.

10.7.8 Offshore versus onshore risk management

Whilst there are no data on recontamination rates, given the strong flight ability of female Asian gypsy moths, their attraction to lights and propensity for laying eggs on inanimate objects there is a risk of recontamination of vehicles if there is a delay between inspection and treatment of vehicles offshore and loading on a vessel. The current regime requires external re-inspection of vehicles stored for more than 10 days (Ministry of Agriculture and Forestry, 2001) although this does not involve re-ramping, except during the Asian gypsy moth flight season. There is no evidence that re-contamination will only occur after a period of ten days. Indeed during the flight season recontamination may occur at any time. The flight season for Japan occurs during the period May to September, but will be narrower at any one port. There is some uncertainty about the likelihood of such newly laid eggs hatching in New Zealand without winter chilling. This warrants further investigation but since there is some evidence that they could hatch, the issue of re-contamination is sufficiently important to require additional mitigation measures.

Such measures might include the use of detector dogs to check off-shore inspected vehicles and new vehicles imported from high-risk locations during the flight season. Trials were conducted by the MAF Quarantine Dog Detector Programme a few years ago, which demonstrated that detector dogs are capable of detecting and indicating the presence of Asian gypsy moth. This would provide an efficient, targeted measure. However a number of operational issues arise when considering the use of dogs on the wharf and a pilot project is necessary to test the feasibility of using the dogs in a wharf situation. Alternative measures could include application of deterrents or insecticides to inspected/treated vehicles or preventing moths accessing inspected and treated vehicles, for instance by covering vehicles. Surveillance around vehicle facilities combined with predictive modelling using weather records could be used to precisely identify the flight period during which recontamination prevention measures are required. This approach has been trialled by one vehicle exporting company in Japan. The efficacy of a package of such measures is not known. It would be necessary to take account of uncertainty over the beginning and ends of the period when surveillance efficacy will be more uncertain.

For moth species which infest vehicles by late instar larvae crawling onto the vehicle and pupating, re-contamination will depend on the proximity of host vegetation to the stored vehicles. The width required for a buffer zone is largely unknown, but there is evidence that fall web worm larvae can crawl up to 40 metres and 1st instar larvae of painted apple moth crawl up to 70 metres.

If risk mitigation measures are undertaken onshore, egg masses could hatch and the first instar larvae disperse before the measures are undertaken. Given the proximity of host plants to ports of entry, such larvae could become established. For moth species entering in the pupal life stage, escape prior to treatment is less likely as it would involve an adult emerging from the pupa at the same time as another of the opposite sex. Time limits for treatment would be required to minimise the likelihood of escape.

In conclusion, there are no clear biological benefits for offshore treatment over onshore treatment for this hazard group. Whichever option is taken measures to prevent re-contamination offshore or escape prior to treatment onshore would be required.

10.8 RECOMMENDED MEASURES

- 1) Mandatory heat treatment at a minimum core temperature of 55°C for 5 minutes or fumigation 48g/ m³ for 24 hours at 21°C **and**
- 2) A systems approach to the management of imported new vehicles incorporating surveillance and appropriate storage yard maintenance measures should be investigated;

In addition, research is recommended to clarify key areas of uncertainty below:

- average and maximum distances that larvae of painted apple moth and fall webworm crawl seeking pupation sites (also expected to be useful information for a number of other Lepidoptera species);
- factors that influence pupation site selection for Lepidoptera and for painted apple moth and fall webworm in particular;
- effect of unusual temperature regimes on Asian gypsy moth hatching (also for other diapausing species, but particularly important for univoltine species).

An alternative package of measures comprising:

- visual inspection and fumigation/heat treatment where necessary; **and**
- additional measures to prevent re-contamination of offshore inspected vehicles including surveillance, buffer zones, and/or physical protection measures; **and**
- bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4); **and**
- continued targeted surveillance at high-risk sites within New Zealand would reduce the risk to a lower level than that associated with the current risk management regime but would not meet the risk management objective.

10.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- There are significant limitations in the interception data available. In particular, they cannot be taken to indicate true contamination rates. The clearest indicators of this are fall webworm and painted apple moth. Based on post-border records, it is possible to determine that fall webworm has entered New Zealand (i.e. crossed the border without being detected by any biosecurity measures) on a minimum of 5 or 6 separate occasions, but has never been detected at the border, although it has subsequently been identified

from specimens collected from imported used vehicles. Painted apple moth has entered New Zealand a minimum of 8 times and has been detected at the border once. Without the post-border detections, particularly the results of the trapping programmes, the interception data would suggest that there was no particular problem with arrivals of fall webworm or painted apple moth. Therefore significant caution needs to be exercised in interpreting the results of interception data for these species and similar species.

- The distance that exotic moth larvae such as fall webworm and painted apple moth, can crawl from host vegetation to pupation sites on vehicles is not known, nor are the factors that determine pupation site selection.
- The likelihood of contamination of new vehicles is unknown. It is the conditions in which the vehicles are stored and the length of time between manufacture and delivery to NZ which is likely to determine whether or not they are contaminated;
- The effects on viability of crossing to the southern hemisphere of univoltine species such as Asian gypsy moth are uncertain. Whilst there have been instances of egg masses hatching on arrival, these may have been laid the previous breeding season and have been subject to a northern hemisphere winter. A significant body of research is likely to be required to determine whether there are arrival periods during which the risk of establishment would be negligible.
- It is assumed that entry of moths into New Zealand across a range of pathways will increase the likelihood of establishment of exotic species;
- Whilst the economic consequences of the establishment and spread of several exotic moth species are understood the impacts on native flora and fauna and ecosystem processes are largely unknown.
- It is very difficult to establish the efficacy of visual inspection for hitchhiker organisms that are infrequent contaminants of vehicles and machinery such as fall webworm, but it is assumed that it will follow the same pattern as other organisms found during the videoscope survey.

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11 Centipedes and Millipedes (Myriapoda)

11.1 HAZARD IDENTIFICATION

11.1.1 Identity

Sub-phylum: Myriapoda

Taxonomic Group: Class: Chilopoda, Diplopoda; Order: Scolopendrida, Polydesmida, Geophilomorpha:

Name: Centipedes and Millipedes

11.1.2 Association with pathway

The myriapod interception records for the pathway are summarised in Table 1.

Table 1. Interception records of centipedes and millipedes between 1994 and April 2006 in association with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Order/family	Country of origin	Vehicle type	Life stage & viability (number of records)
<i>Scolopendra</i> sp.	Scolopendridae	Japan	used vehicle	dead post-border record (1)
unidentified	Schendylidae	Japan	used vehicle	dead adults (2)
unidentified	Polydesmida	Japan	used vehicle	dead adult (1)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Nonetheless, the paucity of records for such a visually notable class of organisms is noteworthy.

Worldwide, there are about 3 000 species of centipede. The New Zealand fauna of 39 species (including naturalised species) is small but reasonably diverse, being distributed among all five centipede orders. Two species in the Scolopendrid family are endemic to New Zealand. One of the introduced species is a house centipede, *Scutigera coleoptrata* (Johns, in press).

Centipedes spend the winter as adults in protected habitats and become active in the spring. During the warmer months, females generally lay eggs in soil and cover them with a sticky substance as protection, although some species give birth to living young. Immature stages (larvae) hatch from eggs several days later. Some centipedes are known to have lived up to six years.

Centipedes prefer to live in moist habitats in soil and leaf litter and during the day occur underneath rocks, logs and other objects in contact with the ground. They are active at night. Centipedes feed on insects and spiders and have very few predators. The largest species may feed on small vertebrates (Goddard, 2003). They kill by grasping prey with their powerful fangs and injecting venom. They can be nuisance pests. The bite is usually not medically threatening except to small children and individuals allergic to venoms.

There are more than 7 500 species of millipede worldwide. New Zealand has an extremely rich millipede fauna with 121 species identified to date, of which 13 are not native. Additional un-described species are known to exist (Johns, in press).

11.1.3 Conclusion

Given that centipedes and millipedes:

- are relatively large and conspicuous and yet are rarely reported to have been intercepted on the vehicle pathway;
- are unlikely to survive shipment from the main vehicle exporting countries, as adults in the absence of a food supply, or as eggs in soil contamination, (given the short incubation period).

They are **not considered to be a potential hazard** on the new or used vehicle or equipment pathway.

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12 Cockroaches (Blattoidea)

12.1 HAZARD IDENTIFICATION

12.1.1 Identity

Category: Insecta

Taxonomic Group: Order: Blattoidea; Family: Blattidae

Common name(s): Cockroaches

12.1.2 Introduction

There are some 4 000 species of cockroach in five families worldwide. Most inhabit the warm tropical regions. About 25 species have attained worldwide distribution due to accidental transport in commerce and their affinity for human habitation. Among these are most of the important pest species. Five species of cockroach occur in New Zealand, one of which, *Maoriblatta rufoterminalata*, has a patchy distribution associated with Kauri forest and is considered threatened (McGuinness, 2001).

The cockroach interception records for the pathway are summarised in Table 1. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Cockroach interception records between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Species	Common name	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Vehicle type	Life form and viability (number of records)
<i>Blatta germanica</i>	German cockroach	yes	Japan	used vehicle	> 50 live adults detected post-border; 3 additional interceptions of live adult females
<i>Periplaneta australasiae</i>	Australian cockroach	yes	Australia	campervan	live adult (1) post-border
<i>Periplaneta fuliginosa</i>	Smokey-brown cockroach	no	Japan	used vehicle	Nymph, unrecorded viability (1)
<i>Periplaneta americana</i>	American cockroach	yes (limited distribution)	Australia Singapore Japan Brazil	used vehicles machinery	all life stages intercepted at border, Life form and viability not recorded, Viable egg intercepted post-border Life form and viability not recorded post-border
<i>Periplaneta</i> sp.		unknown	Japan	used vehicle	Viable nymphs and eggs post-border behind vehicle panel
<i>Supella longipalpa</i>	Brown banded Cockroach	no	Singapore	used vehicle	Viable eggs & adult female (1) post-border
<i>Supella</i> sp.		unknown	Singapore	used vehicle	Eggs and live adult (1)

Species	Common name	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Vehicle type	Life form and viability (number of records)
Unidentified		unknown	Japan	used vehicle	post-border dead nymphs (2)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. At least 2 intercepted species are not present in New Zealand. 64 percent of intercepted cockroaches were viable, and 50 percent occurred post-border. The German and American cockroaches are already established in New Zealand, albeit with a limited distribution. Imported used vehicles are a pathway for spreading these to new areas of New Zealand.

12.1.3 Conclusion

Given that there are interception records for two species of cockroach, not currently found in New Zealand, and the impracticality of identifying individual specimens at the border, cockroaches are considered potential hazards. *Periplaneta fuliginosa* and *Supella longipalpa* are assessed as examples of this group of potential hazards.

12.2 ENTRY ASSESSMENT

12.2.1 Current Distribution

Periplaneta fuliginosa occurs in south-eastern United States, Japan, southeast Asia and Australia, (Appel and Smith, 2002). *Supella longipalpa* originates in Africa but is now widespread in warmer regions and in some parts of the temperate zone (Goddard, 2003, Hill, 1994). It occurs in the United States, Australia and Europe. Both species are found in close association with humans (Goddard, 2003).

12.2.2 Likelihood of association with the pathway

Periplaneta fuliginosa primarily lives outdoors and prefers woods, leaf litter and other humid sites with abundant organic matter. It also hides under rocks, ground cover and building materials. Populations build up outside homes and in garages from where it is often transported indoors. Both sexes fly and are attracted to lights (Appel and Smith, 2002).

Supella longipalpa is more likely to be found in buildings than outside. It prefers starchy foods and appears to have lower water requirements than other cockroaches.

The fertilized eggs of cockroaches are cemented together by the female in a sausage-shaped egg case known as an ootheca, containing from 16 to 32 eggs, depending on the species. Oothecae and adults have been found in cars and trucks in other countries (Appel and Smith, 2002, Waldron, 1972). Nymphs undergo gradual metamorphosis—that is, they grow and mature in six to eight instars, each separated by a moult of the exoskeleton.

An indication of the frequency of contamination by cockroaches is available from the treatment statistics for imported vehicles. Twenty five vehicles out of 68 600 vehicles (0.04 percent) imported into Auckland in car ships over the period 01/01/2004 and 30/09/2005 had cockroach recorded as the reason for requiring fumigation treatment. This figure is derived

from the inspectors recorded comments. These do not follow a prescribed format and the required treatment, but not necessarily the contaminant is recorded by MAF Quarantine Service officers for each imported vehicle.

This is likely to be an underestimate, since it assumes that all cockroaches are detected and recorded. In practice the reason for fumigation treatment is frequently not recorded. Furthermore, cockroaches are difficult to detect by visual inspection. They are sensitive to light and most species are largely nocturnal. The cerci, sensory structures extending from the rear of the abdomen, can sense minute air movements, enabling the cockroach to rapidly detect and flee from potential danger. The 2005 vehicle slippage survey found in cockroaches in more than 1 percent of surveyed vehicles which had already received biosecurity clearance (see 12.7.1).

12.2.3 Likelihood of surviving shipment to New Zealand

Adults and nymphs of *P. fuliginosa* are very dependent on moisture (Appel and Smith, 2002), requiring water every two to three days. They are therefore unlikely to survive shipment. The egg capsule contains an average of 17 eggs and is glued to a harbourage site. Nymphs hatch within 50 days. Mated females deposit an average of 19 oothecae of which about 60 percent are viable (Appel and Smith, 2002). It is assumed that eggs in an ootheca will be protected from environmental extremes encountered during shipment and are likely to survive the journey. This assumption is confirmed by the post-border interception record for viable eggs, although the proportion that survive is not known.

Supella longipalpa ootheca are glued to an object, usually in a dark crevice. The eggs hatch in around 70 days, depending on the temperature. Adults live about six months past the nymphal stage (Suiter, 2003). Given their omnivorous diet, adults are likely to be able to survive shipment provided there is a source of food in the vehicle. The oily cuticle protects them from dehydration and they can exist without a freestanding water source (Eggleston and Arruda, 2001). *Supella longipalpa* is thus likely to survive shipment either as an adult or as eggs protected in an ootheca.

It is assumed that new vehicles will not be contaminated with food and that any adult cockroach contaminants will not be able to survive shipment. Whilst ootheca could be laid on a new vehicle, the likelihood is considered to be negligible.

12.2.4 Conclusion on entry assessment

Given that:

- both *P. fuliginosa* and *S. longipalpa* are associated with buildings and human habitation;
- eggs of both species, and adults of *S. longipalpa* are likely to be able to survive shipment to New Zealand and viable adults and eggs have been intercepted on imported vehicles;
- the frequency of interception of cockroach species that are not already present in New Zealand is relatively low but likely to be considerably under-recorded.

It is concluded that the likelihood of *P. fuliginosa* and *S. longipalpa* entering New Zealand on the **used** vehicle and machinery pathway is **non negligible**.

The likelihood of entry of cockroaches on the **new** vehicle and machinery pathway is considered **negligible**.

12.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

12.3.1 Environmental suitability of New Zealand

Periplaneta fuliginosa tends to lose moisture through the cuticle more than other species of cockroach. Detailed studies of its spatial distribution in Florida have shown that populations are centred on moist, dark and warm locations free from the desiccating effects of airflow. The northern parts of New Zealand are likely to provide such habitat. Whilst it cannot survive freezing conditions, it can become established inside houses (Appel and Smith, 2002). It is prey to centipedes, spiders, frogs, lizards, ants and wasps. The oothecal parasite *Tetrastichus hagenowii* (Hymenoptera: Eulophidae) occurs in the USA and Japan and can affect a significant proportion of oothecae (Appel and Smith, 2002).

Supella longipalpa is mainly a temperate pest, thriving in heated buildings despite cold winters (Schal et al. 1984). It prefers temperatures over 27°C and temperatures below 24°C retard its development (Suiter, 2005). If *S. longipalpa* was introduced without the accompanying egg capsule parasite, *Comperia merceti* (Hymenoptera: Encyrtidae), it would have a greater likelihood of becoming established.

12.3.2 Biological characteristics

For *P. fuliginosa* to become established from ootheca entering New Zealand on a vehicle it would be necessary for the ootheca to be laid on the vehicle no longer than about a fortnight prior to shipment and for the vehicle to be transferred to a suitable location within New Zealand within a fortnight of arrival. The vehicle would need to be located sufficiently close to suitable habitat for the nymphs to reach it prior to desiccation on hatching. The likelihood of a sufficient number of nymphs surviving in these circumstances to establish a new population is considered negligible. The likelihood of *P. fuliginosa* establishing in New Zealand via the vehicle pathway is considered to be negligible.

Supella longipalpa has an average incubation period variously reported as 70 days (Suiter, 2005) and 40 days (Schal, 1984) and an average hatching of 13 young from an ootheca at 30°C, of which an average of 85 percent mature (Schal, 1984). Since the species is able to resist desiccation, they could survive and establish a population within a vehicle provided there is an adequate food supply. A mated female lives several months, producing an ootheca every 5-7 days (Schal, 1984; Smith and Schal, 1990). Thus a single mated female transferred to appropriate habitat shortly after arrival in New Zealand could establish a population. While as a general rule it is considered that the larger the founder population size, the greater the likelihood of establishment, there is unlikely to be a precise threshold above which establishment is certain (Simberloff, 1989). Successful establishment of arthropods (from studies on the release of biocontrol agents) has been recorded from introduction of fewer than 20 individuals e.g. (Berggren, 2001; Hee et al. 2000; Simberloff, 1989). In terms of optimising gorse thrips (a biological control agent) releases, (Mommott et al. 1998) suggested that a number of smaller introductions would be more likely to lead to successful establishment than a smaller number of larger introductions. Since in the case of *S. longipalpa*, the number of individuals surviving to maturity from any one release event is likely to be low, and the number of release events in any one area is likely to be very small, the overall likelihood of establishment is considered to be low.

A significant uncertainty in predicting the likelihood of establishment of a new species is the impact of predation, parasitisation and competition in a new environment and the consequences of this for the size of founder population necessary for establishment. However,

since natural cockroach predators such as lizards do not frequently occur in urban environments in New Zealand, they are unlikely to have a major effect on any newly established population.

12.3.3 Likelihood of transfer to suitable environment

Since it is likely that many imported used vehicles will be retained in an urban environment, the likelihood of *S. longipalpa* being transported to a built environment where conditions are suitable for establishment is high.

The rate at which exotic cockroaches would spread in New Zealand is uncertain. However the human assisted means by which the species arrive in New Zealand are also pathways for domestic spread. None of these pathways have any biosecurity measures or restrictions on them.

12.3.4 Conclusion on establishment assessment

Given that:

- used vehicles and machinery can be taken to and used anywhere within New Zealand;
- *Supella longipalpa* is an urban species which lives in protected environments which are often in close proximity to areas where vehicles are parked;
- Population restricting parasites may not be introduced with an ootheca;
- a single mated female could establish a population, but repeat introductions are likely to be necessary for the species to become established.

it is concluded that the likelihood of establishment of *S. longipalpa* in association with the **used** vehicle and machinery pathway is **non negligible**. The likelihood of *P. fuliginosa* becoming established is considered to be **negligible** because it is unlikely that an ootheca will survive sufficiently long for the contaminated vehicle to be transferred to a suitable location and for the hatching nymphs to relocate to a suitable habitat prior to desiccation. This species will not be considered further in this assessment.

12.4 CONSEQUENCE ASSESSMENT

Experience from responding to two new cockroach incursions in New Zealand in recent years has highlighted an absence of tools for adequate delimitation or survey. Their behaviour also makes them very difficult to detect, particularly when outside the built environment. These factors make successful eradication of cockroaches virtually impossible (S. Bissmire, pers.comm.).

12.4.1 Direct effects

Supella longipalpa can foul food, damage wallpaper and books, eat glue from furniture and produce an unpleasant odour (Baumholtz et al. 1997; Fischer et al. 2003). Cockroach excrement and cast skins contain a number of allergens to which sensitive people may exhibit allergic responses. Opinions differ regarding the role of cockroaches in disease transmission. However many disease-causing organisms have been found on the legs, other body parts, or faecal pellets of cockroaches (Goddard, 2003).

12.4.2 Indirect effects

Cockroaches are considered distasteful by many people and their presence in domestic situations can be distressing. Whilst exotic nuisance cockroaches have already established in New Zealand, their distribution is limited. Repeated introductions of new species or of species already present could result in significant social and health implications together with the associated costs of control.

The environmental impacts associated with the establishment of a new exotic species of cockroach are not known, but impacts of introduced cockroaches on native cockroaches have been reported from caves in Malaysia (C.Reed pers. comm. 2006) and impacts on the wider invertebrate fauna are possible.

Cockroaches are difficult to eradicate once they become established.

12.4.3 Conclusion of consequence assessment

The social and human health consequences of the entry and establishment of cockroaches such as *Supella longipalpa* in New Zealand is **non negligible**.

12.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of *S. longipalpa* in association with the used vehicle and machinery pathways is non negligible; and
- the social and possible human health consequences of establishment is non negligible.

The risk is considered to be **non negligible for used vehicles and machinery** and risk management measures are justified.

The risk associated with new vehicles and machinery is considered to be negligible.

12.6 RISK MANAGEMENT

The objective is to reduce to an acceptable level the likelihood of exotic cockroaches entering via the vehicle and machinery pathway and establishing in New Zealand.

12.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

12.7.1 Visual inspection

Cockroaches are difficult to detect by visual inspection. They are sensitive to light and most species are largely nocturnal. The cerci, sensory structures extending from the rear of the abdomen, can sense minute air movements, enabling the cockroach to rapidly detect and flee from potential danger. Given this and the small size of the egg capsule (five mm long) it is likely that visual inspection is not very effective. This is supported by the high proportion of post-border interception records (50 percent of all interception records).

No cockroaches were found during a survey of 300 vehicles using a videoscope to find contamination in parts of the vehicle not visible through routine visible inspections (Biosecurity Monitoring Group, 2006). This is not surprising given the small sample size. However, the survey found vehicles contaminated with spiders, which have similar secretive habits that were not detectable through standard inspection. The used vehicle slippage survey of 541 vehicles found six vehicles still contaminated with cockroaches after biosecurity clearance two of which were alive and the rest had an unrecorded viability (Wedde et al. 2006). In conclusion visual inspection has limited efficacy for this hazard group.

12.7.2 Vacuuming

Vacuuming is unlikely to remove any cockroaches located in inaccessible locations. However, pre-shipment removal of all potential cockroach food sources including food scraps and dead insects would reduce the likelihood of survival and therefore entry of any adult cockroaches or any nymphs that hatch from an ootheca during shipment. Visual inspection and fumigation where necessary, coupled with mandatory vacuuming offshore to remove all potential food resources would reduce the risk of entry of cockroaches.

12.7.3 Pressure wash

Pressure washing is unlikely to remove cockroaches or ootheca in inaccessible parts of a vehicle.

12.7.4 Heat treatment

The critical thermal maximum for the cockroach species assessed in this analysis is not known. A review of the heat tolerance of a range of insects concluded that desert ants have the highest critical thermal maximum (CTM) of up to 55°C for active life stages, depending on the species (Sherwood, 1996). It is assumed that this range applies to cockroaches. There is no indication that the eggs of cockroaches are any more resistant to heat than are adults. Treatment at a temperature of 46°C for 45 minutes in all harbourages, confirmed by data loggers, is reported to be effective in controlling cockroaches. In a large facility this takes 4 to 5 hours to achieve and requires air temperatures of up to 66°C (Williams et al. 2002). In experiments in a food plant dry mix area five adult *Blatella germanica* contained in plastic petri dishes were killed by treatment at 54.4°C for 24 hours, although the treatment time at which they died is not recorded (Heaps and Black, 1994). This study reported rapid movement of test cockroaches during the heating process indicating the need for rapid temperature ramping to avoid escape of pest organisms. *Blatella orientalis* has been found to be more tolerant than *B. germanica* or *Periplaneta americana* but in laboratory tests adults of all three species were killed by one hour's exposure to dry air at 46°C and 43°C in moist air (Gunn and Notley, 1936). It is assumed that treatment at a core temperature of 55°C for 10 minutes would kill cockroaches in vehicles.

12.7.5 Fumigation

Methyl bromide is generally considered to be effective against most insect pests. There are few studies of the effectiveness of fumigants on cockroaches. However, Searls et al. (1944) report treatment with methyl bromide at 20 pounds/1000 cu.ft. at 70°F (equivalent to 20 g/ m³ at 21°C) for 8 hrs to be effective against laboratory bred cockroaches, *B. germanica* in warehouses. This equates to a concentration time product of 160gh/ m³.

The current vehicle fumigation rate of 48g/ m³ for 24 hours or a concentration time product of 1152 gh/ m³ is more than is required to kill most arthropod and vertebrate contaminants including cockroaches.

12.7.6 Offshore versus onshore risk management

Whilst there are no data on recontamination rates, there is a risk of recontamination between treatment offshore and arrival in New Zealand. Many cockroaches are omnivorous and could feed on food scraps and dead insects associated with the vessel in transit (Weber, 1939). Contamination is less likely on a clean vehicle without food sources. Therefore offshore treatment is likely to be more effective than treatment on arrival in New Zealand.

12.8 RECOMMENDED MEASURES

It is not necessary to recommend measures to manage the risk from this hazard group because the measures recommended for the management of other hazard groups with high consequence pests are considered likely to be effective for cockroaches (see Chapter 35).

12.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised

below. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed.

- the frequency of entry of exotic cockroaches via the vehicle pathway is unknown. The data for this group of hazards are limited, the estimate of a minimum of 0.1 percent is assumed to be an underestimate;
- it is assumed that at least some ootheca can survive shipment to New Zealand, but the proportion that survive is not known;
- it is assumed that removal of all potential roach food sources including food scraps and dead insects from a vehicle prior to export would reduce the likelihood of survival and therefore of entry of exotic roaches;
- it is assumed that new vehicles will not be contaminated with ootheca or with food and that any adult cockroach contaminants will not be able to survive shipment;
- the likelihood of establishment of *S. longipalpa* outside protected environments in New Zealand is not known.

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13 Crickets and grasshoppers (Orthoptera)

13.1 HAZARD IDENTIFICATION

13.1.1 Identity

Category: Insects

Taxonomic Group: Order: Orthoptera

Name: Crickets and grasshoppers

The Orthoptera comprise 17 families and about 17 000 species (Hill, 1994). They are medium or large sized insects with strong biting mouthparts. The hind legs are usually enlarged for jumping and many species have specialized stridulatory and auditory organs.

13.1.2 Association with pathway

The orthopteran interception records for the pathway are summarised in Table 1. Status in New Zealand is specified as 'unknown' for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Orthopteran interception records between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin	Vehicle type	Life stage (number of records & viability)
<i>Acrida</i> sp.	Acrididae	no	Japan	used vehicle	live adult (1)
			Australia	used vehicle	dead adults (2) dead adult (1)
<i>Locusta migratoria</i>	Acrididae	no	Fiji	new machinery	live adult (1)
			unknown	used vehicle	dead adult (1)
<i>Pteronemobius</i> sp.	Gryllidae	no	Japan	used vehicle	live adult (1)
unidentified	Gryllidae	unknown	Japan	used vehicle	dead adult (2) live adult (1)
<i>Euconocephalus</i> sp.	Tettigoniidae	no	Japan	used vehicle	live adults (2)
<i>Conocephalus semivittatus</i>	Tettigoniidae	no	Japan	used vehicle	live female (1)
unidentified	Tettigoniidae	unknown	Japan	used vehicle	live adults (2)
unidentified	Rhaphidophoridae	unknown	Japan	used vehicle	live male (1 post-border)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. There are interception records for five genera in four different families. The majority of records are of live adults and are on vehicles imported from Japan.

Brief summaries of distribution, biology and pest potential of each family are set out below. Information is derived from (Hill, 1994).

Acrididae (short-horned grasshoppers and locusts): 9 000 species worldwide, predominantly in the warmer regions. They virtually all feed on grasses. As many as 500 species are regarded as important agricultural pests, and the locusts, *Locusta* spp. are of particular concern given their great fecundity and powers of population eruption. However the vast majority of species have a limited distribution. Eggs are usually laid in the soil in an egg pod or ootheca.

Gryllidae (crickets): 2 300 species. Crickets live underground or in leaf litter. Most species are detritivores, a few are herbivores. Eggs are usually laid underground in a nest.

Tettigoniidae (long-horned grasshoppers, bush crickets, katydids): 5 000 species, predominantly tropical and forest dwelling. Most species have a localised distribution. They generally oviposit in foliage in their forest habitat, using a swordlike ovipositor to cut a slit in a twig or leaf. Oviposition kills the twig which may then be more likely to fall off the tree.

Rhaphidophoridae (cave crickets, cave wetas, camel crickets): Cave wetas are restricted to Australia and New Zealand but cave crickets and camel crickets have a more cosmopolitan distribution. The adult cave dwellers are wingless and are generally scavengers or herbivores. The appendages are very elongated.

13.1.3 Conclusion

Given that:

- the association of Orthoptera with the vehicle pathway is most likely to be either as adults or in soil which is commonly found in imported vehicles;
- some of the genera intercepted from the vehicle pathway occur in vehicle exporting countries, but not in New Zealand;
- there is uncertainty about the consequences of establishment of new Orthoptera in New Zealand.

It is concluded that **Orthoptera are potential hazards on the used vehicle and machinery pathway**. Given the association of eggs of many Orthoptera with soil, it is assumed that the measures recommended for the management of other hazards associated with soil contaminants of vehicle will adequately mitigate any risk associated with eggs. It is assumed that risk management measures suitable for the treatment of cockroaches will also be effective against adult Orthoptera. Additional analysis is therefore not required.

The likelihood of new exotic species of Orthoptera entering New Zealand via the **new** vehicle pathway is considered to be **negligible** and risk management measures are not justified.

13.2 REFERENCES

Hill, D S (1994) *Agricultural entomology*. Timber Press; Portland, Oregon.

Scott, R R; Emberson, R M (1999) *Handbook of New Zealand Insect Names. Common and Scientific Names for Insects and Allied Organisms*. Bulletin of the Entomological Society of New Zealand.

14 Dermestid Beetles

14.1 HAZARD IDENTIFICATION

14.1.1 Identity

Category: Insecta

Taxonomic Group: Coleoptera: Dermestidae

Common names: carpet beetles, warehouse or cabinet beetles and hide beetles

14.1.2 Introduction

There are some 700 species of dermestid beetles worldwide. In the wild they are scavengers, feeding on dead animal remains, but many species are now urban pests (Hill, 1994).

Table 1 summarises the dermestid beetle interception records associated with the vehicle pathway. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus and some but not all the species in that genus are present in New Zealand.

Table 1 Dermestid beetle interception records between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Present in New Zealand (Scott and Emberson, 1999)	Country of origin and vehicle type	Life stage (number of records) & viability
<i>Anthrenocerus australis</i> , Australian carpet beetle	yes, not native	Australia USA Unknown Used vehicles	live larvae (2) live larvae (1) dead larvae (1)
<i>Anthrenus coloratus</i>	no, occurs in South east Europe, north Africa, USA, India	Japan Vehicle	adult (1) viability not recorded
<i>Anthrenus museorum</i> , museum beetle	no occurs in holarctic region	Japan used vehicle	live larva (1)
<i>Anthrenus sp.</i>	unknown	Japan used vehicle	live larvae (2) dead larvae (2) adult unrecorded viability (1)
<i>Anthrenus verbasci</i> , variegated carpet beetle	yes, not native	Japan unknown used vehicles	live larvae (17) larvae unknown viability (1) live larvae (1)
<i>Attagenus brunneus</i>	no occurs in Eastern Europe, Mediterranean, Caucasus	Japan used vehicles	live larvae (4) live adult male (1) unrecorded life stage & viability (1)
<i>Attagenus fasciatus</i> , wardrobe beetle	no	Japan used vehicle	cast larval skin (1)
<i>Attagenus pello</i> , fur beetle	yes	Japan used ute	live larva (1)
<i>Attagenus unicolor</i> , black carpet beetle	no	Japan used vehicle used truck used van	live larva (8) pupae (2) viability unrecorded live adults (4) cast larval skins (3)

Organism	Present in New Zealand (Scott and Emberson, 1999)	Country of origin and vehicle type	Life stage (number of records) & viability
<i>Attagenus unicolor japonicus</i>	no	Japan used vehicle used truck used van	live larvae (14) dead pupae (2) live adults (1) cast larval skins (1)
<i>Attagenus</i> sp. carpet beetles	unknown	Japan Singapore USA used vehicles	live larvae (20) dead larvae (1) pupae (1) viability not recorded live adults (1) Adults (4) viability not recorded cast larval skins (1)
<i>Dermestes maculatus</i> , hide beetle	yes	Japan used vehicles	live larvae (2)
<i>Dermestes murinus</i>	no	Japan used vehicles	live larva (1)
<i>Trogoderma granarium</i> , khapra beetle	no	Japan used vehicle	live larvae & pupae (1)
<i>Trogoderma inclusum</i> , larger cabinet beetle	no	Japan used vehicles	live larvae (2) cast larval skins (1)
<i>Trogoderma variabile</i> , warehouse beetle	no	Japan used vehicles used trucks	live larvae (14) dead larvae (1)
<i>Trogoderma</i> sp.	unknown	Japan USA used vehicles used bus	live larvae (15) dead larvae (1) larvae unknown viability (3) cast skins (1)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Virtually all the interception records are associated with vehicles from Japan and the majority involve live larvae. *Attagenus* spp., carpet beetles, are the most common of the identified interceptions. Dermestid beetles are recorded in the interception databases more frequently than most other group of contaminants. Dermestid beetles are well known pest species and are easily identified as a group from cast larval skins (exuviae). It is more likely that they will be recorded than other, less well-known, contaminants. In addition there were two periods, between 1998 and 2000 and between June 2004 and April 2005, during which all dermestid interceptions from vehicles arriving on car ships at Auckland wharf were sent for identification and recorded.

Khapra beetle, *T. granarium* is listed as one of the most important pests of stored materials in the global invasive species database (<http://www.issg.org/database/welcome/>). It is not present in New Zealand. There is only one interception record for Khapra beetle associated with imported vehicles and machinery. Laboratory microscopic identification is required to distinguish between *Trogoderma* species. It is possible that some of the interception records for *Trogoderma* spp. were actually *T. granarium*. Border interception specimens that have not been identified to species level are generally only retained by the MAF identification laboratories for three months. Four retained *Trogoderma* spp. specimens were re-examined in November 2005 and although they could not be identified to species level it was confirmed that they are not *T. granarium* (A.Flynn pers. comm.). Despite the paucity of identified

interceptions of this species, imported agricultural equipment has been identified as a high-risk pathway for this species in New Zealand in an earlier pest risk analysis Martin (2002).

14.1.3 Conclusion

Anthrenocerus australis, *Anthrenus verbasci* and *Dermestes maculatus* are present in New Zealand. They are not known to vector other potential hazards, are not under official control, are not geographically bounded or known to be associated with a different host in New Zealand. They are not considered to be potential hazards, but are not readily distinguishable from other dermestid species at the border. Given that there are interception records for seven species of dermestid beetle not currently found in New Zealand, associated with imported vehicles and equipment, and the impracticality of identifying individual species at the border, all dermestid beetles are considered potential hazards.

T. granarium, a species of clear biosecurity concern, is one of the more difficult organisms of its type to control and will be considered in the risk assessment below as an example of this group of potential hazards. *T. granarium* is the subject of a number of pest risk assessments, notably (Martin, 2002). This assessment summarises the information in these earlier assessments.

14.2 ENTRY ASSESSMENT

14.2.1 Current Distribution

Many of the dermestid beetles originate in Europe, but now have a more cosmopolitan distribution and are found in many of the vehicle exporting countries. *T. granarium* is believed to have originated in India. It is prevalent in parts of the Middle East, Africa, South Asia and Korea. It occurs in protected environments in Japan (Sonda, 1968) and parts of Europe. It does not appear to be established in Australia, South-east Asia, or South America and has been eradicated from the USA (Martin, 2002).

14.2.2 Association with the pathway

It is assumed that dermestid beetles can enter used vehicles and machinery through open windows, or in association with contaminated grain, and lay eggs in them. This is supported by the relatively high number of interception records. MAF Quarantine Service procedures draw attention to known risk areas where dermestid beetles have been intercepted in the past, namely the boot, and beneath mats and seats, particularly in buses and trucks (MAF Quarantine Service, 2006). Since dermestid beetles are internal contaminants of vehicles, and since it is unlikely that new vehicles or machinery will be stored with their windows open, it is unlikely that new vehicles would be infested.

Adult *T. granarium* live only a few days, and do not feed or require water. They have the potential to lay eggs within a vehicle particularly if a population is established in grain contaminated with eggs or larvae, spilt within the vehicle. Khapra beetle larvae will feed on most dried plant or animal matter, but prefer seeds, grains, flour, noodles etc. They can feed on products with as little as 2 percent moisture content (Martin, 2002). Diapausing larvae hide in cracks and crevices and can remain dormant for several years. Adult beetles cannot fly, so contamination of the pathway is by crawling adults and/or larvae, or by infested products transported in the vehicle. It is not known what distance *T. granarium* adults and larvae can crawl. It is assumed that any vehicle can become infested if used or stored near sources of

beetle larvae, and that the likelihood is much higher for agricultural equipment and vehicles transporting infested products.

In contrast, adult carpet beetles feed outdoors on pollen and nectar. They are able to fly and migrate indoors, attracted by lights, to lay eggs about a week after emergence. Eggs hatch within about 2 weeks in warm weather. The larvae feed on fabrics, grains etc depending on the species. The larval stage can last between 2 months and 2 years (Lyon, 2000).

An indication of the likelihood of entry of dermestid beetles on used vehicles and machinery is provided by:

Sample contaminant recording

MAF Quarantine Service officers recorded contaminants by hazard group on inspected vehicles during the period 12-20 March 2006. Any evidence of infestation by dermestid beetles including live or dead adults, larvae or pupae and cast larval skins were recorded (Table 2).

Table 2. Evidence of dermestid infestation in imported vehicles 12-20 March 2006 (MAF unpublished data)

Place of inspection	Number of Vehicles inspected internally	Vehicles cleaned prior to inspection	Vehicles with evidence of dermestid beetle contamination (including larval exuviae)	Vehicles with live dermestid life stages
Japan	2137	96% of internally inspected vehicles	21 (0.98 %) of internally inspected vehicles	4
New Zealand	1469	0	38 (2.6%) internally inspected vehicles	11

Table 2 suggests that cleaning vehicles prior to biosecurity inspection removes evidence of dermestid beetle contamination. All instances of dermestid contamination were found inside vehicles. The inside of the bonnet and the boot are included within this definition.

Since none of the vehicles that were inspected in New Zealand were subject to cleaning prior to inspection, the contamination rates for vehicles inspected in New Zealand (2.6 percent) are likely to reflect rates in the absence of management. Note that this survey was a brief snapshot and there may be differences in levels of contamination during different seasons, which are not reflected in these figures. Records from all the Terminal Receiving Facilities in Japan have been amalgamated, as have the records from all ports of entry into New Zealand. It is assumed that there are no significant differences in contamination rates or detection rates between facilities and ports and that there is a reliable association between larval skins and live life-stages.

Note that only four items of machinery were included in the survey.

Recent fumigation records.

A total of 2 147 or 3.1 percent of 68 600 used vehicles imported through the port of Auckland break-bulk in carships during the period 01/01/2004 to 30/09/2005 required fumigation for dermestid beetles. Identification of dermestid beetles to family or genus is relatively easy and can be done by inspectors in the field, although identification to species level can not.

Vehicles are sent for fumigation if any evidence of dermestid beetles is found, including spent larval skins which are one of the more obvious signs of infestation (MAF Quarantine Service, 2006). These figures are derived from the comments fields for vehicles requiring fumigation and 'other treatment' and probably represent a minimum since the required treatment, but not necessarily the contaminant is recorded by MAF quarantine inspectors for each imported vehicle. It is not known what proportion of vehicles contaminated with spent dermestid larval skins are actually contaminated with viable life stages.

Dermestid recording

During the period June 2004 to April 2005, Quarantine inspectors sent all dermestids intercepted on vehicles arriving in Auckland for identification. There were 52 recorded interceptions during this period. This is a surprisingly low figure which may be explained by the fact that only whole organisms were sent for identification, whereas empty larval skins were not. They are however, taken as evidence of the potential for viable eggs to be present and these vehicles are sent for fumigation.

There remains considerable uncertainty around the specific identity of the beetles intercepted and whether they are actually regulated pests. In a small-scale investigation, microscopic identification of 60 specimens from used vehicles imported from Japan in 2006 revealed that 57 (95 percent) of specimens were *Anthrenus verbasci* which is already widespread in New Zealand (R. Kleinpaste, pers. comm.).

14.2.3 Likelihood of surviving shipment to New Zealand

Since live adult dermestid beetles and larvae have been intercepted at the border, it is clear that dermestid beetles have the potential to survive shipment to New Zealand. The adults of most species live from nine months to three years. The larval stage may last from three months to two years and the pupal stage may last from six to 24 days. Eggs hatch within six to ten days. Thus any of the life stages may be present on entry into New Zealand.

As adult *T. granarium* only live a few days they will not survive shipment to New Zealand. Eggs laid in a vehicle prior to shipment are likely to hatch before arrival in New Zealand. Since larvae can hide in crevices away from food sources and have facultative diapause, they can survive for up to six years in this condition through wide temperature variations (Martin, 2002). Diapause is induced by low temperatures and the accumulation of faecal pellets in the food (Burgess, 1961). A population can therefore become established within a vehicle, provided there is a food supply, and the full range of life stages could be present at any given time.

14.2.4 Conclusion on entry assessment

Given that:

- Dermestid beetles and *T. granarium* in particular occur in countries from which used vehicles and equipment are imported;
- Dermestid beetles are urban pests and are thus likely to be in a position to contaminate vehicles;
- larvae are resilient and able to enter facultative diapause and live life stages of dermestid beetles have been intercepted on imported vehicles;
- the proportion of cars contaminated with dermestid beetles is likely to be higher than those with other hazard groups (between 2 and 4 percent);

it is concluded that the likelihood of dermestid beetles in general entering New Zealand on the **used** vehicle and equipment pathway is **non negligible** and relatively high. However there is considerable uncertainty over the proportion of beetles that are regulated pests. Used agricultural machinery and trucks used for transporting stored products are much more likely to be infested with *T. granarium* than other types of vehicle due to the nature of their use and likely storage locations. There is no information on the volume of such imports but since approximately 600 used trucks were imported during 2005 (MAF unpublished data from Quancargo database) it is expected to be relatively low.

Dermestid beetles are internal contaminants of vehicles and are not likely to infest new vehicles. The likelihood of entry via **new vehicles** is considered to be **negligible**.

It is noteworthy that imported seeds for sowing and imported grain are also significant pathways for entry of dermestid beetles into New Zealand.

14.3 ESTABLISHMENT ASSESSMENT

14.3.1 Environmental suitability of New Zealand

Little information is available on the environmental tolerances of carpet beetles. Since they occur in a wide range of countries, including those with a temperate climate and breed in protected environments, it is likely that they would be able to establish within New Zealand, at least within protected environments. Several species within the group including *Anthrenocerus australis* and *Anthrenus verbasci* have already established and become widespread within New Zealand.

Optimum conditions for breeding of *Trogoderma variabile* occur at 32.2° C and 50 percent relative humidity (Partida and Strong, 1975). There has been an incursion of *T. variabile* in a stored product warehouse at Levin. The incursion took five years to eradicate (Wong, undated). The infestation is believed to have come from imported seed. This incident demonstrates the potential for survival in New Zealand within buildings.

Conditions for establishment of *T. granarium* are similar to those for *T. variabile* and have been defined as a mean monthly temperature of over 20° C and a mean relative humidity less than 50 percent for at least four consecutive months. At 32° C egg viability averages 94 percent and an average of 93 viable eggs are laid per female (Banks, 1977). Since no part of New Zealand regularly meets these climatic conditions (NIWA Science, 2006), it is unlikely that *T. granarium* would establish in New Zealand. However, grain stores and some places that process food have higher temperatures and drier conditions than the external ambient environment and could provide suitable conditions for khapra beetle to breed. For example, it survived for many years in UK malt houses. It has also established in some areas of unfavourable climate, in protected environments, for example in Western Europe and Japan (Sonda, 1968). Unlike most other dermestids, *T. granarium* prefers whole grain and cereal products to substances of animal origin but may feed on substances such as dried milk (Lindgren et al. 1955).

There are many insect pests of stored products in New Zealand, including *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae), *Sitophilus granaries* (L.) and *S. oryzae* (L.) (Coleoptera: Curculionidae). The rate of increase of khapra beetle populations at 33-37°C is about 12.5 times per month. This compares with 20 times at 32-35°C (minimum RH 30

percent) for *R. dominica* and 25 times at 27-31°C (minimum RH 50 percent) for *S. oryzae*, principal competitors of the khapra beetle. It is believed that at high humidity khapra beetles cannot compete against other insects feeding on stored products, whereas the species has a competitive edge in dry to very dry conditions (Martin, 2002).

Several parasitoids, predators and pathogens of khapra beetle are known. It cannot be assumed that these would be transferred to New Zealand with the beetle and the effect of these on the likelihood of it establishing in New Zealand is not known.

14.3.2 Biological characteristics

Carpet beetles undergo complete metamorphosis, passing through the egg, larva, pupa, and adult stages. This cycle requires two months to two years depending on the temperature and species. Females lay between 20 and 100 small eggs which hatch in 8 to 15 days, depending on the temperature. Eggs are deposited in lint, cracks, and other areas near larval food supply where they are rarely seen. The larvae avoid light and curl up into a ball when disturbed. They can survive up to two years and will hibernate through the winter. The length of the larval life depends upon humidity, temperature and quality of diet. During this time they generally moult at least 6 times, but the longer they persist the more moults occur. Cast larval skins are often seen on infested fabrics and can easily be mistaken for living larvae. Pupation occurs in the last larval skin after the majority of larval feeding and growth occurs. The pupal stage lasts six to twenty four days. Adult carpet beetles feed outdoors on pollen and nectar, migrating indoors to lay eggs about a week after emergence. Usually there are three to four generations per year except for the black carpet beetle that may have one generation per year (Lyon, 2000).

Under optimum conditions of 37°C and 25 percent relative humidity, the life cycle of *T. granarium* can be completed in as little as three weeks (Hill, 1994). The life cycle of *T. granarium* is sufficiently flexible to enable the beetle to thrive if transferred to suitable conditions (Martin, 2002).

14.3.3 Likelihood of transfer to suitable environment

Likelihood of transfer to a suitable environment is influenced by where infested vehicles go within New Zealand and the availability of food sources in those areas. Transfer is likely if the infested vehicles are used or stored in a place with suitable foods. In the case of carpet beetles this could be wide ranging and since the adults fly, provided they are not trapped in a vehicle, transfer would be relatively easy. The likelihood of transfer is unlikely to be affected by time of year or geographic location. Unlike the other dermestids, adult *T. granarium* do not fly and although the larvae are quite active, dispersal is only likely by transfer of infested materials from the vehicle to a new appropriate environment, for instance through vehicle sweepings being disposed of on the ground in the proximity of a warehouse. Movement of infested materials has been identified as one of the main dispersal mechanisms for this species (Lindgren et al. 1955).

T. granarium has not established in Australia although trade between Australia and countries such as India where the beetle is commonplace has been carried out without rigorous quarantine measures for many years. It has been suggested that it has been introduced into Australia but not established possibly due to climatic factors, and particularly high relative humidity at the ports (Banks, 1977). It is possible that this may also have been the case in New Zealand.

14.3.4 Conclusion on establishment assessment

Given that:

- used vehicles and equipment can be taken to and used anywhere within New Zealand;
- the habit of larval facultative diapause would enable *T. granarium* to survive until transferred to a suitable environment;
- Carpet beetles, other than *T. granarium* have a wide range of food sources and are likely to be able to survive at least within protected environments in New Zealand;
- Dermestid beetles have the potential for multiple generations in a year;
- the likelihood of transfer of *T. granarium* from an infested vehicle to a suitable environment is low.

And taking account of the uncertainty of the effect of any competitor species or predators already present in New Zealand, it is concluded that the likelihood of establishment of a new species of dermestid beetle in protected environments in association with the **used** vehicle and machinery pathway is relatively low but **non negligible**. The likelihood of establishment of *T. granarium* is considered to be negligible except in association with used agricultural machinery and trucks as these are the only types of vehicle likely to be transferred to locations suitable for its establishment in New Zealand.

14.4 CONSEQUENCE ASSESSMENT

The majority of the dermestid beetles have little economic importance, but identification of the most important stored product pest, *T. granarium* is difficult and needs experience with the family. Most specimens collected are in larval form and need special preparation to enable examination through a compound microscope. Adult specimens are usually scarce and damaged therefore the genitals usually need to be dissected and examined (Banks, 1994).

14.4.1 Direct effects

The larvae of carpet beetles are considered to be general feeders but economic damage primarily occurs on household fabrics containing keratin. They are known to eat large, irregular holes through any acceptable food material. They prefer to feed on the surface of wool products while hairs are cut at the base of furs leaving bare spots on the hide. On most fabrics the nap is usually consumed leaving the base threads intact. Damage caused as a result of carpet beetle infestations render most fabrics aesthetically unappealing and useless.

Additionally, carpet beetles may be a pest of stored products if they invade containers of cereals, nuts, and stored grain. Given the wider host range of *T. variabile* compared with *T. granarium*, their establishment would be likely to have consequences for other industries such as the milk powder industry.

Dried insect specimens, such as those found in insect collections, are also devoured.

People in close association with black carpet beetles and *Trogoderma* spp. may suffer allergic reactions as a result of exposure to beetle fragments, cast skins, or dust (Cuesta-Herranz et al. 1997).

T. granarium larvae feed on seeds and grain, destroying them and lowering the quality of remaining grain by making it unpalatable or unmarketable. Beetle feeding can also reduce levels of several nutrients in the grain. Similarly the beetle can damage a wide range of other

dry vegetable products including processed foods. The beetle is most damaging in hot dry climates or equivalent conditions inside buildings (Martin, 2002). It is considered one of the most important stored product pests worldwide and is listed on the global invasive species database. <http://www.issg.org/database/species>. Once established it is very difficult to eradicate.

There are no known environmental impacts, since dermestid beetles are not likely to establish in the external environment.

14.4.2 Indirect effects

The discovery of *T. granarium* in New Zealand would indirectly affect exports of grain, processed grain and food due to quarantine restrictions from countries without the pest. The presence of the beetle may also restrict the movement of potentially affected items within New Zealand during attempts to prevent its spread and possible eradication attempts. Buildings that are or could be affected would require additional monitoring, disinfestations and hygiene procedures.

14.4.3 Conclusion of consequence assessment

There are likely to be significant economic, and possible human health consequences from the entry and establishment of *T. granarium* into New Zealand. The consequences are therefore **non negligible**. *T. granarium* is considered a high consequence pest. The economic and social consequences arising from the introduction of other Dermestid species into New Zealand are less severe. Two species are already present in New Zealand.

14.5 RISK ESTIMATION

Given that:

- the likelihood of entry into New Zealand and establishment within protected environments of an exotic dermestid beetle in association with imported vehicles and machinery is non negligible; and
- the economic and possible human health consequences of establishment of would be non negligible.

The risk is considered to be **non negligible** for **used** vehicles and machinery and risk management measures are justified. The likelihood of entry and establishment is lower for *T. granarium* than for other dermestid beetles and is restricted to trucks and agricultural machinery which have been used for transporting stored products. This species is much more likely to enter New Zealand via imported stored products. The consequences of establishment of *T. granarium* would however be high, whilst they are likely to be low for other dermestid beetles. The difficulty is that it is not possible to distinguish *T. granarium* from other dermestid beetles at the border.

The risk of entry for **new** vehicles and machinery for dermestid beetles is **negligible** and therefore the overall risk is negligible and mitigation measures are not justified.

14.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of dermestid beetles entering on imported used vehicles and machinery and establishing in New Zealand.

14.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in chapter 4 are summarised below.

14.7.1 Visual inspection

Dermestid eggs are very small, less than 1/64 inch (equivalent to 0.04 cm) in length (Lindgren, 1955) and would probably not be detected by visual inspection. Whilst the journey times from the main vehicle exporting countries are longer than the average hatching time for eggs, they could be present if laid during the journey and if they hatched the larvae could be hiding in crevices and not yet have moulted to leave an indicative cast skin. Cast larval skins are fairly obvious and under current procedures, any vehicle that has signs of infestation by Dermestidae including cast larval skins is fumigated. Contaminants are not routinely identified to species level, and fumigation is a precautionary measure against the more serious dermestid pests.

The used vehicle slippage survey of 541 vehicles, found one instance of a dead adult *Anthrenus* sp. after a vehicle had received biosecurity clearance (Wedde et al., 2006). In conclusion visual inspection is likely to be an effective risk mitigation measure, except against eggs, provided that the vehicle has not been pre-cleaned – see below.

14.7.2 Vacuuming

Table 2 suggests that cleaning vehicles prior to biosecurity inspection removes evidence of dermestid beetle contamination and fewer vehicles are treated for dermestid beetle contamination by fumigation as a result. It is not known how effective vacuuming is in removing all viable dermestid life-stages and therefore whether vehicles are being given appropriate biosecurity clearance. Pre-shipment removal of all potential *T. granarium* food sources especially grains would reduce the likelihood of survival and therefore of entry of *T. granarium*, except for diapausing larvae, but not of other dermestid beetles which have a wider range of hosts and are able to feed on carpets and other fabrics within a vehicle.

No dermestid beetles, or spent larval skins were found in the videoscope survey of 300 vehicles (Biosecurity Monitoring Group, 2006). This might have been because any evidence of contamination had been removed by vacuuming prior to the survey, or it might have been that the sample size was too small.

In conclusion the efficacy of vacuuming as a risk management measure is unknown.

14.7.3 Pressure Wash

This treatment is not an appropriate treatment, since dermestid beetles are solely internal contaminants.

14.7.4 Heat treatment

Establishing an appropriate heat treatment regime for dermestid beetles in vehicles is difficult since most of the literature relates to treatment of large volumes of grain, e.g. (Mookherjee et al. 1968) and is not applicable to the vehicle pathway. Diapausing dermestid larvae are generally more thermo-tolerant than other life-stages and have been found to suffer 99.99 percent mortality when treated at 55°C for 5.6 minutes in laboratory tests (Wright et al. 2002). Their temperature tolerance is considered to be greater than that for other stored product pests except *T. granarium* whose large larvae are the most heat resistant life stage. Experimental

treatment for 15 minutes at 55°C is required to kill 95 percent of 4th instar larvae and pupae of *T. granarium* at 75 percent humidity but only 8 minutes are required at lower humidity (Lindgren et al. 1955). An exposure to 60°C for 30 minutes has been reported to result in 100 percent mortality of all life stages of *T. granarium* (Ismail et al. 1988 cited in the EPPO data sheet for *Trogoderma granarium*), but this paper has not been acquired. The tobacco beetle, *Lasioderma serricorne* and the lesser grain borer, *Rhyzopertha dominica* are also heat tolerant species. Laboratory tests indicate that 40 minutes are required to control all life stages of these species at 55°C (Adler, 2002).

Given the propensity for dermestid beetle larvae to be found within food residues or in crevices that are slow to heat up, allowance must be made in the treatment regime for the time that it will take for the heat to penetrate food residues and crevices (Wright et al. 2002).

From these results it appears that core heat treatment at 55°C for fifteen minutes will kill all life-stages of most of the dermestid pests. It is less clear that it will be effective against all life-stages of *T. granarium* and a precautionary approach of treatment at 60°C for up to 30 minutes may be required for this species.

One study indicates that larvae of some wood-boring beetles (*Lyctus* sp.) have a higher temperature tolerance and require treatment for 30 minutes at 82°C air temperature to kill larvae inside wood (Snyder, 1923). It is assumed that it would take longer to reach a specified core temperature in wood than a vehicle. Unpublished results of small scale laboratory thermal death point tests of adult *Arhopalus tristis*, burnt pine long horn beetle established 100 percent mortality after treatment at 47°C for ten minutes (Crabtree, 2002). This supports the assumption that core heat treatment at 55°C for fifteen minutes will effectively treat all beetles associated with imported vehicles except possibly *T. granarium*.

14.7.5 Fumigation

The diapausing larvae *T. granarium* are more tolerant of methyl bromide fumigation treatments than other stored product pests (Bell et al. 1985; Bond, 1984). Effective control in vehicles requires high concentrations maintained over the fumigation period to enable gas penetration into cracks and crevices. The current New Zealand requirement for vehicles is 48 g/m³ at 21°C for 24 hours (concentration time product of 1152 g.h/ m³) based on the FAO recommended treatment schedule for sealed buildings. The USDA treatment schedule for empty railroad cars contaminated with *T. granarium* is 72 g/m³ at 21-26°C for up to 12 hours (concentration time product of 864 g.h/ m³) (United States Department of Agriculture 2004).

In laboratory experiments, 100 percent kill of diapausing larvae is reported with a concentration time product of 550 g*h/ m³ of methyl bromide at 15°C (Bell et al. 1985). Lindgren et al. (1955) suggest at 108 g*h/ m³ 21°C or equivalent for 2 hours is effective against *Trogoderma* spp. larvae. Mehta et al. (1991) report considerable variation in the susceptibility of *T. granarium* life stages to methyl bromide with 10 day old larvae being most tolerant. Hole (1981) reports concentration time products for 100 percent kill for seven species of stored product beetles with Methyl Bromide at 25°C. The highest concentration required is 180 mg/h/l for *Tribolium confusum* and *Tribolium castaneum*. The current standard vehicle fumigation treatment regime of 48g/m³ for 24 hours (Biosecurity New Zealand, 2006) which equates to 1152mg/h/l is considerably higher.

In conclusion it appears that the current treatment rate of 48g/m³ for 24 hours is more than needed to kill all life stages of many stored product beetles.

14.7.6 Insecticide treatment

The habit of *T. granarium* hiding in cracks may make treatment with insecticide less effective than fumigation or heat treatment (Lindgren et al. 1955). It is likely that follow up treatments would be required to kill any larvae that were in diapause or did not come into contact with the insecticide during the first treatment. Treatment of carpets in particular is unlikely to be effective, since the likelihood of contact between insecticide and *T. granarium* are low. Tests of 33 insecticides against stored product pests *A. unicolor* and *Trogoderma glabrum* in transport trailer vans and containers found that pyrethroids applied as dusts were most effective. Cyfluthrin, bifenthrin, permethrin and cypermethrin all resulted in >95 percent mortality at 0.021 g/m³ (Halliday et al. 1987). However the test organisms were not concealed in crevices. Research is needed to test the application and efficacy of insecticides in managing the vehicle pathway.

14.7.7 Surveillance

Since 100 percent mitigation of biosecurity risks associated with the vehicle pathway is not possible, targeted surveillance for high impact pests is a sensible measure in combination with border measures. A trap has been developed which combines a feeding attractant for *Trogoderma granarium* larvae and a pheromone for adult males (Barak, 1989). Industry could be encouraged to undertake such surveillance around high-risk areas such as agricultural stores through an awareness campaign. This would be insufficient to meet the risk management objective in the absence of border measures.

14.7.8 Removal of high-risk parts

Removal of mats and seat covers is likely to improve the efficacy of other treatments such as vacuuming, heat treatment or fumigation.

MAF Quarantine Service (2006) requires bolted rear seats to be removed from buses as this is a known risk area for *Trogoderma* spp. and *Attagenus* spp.

14.7.9 Offshore versus onshore risk management

Whilst there are no data on recontamination rates, it is considered unlikely that vehicles treated offshore would become significantly re-contaminated with dermestid beetles prior to shipment. Treatment off-shore is therefore likely to reduce the likelihood of entry of this hazard group.

14.8 RECOMMENDED MEASURES

Trogoderma granarium is considered to be the most serious dermestid pest. Since the risk assessment for *T. granarium* has concluded that it is not a hazard on vehicles other than used agricultural equipment and trucks, and since there is evidence that the heat treatment requirements for *T. granarium* are more stringent than for other dermestid beetles it is not appropriate to assume that evidence of dermestid contamination in other vehicles might be *T. granarium*.

- 1) For used vehicles other than trucks or agricultural machinery, which are likely to be contaminated by dermestid beetles other than *T. granarium*, visual inspection coupled with fumigation with methyl bromide at 550 mg/h/l or heat treatment at 55°C for

fifteen minutes if there are signs of infestation, will provide an appropriate level of protection, provided that the vehicle has **not** been pre-cleaned **or**

- 2) fumigation of all vehicles with methyl bromide at 550 mgh/l or heat treatment at 55°C for fifteen minutes **and**
- 3) For all used agricultural equipment and trucks used for carrying grain, regardless of whether there is any evidence of infestation, fumigation with methyl bromide at of 550 gh/m³ or heat treated at 60 °C for 30 minutes, because of the increased likelihood of infestation of these vehicles with the more resistant and damaging *T. granarium* **and**
- 4) Industry should be encouraged to undertake surveillance for *T. granarium* around high-risk areas such as agricultural stores.

In addition the following research is recommended

- the effectiveness of vacuuming in removing all life-stages is investigated. If it proves to be effective, mandatory internal cleaning, coupled with removal of mats and seat covers would meet the risk management objective;
- a study to determine the specific identity of dermestid vehicle contaminants and the relative frequency that are regulated pests. This would give a better understanding of the risk;
- trials to confirm the heat treatment regime necessary to kill diapausing *T. granarium* larvae.

14.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- the frequency of entry of exotic dermestids via imported vehicles and equipment is not known. It is assumed that the estimate of 2-4 percent of imported used vehicles is an underestimate. It is not possible to identify individual species at the border. This estimate assumes that all evidence of dermestid contamination is of species not present in New Zealand, but there is some evidence to indicate that this is not the case (R. Kleinpaste pers.comm.);
- it is assumed that the presence of larval exuviae is indicative of the presence of viable dermestid life-stages, but this is not known;
- it is not known what proportion of the dermestid contaminants are *T. granarium*. It is assumed that this species will only contaminate trucks or machinery containing grain;
- it is assumed that the dermestid beetles contaminating vehicles will be transferred to a suitable receiving environment, in at least a proportion of cases;

- the efficacy of treatment options is uncertain. In particular it is not known how effective vacuuming is in removing all viable dermestid life-forms or how effective insecticide treatment would be and the efficacy of heat and fumigation treatment against *T. granarium* is uncertain.

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15 Dragonflies and damselflies (Odonata)

15.1 HAZARD IDENTIFICATION

15.1.1 Identity

Category: Insects

Taxonomic Group: Class: Insecta; Order: Odonata

Name: Dragonflies and damselflies

15.1.2 Association with the pathway

There are some 26 families of dragonflies and damselflies worldwide with about 5000 species (Hill, 1994). They are predacious insects with aquatic larvae.

Table 1 summarises the dragonfly interception records associated with the vehicle pathway.

Table 1 Odonata interception records between 1994 and April 2006 associated with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family & status	Country of origin	Vehicle type	Life stage (number of records & viability)
<i>Aeshna</i> sp.	Aeshnidae, genus native to NZ	Japan	used vehicle	dead adult (1) likely to be a local contaminant
unidentified	Aeshnidae	Japan	used vehicle	dead adult (1)
unidentified	Corduliidae	Japan	used vehicle	dead adult (1)
<i>Sympetrum</i> sp.	Libellulidae	Japan	used vehicle	dead adult (1)
unidentified	Libellulidae	Japan	used vehicle	dead adult (1)
unidentified	Suborder: Anisoptera, 6 species present in NZ	Japan USA	used vehicle used vehicle	dead adults (7) dead adult (1)

There are very few interception records for this potential hazard group. Whilst interception records cannot be used to estimate frequency of contamination by any particular hazard group (Chapter 2), given that adult dragonflies are relatively large and conspicuous more records would be expected if they were found regularly in association with the pathway.

15.1.3 Conclusion

Given that:

- adult dragonflies are relatively large and conspicuous and yet are rarely reported to have been intercepted on the vehicle pathway;
- adult dragonflies are unlikely to survive shipment from the main vehicle exporting countries, in the absence of a food supply;
- the larvae are unlikely to be associated with the pathway given their aquatic and predatory habits.

Odonata are not considered to be a hazard on the new or used vehicle or machinery pathways, and are not considered further in this analysis.

15.2 REFERENCES

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16 Earwigs (Dermaptera)

16.1 HAZARD IDENTIFICATION

16.1.1 Identity

Category: Insecta

Taxonomic Group: Class: Insecta; Order: Dermaptera

Name: Earwigs

16.1.2 Association with pathway

There are eight families of earwig and some 1200 species. They are small (6-20mm) nocturnal insects. Most are omnivorous (Hill, 1994). They hide in warm, humid crevices, and are probably an under-recorded group of potential hazards. There is no evidence that they transmit diseases, but they can be a minor plant pest causing some damage from their feeding activities.

Table 1 summarises the Dermaptera interception records associated with the vehicle pathway.

Table 1. Interception records for Dermaptera in association with imported vehicles and machinery for the period 1994 – 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status (Scott and Emberson, 1999)	Association with pathway
<i>Labidura riparia truncata</i>	Labiduridae	present in NZ	1 post-border record of live adult on an imported used vehicle. Unknown country of origin
unidentified	Forficulidae	unknown	1 record of dead adult on a used vehicle unknown country of origin
unidentified	unknown	unknown	1 record of live adult on new machinery from Pakistan

16.1.3 Conclusion

Given that earwigs:

- are small and likely to be an under-recorded contaminant;
- can in some cases cause adverse impacts to some plant crops;
- they are considered **a potential hazard on the used vehicle and machinery pathway.**

However, given the paucity of species level identification, it is not possible to generalise about the likelihood of entry, establishment and potential consequences of establishment and spread and no further analysis of this potential hazard group is undertaken. It is assumed that the risk management measures recommended for the dermestid beetle hazard group, which are similarly secretive in nature and relatively difficult to control, will effectively mitigate any risks associated with Dermaptera on the used vehicle and machinery pathway.

It is assumed that earwigs will primarily be an internal contaminant of vehicles and that they are therefore unlikely to be a hazard on the **new** vehicle pathway.

16.2 REFERENCES

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17 Flies (Diptera) other than mosquitoes

17.1 HAZARD IDENTIFICATION

17.1.1 Identity

Category: Insects

Taxonomic Group: Order: Diptera

Name: Flies

The Diptera comprise 130 families and about 85,000 species (Hill, 1994). The large number of families reflects the great morphological and ecological diversity in the order. Many families contain few species and are very specialized, which makes generalisation difficult. The risks associated with the Culicidae (the mosquitoes), are assessed in a separate chapter (Chapter 22) as a result of their high human health consequences. This section addresses all the remaining families.

17.1.2 Association with pathway

Table 1 summarises the fly interception records (other than those in the Culicidae) associated with the vehicle pathway. Status in New Zealand is specified as ‘unknown’ for interceptions identified only to genus when some but not all the species in that genus are present in New Zealand.

Table 1. Interception records of Diptera other than Culicidae in association with imported vehicles and machinery during the period 1994-2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin and pathway	Life stage (number of records) & viability
unidentified	Agromyzidae	unknown	Japan new vehicle	live pupa (1)
unidentified	Anisopodidae	unknown	Japan used vehicle	dead adult (1)
unidentified	Anthomyiidae	unknown	Japan used vehicle	dead adult (1)
unidentified	Asilidae	unknown	Cyprus used vehicle	dead adult (1)
<i>Dilophus nigrostigma</i>	Bibionidae	yes	Japan used vehicle	live adult (1 post-border)
unidentified	Bibionidae	unknown	Japan used vehicle	dead adult (1)
<i>Calliphora</i> sp.	Calliphoridae	4 species present in NZ	Japan used vehicle	dead adult (1 post-border)
<i>Calliphora stygia</i>	Calliphoridae	yes	South Africa used vehicle	dead adult (1)
<i>Chrysomya megacephala</i>	Calliphoridae	yes	Japan used vehicle	live adults (2) dead pupa (1)
<i>Lucilia sericata</i>	Calliphoridae	yes	Japan used vehicle	live adult (1)
<i>Lucilia</i> sp.*	Calliphoridae	unknown	Unknown used vehicle	adult viability not recorded (1)

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin and pathway	Life stage (number of records) & viability
unidentified	Calliphoridae	unknown	Japan used vehicle	live adults (4) dead adult (1)
unidentified	Chironomidae	1 species present in NZ	Japan used vehicle	dead adults (7) live adults (4)
unidentified	Dolichopodidae	unknown	Japan used vehicle	dead adult (1)
<i>Lonchoptera hakonensis</i>	Lonchopteridae	no	Japan used vehicle	live adult (1)
<i>Atherigona</i> sp.	Muscidae	no	Australia used vehicle	live egg (1)
<i>Musca domestica</i>	Muscidae	yes	Australia used vehicle	live adult (1)
<i>Pygophora apicalis</i>	Muscidae	no	Japan used vehicle	live adult (1)
unidentified	Mycetophilidae	unknown	Japan used vehicle	dead adult (1)
<i>Megaselia</i> sp. humpbacked fly	Phoridae	2 species present in NZ	Philippines machinery	adult (1) larva (1) viability not recorded
unidentified	Phoridae	unknown	Japan used vehicle Australia machinery	pupa (1) live adult (1)
<i>Bradysia</i> sp. fungus gnat	Sciaridae	no	Japan used vehicle	live adult (3)
<i>Hermetia illucens</i>	Stratiomyidae	yes	Japan used rubbish truck Japan Used vehicle	live larva (1) adult viability not recorded (1)*
unidentified	Stratiomyidae	unknown	Japan used vehicle	adult (1)
<i>Eristalinus aeneus</i>	Syrphidae	yes	vehicle of unknown origin	live adults (1)
<i>Eristalis tenax</i>	Syrphidae	yes	Japan used vehicle	dead adult (1)
Syrphidae	Syrphidae	7 species present in NZ	Japan used vehicle UK used vehicle	dead adults (2) dead adult (1)
<i>Tabanus chrysurus</i>	Tabanidae	no	Japan used vehicle	dead adult (1)
unidentified	Tachinidae	unknown	Japan used vehicle	live adult (1) dead adult (1)
unidentified	Tanyderidae	unknown	Japan used vehicle	dead adult (1)
<i>Leptotarsus huttoni</i> *	Tipulidae	yes	Singapore used vehicle	dead adult (1)
<i>Zelandotipula novarae</i> , swamp crane fly	Tipulidae	yes	Japan used vehicle	live adult (1)
<i>Macromastix</i> sp.	Tipulidae	unknown	Japan used vehicle	dead adult (1)
unidentified	Tipulidae	unknown	Japan used vehicle	live adult (3) dead adult (2)

Organism	Family	Present in New Zealand (Scott and Emberson, 1999)	Country of origin and pathway	Life stage (number of records) & viability
<i>Xylophagus</i> sp.*	Xylophagidae	no	Unknown used vehicle	Adult viability not recorded (1)

* recorded during Biosecurity Monitoring Group used vehicle survey (Wedde et al. 2006)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. There are interception records for 18 genera in 20 families. Most were intercepted on vehicles imported from Japan and 50 percent were of live organisms. Although several of the interception records were for species present in New Zealand, five species/genera intercepted are not present in New Zealand and the records that were not identified to species level may also be of species not present in New Zealand.

Brief summaries of distribution, biology and pest potential of each family are set out below. Information is derived from (Hill, 1994) unless otherwise specified.

Agromyzidae (leaf miners): 2 000 species. Tiny flies whose larvae are mostly leaf miners in a very wide range of plants.

Anisopodidae: 100 species. A primitive group of small flies.

Anthomyiidae (root flies): 1 200 species. Similar in ecology and biology to the Muscidae. The adults are mostly nectar feeders, whilst the larvae are mostly phytophagous and can be significant plant pests.

Asilidae (robber flies): 5 000 species. A group of predatory flies, the larvae of which live in soil, rotten wood and leaf litter.

Bibionidae (fever flies, March flies): 700 species. Large robust flies whose larvae can cause damage to plant roots and seedlings. Most abundant in the temperate parts of the Holarctic region but well represented in Australasia.

Calliphoridae (blow flies, bluebottles): 1 100 species with worldwide distribution. Most are saprophagous carrion or dung eaters, but there are some parasites. Adults take liquid food, mostly nectar from flowers and are therefore important pollinators. Some however feed on blood and wound exudates and can transmit pathogens. Most adults can survive a month without food. *Calliphora* spp are most abundant in the temperate Holarctic region, whereas *Chrysomya* is typically a genus of the Old World tropics. A number of species are of human health significance as mechanical vectors of disease agents from faeces or dead animals to food stuffs or food preparation areas (Goddard, 2003). Larvae of some calliphorid species are obligate parasites of living flesh, feeding during the entire larval period inside a mammalian host (Goddard, 2003).

Chironomidae (lake midges; blood worms): 5 000 species. The adults have poorly developed mouthparts and most species do not feed in the adult stage. They are generally short lived. The larvae are aquatic and have an important ecological function feeding on plankton and organic debris. The subfamily, Tanypodinae are carnivorous and feed on the

larvae of other insects. The larvae are unlikely to survive shipment to New Zealand unless in association with water containing significant organic matter. A few larvae are not aquatic and occur in soil, dung, compost and rotting wood. A few are pest species mainly causing damage to rice seedlings.

Dolichopodidae (long-legged flies): 4 500 species. These flies mostly occur in wet places, among low herbage. The adults are predacious. Larval habits are varied, some are aquatic, some live in soil or humus, and some prey on wood boring Coleoptera.

Lonchopteridae (pointed winged flies): 35 species worldwide. Adults are found in shady, humid and/or semi-aquatic habitats. Immature stages are found in detritus in moist conditions.

Muscidae (houseflies): 3 900 species. The adults are significant potential pests, as they are dependent on humans and domestic animals, feeding on sweat, urine, dung and in some cases blood, using sponge-like mouthparts. They periodically regurgitate food and defecate on the food source, thereby transmitting disease. The major pest species, *Musca domestica* is already present in New Zealand, but it is possible that flies entering via the vehicle pathway could be vectors of new pathogenic organisms. Most species lay large numbers of eggs. The life cycle varies according to temperature from eight days at 33-35°C to 40-50 days at 10-15°C. Adults live between two and ten weeks and can disperse a number of kilometres. Association with the vehicle pathway is likely to be either through trapped adults, or through contamination for instance by foodstuffs with eggs.

Mycetophilidae (fungus midges): 2 000 species. Widely distributed worldwide. The larvae live gregariously in fungal fruiting bodies and rotting vegetable matter.

Phoridae (carrion and humpbacked flies): 3 000 species. A group of tiny flies. Most adults are found among decaying vegetation, but some are associated with termites and ants and sometimes occur in domestic situations in large numbers. Some species are pests of cultivated mushrooms and others are parasitic on other insects. The main breeding areas and larval habitats are animal corpses, fungal mycelia and rotting vegetation.

Sciaridae (fungus gnats): 1 000 species. These small midges are adapted to a very wide range of conditions. The larvae feed on organic matter in the soil. They can cause significant damage in green houses through root damage.

Stratiomyidae (soldier flies): 1 300 species. Uniformly distributed around the world throughout all regions. The larvae are found in soil, mud or dung and can be aquatic.

Syrphidae (hover flies): 5 000 species worldwide. Most adults feed on nectar and pollen and are important pollinators. The larvae are diverse and include predaceous, phytophagous, fungivorous, and saprophagous types.

Tabanidae (horse flies): 3 500 species worldwide. Many species are significant pests of medical and veterinary importance (Goddard, 2003). Male flies feed mostly on nectar and plant juices, whilst females prefer vertebrate blood and are vectors of parasitic organisms. The usual hosts are mammals, reptiles and amphibians, but rarely birds. The larvae are semi-aquatic, found in wet soil at the margins of ponds and rivers.

Tachinidae (parasitic flies): 8 000 species. A cosmopolitan group which spend their larval lives as internal parasites of other insects, spiders, woodlice and centipedes. Identification is difficult.

Tanyderidae: 42 species in 10 genera, most of which are regional endemics to the south-western Nearctic Region (1 genus), southern South America (3 genera), southern Africa (1 genus), Australia (2 genera), and New Zealand (1 genus). The larvae are often aquatic.

Tipulidae (crane flies): 13 500 species. The only species in this family recorded from the vehicle pathway is present in New Zealand and may have contaminated the vehicle after arrival in New Zealand. Adult tipulids are short lived and unlikely to survive shipment from Japan.

Xylophagidae (awl flies): A small family whose larvae are often saprophytes, found in rotting wood

17.1.3 Conclusion

Given that:

- there are a very large number of species of flies that could potentially be associated with the vehicle pathway, most of which will not be possible to identify at the border;
- flies are likely to contaminate vehicles either as adults or as larvae or eggs in association with soil or food material;
- the interception records show that at least some adults can survive shipment, even from more distant exporting countries such as Japan;
- some of the genera intercepted from the vehicle pathway occur in vehicle exporting countries, but not in New Zealand;
- at least some of genera intercepted include significant agricultural, human health and environmental pests.

It is concluded that Diptera, are **potential hazards on the used vehicle and machinery pathway**. Given the association of fly larvae with soil, plant and animal debris contamination, it is assumed that the measures recommended for the management of soil, plant and animal debris will adequately mitigate the risk associated with fly larvae. It is assumed that the measures recommended against Lepidoptera will also be effective against adult Diptera.

This hazard group is therefore not assessed further.

The likelihood of flies entering via the **new** vehicle pathway is considered to be **negligible** and risk management measures are not justified.

17.2 REFERENCES

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18 Frogs and toads (Amphibians)

18.1 HAZARD IDENTIFICATION

18.1.1 Identity

Category: Taxonomic Group: Class: Amphibia; Order: Caudata, Anura, Gymnophiona

Name: Frogs, toads, salamanders, newts and caecilians

18.1.2 Introduction

The Class is only represented in New Zealand by the Order Anura, frogs and toads. There are four extant species of native frogs, all endemic to New Zealand and all in the primitive genus *Leiopelma*. They are all threatened and have a restricted distribution (Bell, 1994; Hitchmough, 2002). They are unusual in that they are terrestrial and lack a tadpole stage. There are also three Australian species naturalised in New Zealand, all in the Hylid genus *Litoria*. Some urodeles are kept in captivity in New Zealand.

There are some 6 000 amphibian species worldwide. Some 30 percent are considered threatened. However some are invasive and four species are listed on the global invasive species database including the cane toad *Bufo marinus*.

18.1.3 Association with pathway

Most intercepted amphibians are sent to Whitaker Consultants Limited for identification. Table 1 summarises the records from imported vehicles, boats and machinery from their database.

Table 1. Interception records of amphibians in association with imported vehicles and machinery 1994 to 2006 Source: Whitaker Consultants Limited

Organism	Family	Present in New Zealand (Gill & Whitaker, 1996)	Country of origin	Vehicle type	Life stage (number of records and viability)
<i>Hyla japonica</i> Japanese tree frog	Hylidae	no, native to Japan, China	Japan	used car	border dead adult (2)
<i>Hyla gratiosa</i> Barking tree frog	Hylidae	no, native to USA	USA	boat	border live adult (3)
<i>Osteopilus septentrionalis</i> , Cuban tree frog	Hylidae	no, native to Caribbean, introduced to Florida and Hawaii.	USA	boat	border live adult (1)
<i>Rana temporaria</i> common frog	Ranidae	no, native to Europe	Germany	new car	post-border dead adult (1)
unidentified	unidentified		Japan	vehicle	border dead adult (1)

There are interception records for four species, none of which occur in New Zealand. The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates.

The Cuban tree frog, *Osteopilus septentrionalis* is a pest species, capable of achieving very high densities in natural areas, as well as suburban neighbourhoods. It is highly predaceous with a broad diet including invertebrates, frogs, and lizards. It can survive in a variety of habitats from sea level to over 900m. Whilst native to the Caribbean, it has been introduced to Florida and Hawaii. The pet trade is probably the main pathway for transfer of this species (McKeown, 1996).

With a few exceptions, most amphibians are biphasic, meaning that they go through an aquatic stage, and a terrestrial stage at some point in life. It is only the terrestrial stages that are likely to be associated with imported vehicles. Desiccation during shipment is likely to occur, but is not necessarily fatal for a frog in a confined space during shipment. Live anurans have been intercepted from boats on this pathway, and they have also been found in imported containers (A.H. Whitaker, pers. comm.).

In addition to the records in Table 1, there have been post-border incursions of *Bufo marinus* and of European green toad, *Bufo viridis*. The entry pathway for these is not known, but there are reports of the cane toad *Bufo marinus* being transported on trucks elsewhere (<http://www.issg.org/database/species/ecology.asp?si=113&fr=1&sts=sss>). Cane toads are extremely serious pests in the places they have been introduced. It is not clear whether they could establish in northern New Zealand but should they do so, they would pose a serious environmental threat and would be difficult or impossible to eradicate if spread over a wide area.

The accidental importation of anurans is of particular concern because of the possibility of their bringing in novel pathogens or parasites that might establish and infect native frogs (Gill et al. 2001). For instance, the lethal chytrid fungus, *Batrachochytrium dendrobatidis* was first discovered in New Zealand in 1999. It is thought that it can be readily transmitted through translocation of juveniles, natural dispersion and possibly through movement of boots and field gear of human visitors to infected ponds. The consequences of its spread to native frog populations are of major concern (Waldman and van de Wolfshaar, 2001).

18.1.4 Conclusion

Given the records for live adult anuran hitchhikers in boats imported from the USA, **frogs and toads are considered a potential hazard for the used vehicle and machinery pathway**. The likelihood of entry is greater on boats than on other types of vehicle and machinery.

Since the biology of frogs and toads is similar to that of reptiles, it is assumed that any anuran hitchhikers on the vehicle pathway will be managed by the measures that are recommended for the treatment of reptile hazards. They are therefore not assessed further. The recommended risk management measures for reptiles will not however address the likelihood of entry on boats carried as cargo. Since the volume of boats imported in this way is small, it is considered that visual inspection will adequately mitigate the risk.

Whilst there is a record of a dead common frog from a new vehicle, the likelihood of amphibians entering via the **new** vehicle pathway is considered to be **negligible** and risk management measures are not justified.

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19 Mantids (Mantodea)

19.1 HAZARD IDENTIFICATION

19.1.1 Identity

Category: Insecta

Taxonomic Group: Order: Mantodea, Family: Mantidae

Name: Praying Mantids

19.1.2 Introduction

There are approximately 2 000 species of mantids world-wide; all are predatory, most are tropical or subtropical, but several species live in temperate climates (Hill, 1994). The mantid *Statilia maculata* is found only in Japan. Only two species occur in New Zealand, one of which is native (Ramsay, 1990).

19.1.3 Association with pathway

The mantid interception records for the pathway are summarised in Table 1.

Table 1. Interception records of mantids in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand (Ramsay, 1990)	Country of origin	Vehicle type	Lifestage (number of records and viability)
<i>Hierodula patllifera</i>	Mantidae	no	Japan	used vehicle	non-viable eggs (1)
<i>Miomantis caffra</i> , South African mantid	Mantidae	yes naturalised	Japan	used vehicle	live adult (1 post-border) live adult (1) dead adult (1)
<i>Statilia</i> sp.	Mantidae	no	Japan	used vehicle	eggs (1)
<i>Statilia maculata</i> , Japanese praying mantis	Mantidae	no	Japan	used vehicle	live eggs and nymphs (5 post-border) dead eggs/nymphs (3)
<i>Tenodera intermedia</i>	Mantidae	no (1 pre 1870 record- thought to be vagrant from Australia)	Japan	used vehicle	live egg case (1) dead egg case (1)
<i>Tenodera</i> sp.	Mantidae	no	Japan	used vehicle	live egg case (1) dead egg cases (2)
unidentified	Mantidae	unknown	Japan	used vehicle	dead adults/eggs (27) live eggs and nymphs (11) live eggs and nymphs (5 post-border)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. A comment recorded on the database states that *Statilia maculata* ‘is commonly intercepted on Japanese cars’. The number of live post-border interceptions is noteworthy. The most recent interception occurred at a compliance centre where a mechanic found two

egg cases in the front brake system. One egg case appeared potentially viable, but was assumed not to be since the vehicle had been fumigated on arrival.

Mantids have one generation a year and have incomplete metamorphosis. Between 30 and 300 eggs, depending on the species are laid in a protective ootheca either in the soil or wrapped in plant material. The hardened case enables them to survive adverse conditions. Mantids fly more at night and do not migrate long distances. Their biology is similar to that of cockroaches.

Mantids are wholly carnivorous and the non-native species already present in New Zealand, *Miomantis caffra* has been reported preying on the native species, *Orthodera nova zealandiae*. *M. caffra* originated in South Africa and is extending its range in northern New Zealand. It appears to have displaced *O. novazealandii* in some areas (Ramsay, 1990).

Insufficient information is readily available on *S. maculata* and other unidentified mantids to assess the likelihood of their establishing in New Zealand, however, given their predatory nature it is likely that they could have a significant effect on the indigenous invertebrate fauna.

19.1.4 Conclusion

***S. maculata* is considered a potential hazard on the used vehicle and machinery pathway.** It is assumed that risk management measures suitable for the treatment of cockroaches will also be effective against mantids. No further assessment is undertaken.

Insufficient information is available to determine whether mantids are likely to be a hazard on the **new** vehicle pathway.

19.2 REFERENCES

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20 Micro-organisms associated with soil, plant and animal debris, faecal material and food

20.1 HAZARD IDENTIFICATION

Soil, plant and animal debris are the most frequent groups of contaminants associated with the vehicle and machinery pathway. In addition wood sometimes occurs as part of the structure of the vehicle for instance in the wooden beds of trucks. Food debris and birds nests are also found from time to time. These materials are not necessarily biosecurity hazards in themselves, but are often associated with a wide range of microscopic organisms. Since these organisms are not usually detectable by visual inspection they are not routinely isolated and identified and there are few interception records for them from imported vehicles and machinery.

Nonetheless, importation of soil is universally considered to present a serious quarantine risk, based on its potential to transport pests and infectious disease agents of plants and animals, (Canadian Food Inspection Agency, 2002; Gadgill et al. 2000; D. Ironside, pers.comm.; Marshall, 2004; U.S. Department of Agriculture, 2001). Some of these agents are obligatory pathogens and are only accidental inhabitants of soil where they survive for varying periods in decaying plant material or after being shed from an infected host in faeces, urine or other body secretions. Others are saprophytes that are normally found in soil and other environmental substrates such as water, decaying plant or animal tissues etc, but are opportunistic or accidental pathogens.

A similar recognition of the difficulties in undertaking meaningful pest risk analysis for wood packaging (the diverse origins of the commodity, the difficulty in tracing its history, and the difficulty of identifying individual pathogens in wood at the border), has resulted in an international standard being developed to manage the associated quarantine risks (International Plant Protection Convention, 2006). However, there is no equivalent international consensus regarding the quarantine risks associated with plant and animal debris. A 1996 risk assessment of plant debris and soil on imported used vehicles and machinery concluded that both groups of contaminant posed a risk to New Zealand's forests and trees (Forest Research Institute, 1996).

The groups of organisms likely to be associated with soil, plant and animal debris, wood, faecal material and food are discussed in the following sections:

20.1.1 Bacteria

There are no specific records of bacteria isolated from the vehicle and machinery pathway, although as these organisms have not been targeted for identification none are expected. The majority of soil bacteria are decomposers of organic material. A number of pathogens such as *Ralstonia solanacearum* which causes bacterial wilt of solanaceous crops and is an unwanted organism in New Zealand, are soil inhabitants and can maintain their populations within the soil (Agrios, 1988). Other plant pathogenic bacteria enter the soil in host tissue or as free cells. These persist in the soil for as long as the host tissue resists decomposition or for varying durations depending on the species and soil conditions. On plant material, bacteria may survive epiphytically or inside the tissues that they infect. For instance, bacterial spot of tomato and pepper, *Xanthomonas campestris* pv. *vesicatoria*, over-winters on seed or on

infected plant debris (Agrios, 1988). It is widespread in Europe, the USA, and Australia (Smith et al. 1988) but is not established in New Zealand.

Animal and human pathogens such as *Salmonella* spp., some types of which do not occur in New Zealand, can be associated with contaminants such as sewage and manure (Sabirovic, 1994) and in some cases food. However most obligatory pathogens do not survive long in the environment and transportation of soil on vehicles is not a recognised method of transmission of these disease agents (Worthington, pers.comm.).

Spore forming bacteria can live for long periods in the soil. *Coxiella burnetii*, causal agent of Q fever, which has an almost global distribution but is not established in New Zealand has a condensed form that is highly resistant to unfavourable environmental conditions and may survive for some months. There is strong circumstantial evidence that *C. burnetii* can be transmitted in dust (Kelly, 2004). However, there is nothing in the literature to suggest that it has been carried between countries by soil on cars.

New Zealand is also free from anthrax, and the etiological agent, *Bacillus anthracis* can survive long periods, possibly hundreds of years, as spores in soil. The association between contaminated soil and anthrax in animals has been repeatedly demonstrated. However, even in endemically infected countries, soil will only be infected where animals have died from anthrax and the carcasses have been opened (De Vos and Turnbull, 2004). Soil on the vast majority of farms will not be contaminated by anthrax spores.

20.1.2 Viruses

There are no specific records of viruses isolated from the vehicle and machinery pathway, but these organisms have not been specifically targeted and viruses do not generally survive for long outside their host organism. Plant viruses are not commonly transmitted through soil, but may be transmitted via other soil contaminants such as nematodes, mites, fungi and seed (Agrios, 1988). Seed contaminants are considered in Chapter 23. Mechanical transmission of plant viruses occurs through direct transfer of sap. Although there are occasional reports of fresh plant material such as a conifer branchlet being found in association with vehicles (MAF Biosecurity Authority, 2004), virtually all plant debris is dry material (Smith and Toy, 2006). Sap-transmitted plant viruses are therefore not considered to be potential hazards on the vehicle pathway.

No soil-saprophytic viruses are known to be accidental or opportunistic pathogens of man or animals. However, a large number of obligatory pathogens of animals and man, including several which are not established in New Zealand can survive for varying lengths of time and remain infectious in soil and the environment (Worthington, pers.comm.). Foot and mouth disease and Newcastle disease virus are two examples that are excreted in the faeces and urine of infected animals (Sabirovic, 1994). Indirect transmission of animal pathogens by inanimate vectors such as machinery, as well as manure, slurry, hay, straw and soil can be important for viruses. A major outbreak of swine fever in the Netherlands was attributed to a failure to adequately clean trucks that had transported infected pigs in Germany. Although soil on these trucks could be infected, contaminating animal excretions are more likely to carry infectious agents than soil (Elber et al. 1999; Van Oirschot, 2004). Cars that are being imported could have soil or other materials such as dried manure attached to them. However the likelihood of soil attached to a car containing infectious viruses would be remote unless it came directly from an infected farm.

20.1.3 Fungi

Fungal taxonomy is in a state of flux. The latest estimates of the number of fungal species are around 1.5 million (Crous and Groenewald, 2005). Most of these are saprophytic, living on dead organic matter which they help to decompose. There are numerous species known to cause diseases in animals (Picard and Vismer, 2004) and humans. McGinnis et al. (1999) for example cited over 120 medically important fungus species. Those known to cause diseases in plants numbers thousands (Agrios, 1988). However it is very difficult to establish the pest status of fungal species. A record of the presence of a morphologically-characterised taxonomic species in a country does not mean that all subspecies, formae speciales, varieties or races of that species are present in the country. For example some fifty four formae speciales of *Fusarium oxysporum* are recognised worldwide, of which only twelve are recorded within New Zealand (Pennycook and Galloway, 2004). Different forms vary in pathogenicity and host specificity and are often morphologically indistinguishable. Since exact identification of species is difficult it is probable that many species have not yet been described. In addition, the number of species isolated and identified in most countries is small compared to the number of fungi that actually occur in the environment. Therefore the absence of records from a country does not necessarily mean that a species is not present.

Assessing the risk of individual fungal contaminants on imported timber is difficult (Janson and Farrell, 2000a and 2000b). In trials, even the targeting of pathogens predetermined as having potentially serious detrimental effects to both New Zealand's commercial and indigenous forests with DNA probes were inconclusive. The authors therefore suggested that identification to a level that could conclude whether the fungus was pathogenic and whether it occurred in New Zealand was not possible. One of the samples came from a used Japanese car. However, known pathogens have been isolated from imported material (Gadgil *et al.* 2000; Gadgil *et al.* 2002; M. Dick, Ensis, unpublished data).

Almost all plant pathogenic fungi spend part of their lives on their host plants and part either on plant debris in the soil or in the soil itself (Agrios, 1988). In some cases it is only spores that are present in the soil awaiting transfer to a host. In others, such as *Venturia* species, part of the life cycle is spent on the host as a parasite and part on dead tissues on the ground as a saprophyte. Still other species may move out of the host debris in the soil and survive many years in the absence of their hosts.

A number of species of fungi and yeasts associated with birds have been isolated from feathers and others have been isolated from bird faeces which could in turn, contaminate feathers. Most of these fungi are either not recognised as pathogens in birds, or are already present in New Zealand (Biosecurity New Zealand, 2006).

Records of fungi associated with imported vehicles and machinery entering New Zealand are available from the following sources and are summarised in Table 1:

- An analysis of 364 samples of plant debris and some soil, collected by quarantine officers from used vehicles and machinery between January 1994 and mid July 1996 by the Forest Research Institute. Only fungi of forestry interest were identified and nearly all these only to genus level (Forest Research Institute, 1996). Since this is the only systematic recording that has been undertaken, Table 1 is strongly skewed to plant pathogens on plant debris.
- Biosecurity Monitoring Group interception database, which includes records from the Ensis database. Chapter 2 of this risk analysis describes the limitations of these records.

Note that the taxonomy of many fungal groups is in such a state of flux that any statement of number of species is accurate only for a relatively short period of time, and depends on the balance of taxonomic opinion at the time. For example many of the species originally classified as *Pestalotia* have been reclassified as *Pestalotiopsis*. Many *Cercospora* spp. have been reclassified in recent years in *Pseudocercospora*. The status of any individual organism cannot therefore be stated with the same degree of confidence as is possible for some other hazard groups. The information on presence in New Zealand is based solely on the Landcare Research database of fungi, which is not comprehensive. Information on pathogenicity is based on Pennycook (2003) and the relevant Crop Protection Compendia, 2005 edition, internet datasheets, accessed December 2005. The names used in Table 1 are those supplied by the original identifier, they have not been updated to reflect taxonomic developments.

Table 1 Summary of fungi isolated from contaminants associated with imported vehicles and machinery

Organism	Present in New Zealand *	Pathogenicity (Pennycook, 2003)	Vehicle type & country of origin	Contaminant	Viability
<i>Alternaria</i> sp.	unknown,	some plant and human pathogens	log yarder, USA; vehicles, Japan,.	soil and plant debris	sporulating
<i>Amerosporium</i> sp.	no	unknown pathogenicity	used machinery Japan,	plant debris	sporulating
<i>Aspergillus</i> sp.	unknown	many human pathogens	truck, Japan	soil and plant debris	unrecorded
<i>Apioportha</i> sp.	unknown	Plant pathogen.	vehicle, USA	unrecorded	unrecorded
<i>Bartalinia</i> sp.	no	unknown pathogenicity	vehicle, Japan.	plant debris	unrecorded
<i>Botryosphaeria</i> sp.	unknown	some species are plant pathogens	vehicles and excavator; Japan, log skidder, USA	plant debris	sporulating.
<i>Capnodium</i> sp.	unknown	sooty moulds	vehicle, Japan	plant debris	unrecorded
<i>Cercospora</i> sp./ <i>Pseudocercospora</i> spp.	unknown	many species are plant pathogens	vehicles, Japan	plant debris	unrecorded
<i>Chaetomium</i> sp.	unknown	at least one species is a plant pathogen & one known to affect humans.	truck, Japan	soil	unrecorded
<i>Cladosporium</i> sp.	unknown,	some species are plant pathogens & some of human health significance	vehicle, Japan	plant debris	fruiting
<i>Cladosporium cladosporioides</i>	yes	the genus is of medical significance	used vehicle, Singapore.	plant debris	Viable
<i>Colletotrichum</i> sp.	unknown,		used vehicle, Australia	leaves	unrecorded
<i>Curvularia lunata</i>	yes	a human pathogen	new machinery, USA	unrecorded	unrecorded
<i>Cyclaneusma</i> sp.	yes		cars, Australia & Japan.	plant debris	sporulating
<i>Cytospora</i> sp.	unknown	some species are plant pathogens	vehicles, Japan & Australia.	plant debris	sporulating
<i>Diatrype</i> sp.	unknown	some species are plant pathogens	vehicle, Japan.	plant debris	unrecorded
<i>Diplodia</i> sp.	unknown	some species are plant pathogens &	vehicle, Japan.	plant debris	unrecorded

Organism	Present in New Zealand *	Pathogenicity (Pennycook, 2003)	Vehicle type & country of origin	Contaminant	Viability
		some are of human and animal health significance			
<i>Dicranidion</i> sp.	no		vehicle, Japan	unrecorded	viable
<i>Discosia</i> sp.	unknown	unknown pathogenicity	vehicles of unknown origin & Japan	plant debris	sporulating.
<i>Epicoccum nigrum</i>	yes	causes allergic reactions in humans	vehicle, Japan	plant debris	unrecorded
<i>Fusarium</i> sp.	unknown	many plant pathogens & species of human health significance	used truck, Japan	soil	unrecorded
<i>Gliocladium</i> sp.	unknown	some pathogenic species causing disease in grasses and some crops. Some species affect humans	sawmilling machinery, Canada	plant debris	fruiting.
<i>Herpotrichia</i> sp.	unknown	a few pathogenic species	vehicle, Japan	plant debris	unrecorded
<i>Hormonema</i> sp.	unknown	some human pathogens.	wood chipper, Canada	plant debris	unrecorded
<i>Hypodontia</i> sp.					
<i>Lophodermium</i> sp.	unknown	some pathogenic species causing disease in conifers.	log hauler, Canada; log skidder and loader, USA; 6 vehicles, Japan; truck, Australia	plant debris	sporulating
<i>Macrophoma</i> sp.	unknown	some pathogenic species causing disease in trees.	vehicle, Japan	plant debris	sporulating
<i>Marssonina</i> sp.	unknown	some species are plant pathogens.	vehicle, Japan	plant debris	sporulating
<i>Microsphaeropsis</i> sp.	yes	some species of human health significance.	vehicle, Japan	plant debris	sporulating
<i>Mucor</i> sp.	unknown	some natural enemies of pathogenic species. Some are of medical importance.	excavator, Japan	soil and plant debris	unrecorded
<i>Nectria</i> sp.	unknown	some species are plant pathogens	vehicle, Japan.	plant debris	unrecorded
<i>Paecilomyces</i> sp.	unknown	many species pathogenic to insects. A few are opportunistic animal/human pathogens but most of these are present in NZ	wood chipper, Canada	plant debris	unrecorded
<i>Penicillium</i> sp.	unknown	many animal and some human pathogens, also natural enemies of	tree de-limber and yarder, Canada; wood chipper,	soil and plant debris	unrecorded

Organism	Present in New Zealand *	Pathogenicity (Pennycook, 2003)	Vehicle type & country of origin	Contaminant	Viability
		other pathogenic species.	Canada; logging machinery, USA.		
<i>Peniophora</i> sp.	unknown	uncertain pathogenicity.	used machinery, Japan	plant debris	sporulating
<i>Pestalotiopsis</i> sp.	unknown	some species are plant pathogens	vehicle, USA; vehicles, Japan	plant debris	sporulating
<i>Pestalotia</i> sp.	unknown	some pathogenic species.	vehicle, Japan; log yarder, USA	soil and plant debris	unrecorded
<i>Phaeosphaeria</i> sp.	unknown	unknown	used vehicle, Japan	leaf fragment	unrecorded
<i>Phialophora</i> sp.	unknown	some species are animal & human pathogens, others are plant pathogens.	wood chipper, Canada.	plant debris	unrecorded
<i>Phoma</i> sp.	unknown	some species are plant and animal pathogens & are also of human health significance.	cars, Australia, USA and Japan; log skidder' USA.	plant debris	sporulating
<i>Phomopsis</i> sp.	unknown	some plant pathogenic	vehicles, Japan; new machinery.	soil and plant debris	sporulating even on dry leaf fragments and twigs.
<i>Phyllosticta</i> sp.	unknown	some species are plant pathogens	vehicles from Japan.	plant debris	unrecorded
<i>Phytophthora</i> spp.*	unknown	many pathogenic species. Some species are believed to be medically important.	log hauler, Canada; log skidder, Australia	soil and plant debris	unrecorded
<i>Pleospora</i> sp.	unknown	some plant pathogenic species.	vehicle, Japan	wood	unrecorded
<i>Polyporus arcularius</i>	yes		vehicle, Japan	wood	unrecorded
<i>Pseudorobillarda</i> sp.	no	unknown pathogenicity	vehicle, Japan.	plant debris	unrecorded
<i>Pycnoporus cinabarinna</i>	no	plant pathogen from northern temperate zone.	vehicle from Japan	unrecorded	unrecorded
<i>Rhizosphaera</i> sp.	unknown	plant pathogen.	vehicles from Japan	plant debris	sporulating
<i>Sirococcus strobilinus</i>	no	plant pathogen	log yarder, USA	plant debris	unrecorded
<i>Schizophyllum commune</i>	yes	human & animal health significance.	vehicle, Japan	unrecorded	fruiting
<i>Sclerophoma</i> sp.	unknown	at least one plant pathogen	vehicles, Japan	plant debris	sporulating
<i>Stigmina</i> sp.	unknown	many plant pathogens	vehicles, Japan	plant debris	unrecorded
<i>Trametes versicolor</i>	yes	decay fungus	excavator, Japan; machinery, USA	soil	unrecorded
<i>Thyrinula</i> sp.	yes	unknown pathogenicity	vehicle, Australia	plant debris	unrecorded
<i>Trichoderma</i> sp.	unknown	no plant pathogens, many species	excavator Japan;	soil and plant debris	unrecorded

Organism	Present in New Zealand *	Pathogenicity (Pennycook, 2003)	Vehicle type & country of origin	Contaminant	Viability
		antagonistic to other pathogenic fungi, 1 opportunistic animal pathogen already present in NZ. Opportunistic human pathogens & the cause of respiratory allergies.	used car, USA.		
<i>Trichoderma viride</i>	uncertain status in NZ	a cause of allergies in humans.	used vehicle from Japan	unrecorded	viable
<i>Uncinula</i> sp.	unknown	some pathogenic species causing disease in deciduous trees	vehicle from Japan	plant debris	unrecorded
unidentified	unknown	unknown			

* <http://nzfungi.landcareresearch.co.nz/html/mycology.asp> December, 2005

** *Phytophthora* spp. are Oomycetes, but included in this table as they have a similar life cycle.

Stemonitis spp are myxomycetes (slime moulds) and are now classified as protozoans

In addition, there are reports of fungi (moulds, mildews and rot) on timber decking, carpeting and upholstery, but these have not been identified. There are a wide range of wood decay fungi, most of which are not pathogenic to living hosts. They simply decompose the wood in dead or fallen trees, in wooden structures and sometimes within living standing trees without affecting host health. There are also a number of pathogenic species especially in the genera *Heterobasidion* and *Phellinus*. *Heterobasidion parviporum* occurs in Japan, Europe, USA, and Canada and *Heterobasidion insulare* is widespread in Japan (Dai et al. 2002) and traditionally regarded as non-pathogenic but has been reported as a pathogen on pines in Taiwan (Yen et al. 2002, English abstract and tables). It is therefore possible, although unlikely that decks would support pathogenic wood decay fungi. Some wood decay fungi can cause economic impacts to wooden structures such as houses by reducing wood strength. Spores released by wood decay fungi can also cause health impacts in susceptible animals or humans. While it is likely that the most invasive wood decay fungi have already established in New Zealand, many less invasive or less common wood decay fungi would not have done so (Dr. M. Ormsby, pers comm.).

20.1.4 Protozoa

Infectious protozoa seldom occur in the environment and most species such as *Plasmodium* spp. and *Trypanosoma* spp. are obligatory pathogens that only occur in their host animals or arthropod vectors (Worthington, pers.comm.). The likelihood that any protozoal disease agents would be introduced into New Zealand by soil on vehicles and machinery is considered to be negligible. Taxonomic changes mean that myxomycetes (slime moulds) such as *Stemonitis* spp. (recorded from plant debris from a log loader from Japan) are now classified as protozoans.

20.1.5 Nematodes

There are tens of thousands of species of nematodes, most of which live freely in water or soil feeding on microscopic plants and animals. However many are parasites of plants, animals and humans and may cause severe diseases of crops and livestock (Wharton, 1986). Almost all plant-pathogenic nematodes spend part of their life cycles in the soil. Nematodes can be

easily spread by anything that can carry particles of soil, including farm equipment, flood waters, animal feet and dust storms (Agrios, 1988). Nursery stock and farm produce are also important vectors (Thomason and Caswell, 1987). Although nematodes live in a film of water, they have several mechanisms for surviving in unfavourable environments and some species can survive in dry plant material or soil for many years (Barrett, 1991; McSorley, 2003). Species such as the soybean cyst nematode, *Heterodera glycines* (Tylenchida: Heteroderidae), and *Aphelenchoides bicaudatus* are examples of pest nematodes that could be introduced to New Zealand via the vehicle and machinery pathway. The former has a wide host range, and occurs in Japan and the USA, but not in New Zealand (Knight et al. 1997). *Aphelenchoides bicaudatus* is a parasite of cultivated mushrooms and is a widely distributed soil inhabitant found in Japan, India, Venezuela and Australia (McLeod, 1967).

There are some 5 000 nematode parasites of vertebrates. Most species of economic importance in production animals are shed as eggs or larvae in the faeces, with the mature larvae being taken up by animals grazing on pasture. Nematode eggs or larvae could therefore be present in soil or faeces on cars but larvae of many species are not resistant to desiccation and are unlikely to survive in dry soil on vehicles and machinery. Nematodes that are transmitted by insect vectors (families Filariidae and Setariidae) are unlikely to be associated with soil, plant and animal material contamination of the vehicle and equipment pathway. Mosquitoes are the main potential vectors of such organisms and they are considered in Chapter 22. However parasites such as hookworms, *Ancylostoma* spp. which are not established in New Zealand (McKenna, 1997), can be transmitted through the soil or faecal material.

Table 2 summarises the nematodes identified from soil samples intercepted on vehicles during a used vehicle slippage survey of some 541 biosecurity-cleared vehicles (Wedde et al. 2006). Viability was not determined in most instances.

Table 2 Nematodes recorded from soil intercepted on vehicles after biosecurity clearance had been issued during the vehicle slippage survey carried out in November 2005

Organism	Order	Family	Status (Knight et al. 1997)	Number of records
<i>Aphelenchoides</i> sp.	Tylenchida	Aphelenchoididae	180 species, 11 species present in NZ, several parasites not present in NZ	2
unidentified	Rhabditida	Rhabditidae	unknown	1
unidentified	Rhabditida	Cephalobidae	unknown	3
unidentified	Araeolaimida	Plectidae	unknown	2 (1 alive)
<i>Ditylenchus</i> sp.	Tylenchida	Tylenchidae	3 pest species in this genus already present in NZ	1
unidentified	unidentified	unidentified	unknown	3

With the exception of the major nematode pests, little is known about the nematode fauna of New Zealand. There are consequently major difficulties in assessing the risk associated with nematodes in soil or plant debris contaminating vehicles or equipment. Most species are unlikely to be identified to species level, and it is therefore difficult to determine whether they are already present in New Zealand.

Nematodes are very abundant, exist in almost every conceivable habitat and have a wide range of feeding habitats and food sources. The diversity of their life history, host ranges, and

survival strategies contributes to the difficulty of eliminating them once they become established.

20.1.6 Arthropods

A number of arthropods including beetles, ants, mites, bugs, collembola, psocids and phasmatids are often associated with soil, plant and animal material and food debris. The relevant families are identified and assessed in Chapters 5, 7, 8, 9, 21, 26, 29, 30 and 33.

20.1.7 Plant seeds

Plant seeds can be transported in soil associated with vehicles and machinery. The risks associated with this hazard group are assessed in Chapter 23.

20.1.8 Conclusion

Given that:

- there are pathogenic species of bacteria, viruses, fungi and nematodes associated with soil, plant and animal debris and food contamination that are not present in New Zealand;
- these organisms are generally not visible with the naked eye and it is therefore not possible to distinguish between soil/plant/animal debris supporting pathogens and those that are not, at the border;
- it is time consuming and costly to identify bacteria, viruses, fungi and nematodes to an appropriate level;
- the knowledge of the status of many of the forms of these organisms in New Zealand is incomplete.

It is not practical to identify individual organisms associated with all soil, plant and animal debris on imported vehicles. Instead **all soil, plant and animal debris and food contamination of imported vehicles and machinery is considered a potential hazard**. A generic risk assessment has consequently been undertaken for these groups.

Table 3. Summary association between primary and common vehicle contaminants

Secondary contaminant	Soil	Dry plant material	Animal material (including faecal material)	Food
bacteria	yes	weak	yes	yes
viruses	yes (not plant viruses)	no	yes	yes
fungi	yes	yes	no	yes
nematodes	yes	yes	yes	yes
arthropods	yes	yes	yes	yes
plant seeds	yes	yes	yes	yes

20.2 ENTRY ASSESSMENT

20.2.1 Likelihood of association with the pathway

The likelihood of contamination of a vehicle by soil, plant or animal debris can be assessed by considering the frequency of their contamination of imported vehicles and machinery. Since this information is not routinely recorded, an indication of the relative frequency of these types of contamination has been obtained from the following sources:

Treatment statistics

Eleven percent of used vehicles arriving on car ships in Auckland during the period 01/01/2004 to 30/09/2005 were recorded as requiring steam cleaning/pressure wash prior to receiving biosecurity clearance. The reason for this requirement was not always specified on the MAF Quarantine Service CarShips database, but external contamination by soil was the most frequent justification. This is likely to represent a minimum of vehicles contaminated with soil, since during the same period, a proportion of vehicles with a treatment recorded as 'other' had steam cleaning recorded in the comments. 84 percent of vehicles over the same period were recorded as requiring vacuuming. The reason for this treatment is not readily obtained, but comments in the database describe contamination by soil, seeds, plant and animal debris.

2006 Quarantine Service sample contaminant survey 12-20 March 2006

MAF Quarantine Service officers recorded contaminants by hazard group on a total of 4426 vehicles in March 2006. Vehicles were inspected at six ports in New Zealand and six in Japan. Some of the vehicles inspected in Japan were inspected only internally or only externally during the period of the survey, whilst all the vehicles inspected in New Zealand had both internal and external inspections. The figures in Table 4 are based on all the vehicles surveyed, even if the inspection was only internal or only external. Since fewer vehicles were subject to internal inspection only (see Table 5), the proportion of internal contaminants is likely to be under-recorded. Note that some vehicles were contaminated by more than one type of contaminant.

Table 4. Percentage (and number) of imported used vehicles contaminated by soil, plant and animal debris, from a sample of 4 426 inspected between 12 and 20 March 2006 (MAF unpublished data)

	Inspection in Japan	Inspection in New Zealand
soil	25% (773 out of 3135)	48% (701 out of 1469)
plant debris	34% (1068 out of 3135)	75% (1102 out of 1469)
wood	0.4% (12 out of 3135)	3 % (44 out of 1469)
animal debris	2% (72 out of 3135)	6% (85 out of 1469)

Table 5 summarises the treatment of the vehicles inspected during the period 12-20 March 2006. Many Japanese vehicles are subjected to vacuuming and pressure wash immediately prior to MAF inspection offshore. This is called pre-cleaning. In some instances if an inspector finds a very small quantity of contamination it is removed from the vehicle either by the inspector or by a non- MAF assistant, enabling clearance of the vehicle without further treatment and inspection. This is called assisted cleaning. Since none of the vehicles that were inspected in New Zealand were subject to cleaning prior to inspection, the contamination rates for vehicles inspected in New Zealand are likely to reflect rates in the absence of management. The approximate amount of contaminant was also recorded and 31 percent of all surveyed vehicles (onshore and offshore) contaminated with plant debris had more than ten items (leaves, twigs, bark etc.) Note that only four items of machinery were included in the survey.

Table 5. Treatment of imported used vehicles inspected 12-20 March 2006

	Inspection in Japan	Inspection in New Zealand
number of vehicles inspected	1509 internal & external 628 internal only 998 external only	1469 internal & external
% inspected vehicles pre-cleaned	95%	0
% (and number) vehicles subject to assisted clean	20% (624)	1% (13)
% (and number) inspected vehicles which are trucks, buses, or 4WD	11% (328)	12% (180)
% (and number) inspected vehicles vacuumed after inspection	13% (395)	78% (1142)
% (and number) inspected vehicles pressure washed after inspection	23% (725)	49% (718)

Tables 4 and 5 illustrate differences in the management of the pathway in Japan and New Zealand. Vehicles inspected in New Zealand generally receive no treatment prior to inspection. The contamination rates for vehicles inspected in New Zealand are therefore more likely to reflect actual contamination rates. However since a significant proportion of contamination is not detectable visually and there is also considerable slippage of visible contamination of these types, see section 20.7.1, these figures represent an understated rate. Note that the contaminant recording provides only a brief snapshot and there may be differences in levels of contamination during different seasons, which are not reflected in these figures. Records from all the Terminal Receiving Facilities in Japan have been amalgamated, as have the records from all ports of entry into New Zealand. It is assumed that there are no significant differences in contamination rates or detection rates between facilities and ports.

There are periodic reports of gross contamination on agricultural and forestry machinery. For instance an imported wood chipper has been reported with the chip container full with several kilos of wood material and in another instance, up to 200kg of soil has been removed from used machinery (Smith and Toy, 2006).

Imported new vehicle survey

In a survey of 500 new vehicles in 1999, no soil or plant debris contamination was recorded (Whimp and Moore, 1999). However there is a report of stevedores unloading a new truck from Australia alerting MAF inspectors to heavy contamination with plant debris in the engine compartment, under wiper blades and in the tray supports (MAF Quarantine Service, 2005). Similarly, new agricultural machines which have been field tested before export may be contaminated. A new machine imported into Australia was found to be contaminated with 3 kg of wheat straw and seed (Stansbury et al. 2002). In Japan trees are planted on road sides around all port areas. Leaves from these trees can easily blow onto vehicles stored waiting for shipment and may lodge around the wipers and other areas (Toy and Glassey, 2006).

These surveys are snapshots and give no indication of seasonal variation in levels of contamination. There are anecdotal reports that plant material and soil are more commonly found as a contaminant in northern hemisphere autumn and winter respectively. It is assumed that there will be significant seasonal variation.

20.2.2 Likelihood of microbes being associated with soil, plant or animal debris

There is no information available on the degree of contamination of soil, plant and animal debris in imported vehicles by various microbes. However, Table 6 summarises the results of unpublished research by AgResearch into the biosecurity risk posed by soil on the footwear of international air passengers at Christchurch International Airport (McNeill et al. 2006). This was a limited survey carried out between 08 March and 04 April 2006. 60 samples were taken from footwear, two from soil on tent pegs and two from debris inside tents. Of the 64 samples, 34 were examined for fungi and bacteria. Twenty-one of the samples were examined for nematodes. Relatively high numbers of bacteria and fungi were recovered from all samples, despite many of the soil samples being very dry. Bacteria were isolated from all 34 samples, while 32 samples were found to contain fungi. Nematodes were found in 16 of the 21 samples with the total number of nematodes per sample ranging from 3 to 400. Organisms extracted from the samples were not identified, nor was viability assessed.

Table 6. Summary of contaminants associated with soil sampled from footwear of international passengers entering New Zealand, 8 March to 4 April 2006.

Hazard group	Samples containing hazard	Minimum volume of soil sample containing hazard	Maximum number per soil sample	Comments
fungi	32 out of 34 samples (94%)	0.02 g	8.25 x10 ³ colony forming units per gram of soil	many samples were very dry when collected
bacteria	34 out of 34 samples (100%)	0.02 g	9.5 x10 ⁶ colony forming units per gram of soil	a wider range of colony morphologies indicate the presence of a range of bacterial genera
nematodes	16 out of 22 samples (76%)	0.97 g	1400	>90% nematodes were dauer larvae (resistant life stage)
seeds	35 out of 60 samples (58%)	0.15 g	20	5 different species in 1 sample

These results indicate that very small quantities of soil can support potential hazards. Similarly the record for sporulating *Phomopsis* sp. (a genus containing many organisms of concern) on dry leaf fragments and twigs intercepted on a vehicle (Table 1) indicates that even small quantities of plant debris can contain potential hazards. Teliospore numbers of *Tilletia indica*, causal agent of Karnal bunt, reportedly reach densities of 2-50.5 x10³ per cm³ of soil in contaminated (Murray and Brennan, 1998). The free-living nematode *Panagrolaimus* has been isolated from 5-10 ml of dry soil some 8 years after it was collected. The isolated nematodes bred and the resulting eggs hatched and developed into fertile adults (Aroian et al. 1993). Nematode eggs and juveniles have also been shown to be able to survive anhydrobiotically in plant debris (Barrett, 1991).

A much larger study of microscopic contaminants of soil from shipping containers also demonstrated high levels of fungal contamination. Soil samples were collected from 1150 containers. Out of these, 953 (83 percent) yielded fungi belonging to genera which include forestry pathogens. Only 347 of the soil samples were examined for the presence of nematodes. Of these 279 samples (81 percent) contained nematodes, but only 15 (4 percent of the total) samples contained plant parasitic nematodes. Only forestry pathogens were sought in this study (Gadgil et al. 2000). The extent to which the results of these studies are applicable to soil contamination of vehicles is not known. However since in both cases the samples came from footwear or containers sourced from a wide variety of countries, albeit

with different journey times, similar levels and types of microscopic contamination are expected in soil associated with vehicles.

Less information is available on the frequency with which plant debris is contaminated with pathogens. A Forest Research Institute (1996) analysis of 364 samples of plant debris and some soil, collected by quarantine officers from used vehicles and machinery between January 1994 and mid July 1996 identified only fungi of forestry interest and these only to genus level. The majority of samples (78 percent) supported fungal material, of which 78(21 percent of total samples) supported fruiting or sporulating fungi. This study concluded that vehicles are likely to be a significant pathway for foliage pathogens to enter New Zealand (Forest Research Institute, 1996).

During the Biosecurity Monitoring Group used vehicle slippage survey, plant material intercepted after vehicles had received biosecurity clearance was examined by surveyors in the laboratory under a dissection microscope for signs of fungal disease. Specimens showing signs of infection were sent to the MAF Identification and Diagnostics laboratory for identification. Only three, less than 1 percent of samples of plant material found during the survey, were sent to the laboratory for fungal culturing. Of these, two identifications were inconclusive and one was identified to species level as the non-regulated, ubiquitous, fungus *Cladosporium cladosporioides*.

Neither study specifically looked for nematodes or other plant pathogens. However, whilst anhydrobiotic nematodes would probably not be detectable, the nematodes most likely to be associated with plant material are those associated with galls or eelworm masses, which should be detectable through the microscope. No such evidence was found during the inspection for of plant material for signs of fungal disease in the Biosecurity Monitoring Group survey.

The differences in levels of fungal contamination of plant debris between the two surveys are large. Possible explanations include:

- plant debris which is not intercepted by MAF Quarantine Service officers in their standard inspections differs from that routinely intercepted which was the type analysed in the 1994 survey. For instance, slipped plant material is likely to be smaller than that routinely identified. It is also most frequently located in parts of the vehicle that present a relatively hostile environment, particularly the engine bay and bonnet (see Table 11 and paragraph 20.2.3);
- the Forest Research Institute survey included samples from machinery, whereas the Biosecurity Monitoring Group survey was restricted to passenger vehicles. The plant debris associated with machinery might be expected to have a greater proportion of pathogens. However Table 1 indicates that samples from vehicles also had fungal contaminants;
- the Forest Research Institute survey was undertaken between January and July, whilst the slippage survey took place in November. These seasonal differences may have influenced the results.

For these reasons it seems likely that the Forest Research Institute results are more likely to be representative for **initial** plant debris contamination (prior to inspection or decontamination), however there remains uncertainty about the likelihood of plant debris being contaminated with pathogens.

The likelihood of soil, plant or animal debris contamination associated with the pathway being contaminated by any particular bacteria, virus, fungus or nematode will depend on:

- the prevalence of the organism in the area where the vehicle or machinery was used and/or stored prior to shipment. For instance the potato wart disease is most prevalent in potato growing rural areas (Jennings et al. 1997);
- the time of year at which the vehicle becomes contaminated. For instance the propagules of *Phytophthora ramorum* (the causal agent for sudden oak death, which is not present in New Zealand) are not detected in soil or plant litter during the summer dry season, whereas they are regularly found at other times of year (Davidson et al. 2005);
- the use of the vehicle. Agricultural equipment and machinery is more likely to have been used in locations where organisms of concern occur. Wire ropes on these machines are more likely to be of concern than those on recreational four wheel drive vehicles.

These risk factors have all been found to be important in the contamination of vehicles in Newfoundland with spores of *Synchytrium endobioticum*, potato wart disease. The spores were found both inside and outside vehicles originating from properties infected with the fungus, but not in vehicles from properties without the fungus. Some infected vehicles included those that appeared to be 'clean' (Jennings et al. 1997). Kakau et al. (2004) also concluded that without disinfection at least some *S. endobioticum* can survive on the surface of machinery such as graders even if all visible traces of tubers are removed. In a three year study, spores of *S. endobioticum* were found on average in 8 percent of soil material vacuumed from the floor area of the passenger compartments of cars and vans and the cabs of trucks leaving Newfoundland (Hampson et al. 1996). *Synchytrium endobioticum* is an unwanted organism in New Zealand, and is under eradication in Invercargill.

A study of fungi isolated from plant debris inside a sample of 45 tents accompanying passengers arriving at Auckland airport in 1981 found that potentially pathogenic fungi were present, but spores of forest pathogens were not found to have accumulated in the roof of the tents and the spores that were present had a low viability (Gadgil and Flint, 1983). The likelihood of pathogenic spores contaminating imported vehicles and remaining on the vehicle during shipment is therefore uncertain.

Nematode cysts and fungal spores can be transported in wind blown dust (Thomason and Caswell, 1987). Gadgil et al. (2000) found fungal genera that include pathogens in 83 percent of soil samples in a survey of sea containers. Marshall and Varney (2000) extracted pathogenic fungi from both organic and inorganic soil contaminating the exterior of sea containers. Those associated with inorganic sands were thought to be chance contaminants, most likely wind blown or rain deposited. Samples containing organic material were considered to be of higher risk since they are likely to have been picked up in the original location where the micro-organism occurs. Soil that does not contain organic matter is generally not considered to represent a potential hazard (Canadian Food Inspection Agency, 2002; Department of the Army, 1969; MAF Quarantine Service, 2006; Smith and Toy, 2006; U.S. Department of Agriculture, 2001).

Soil associated with used vehicles and equipment has been recognised as a pathway for the spread of a number of organisms to new countries such as the potato cyst nematode, *Globodera pallida* (North American Plant Protection Organisation).

In a review of interception records sent to Forest Research for identification in the period 1994 to 1997 from six inanimate pathways, vehicles and machinery were the recorded

pathway for 637 out of 1312 (49 percent) of the interceptions, excluding wood boring insects. Plant debris was the most frequently recorded interception type. The study concluded that vehicles are likely to be a significant pathway for foliage pathogens entering New Zealand (Ridley et al. 2000). Forest Research unpublished records supplied by Ensis, for the period 1997-2000, indicate that 45 percent of records were from vehicles and machinery and 71 percent of interceptions were plant debris. Note, however, the nursery stock and cut flowers and foliage pathways, which are also likely to be significant pathways for entry of plant pathogens, were not included in any of these data.

A pest risk analysis of Pine Pitch Canker (caused by *Fusarium circinatum*) assessed five potential pathways for entry of the fungus into New Zealand. It concluded that plant material associated with used logging machinery, and seed had the highest probability of resulting in establishment. Given records of pitch canker in Japan, the assessment also highlights the risk associated with plant debris associated with domestic vehicles from Japan (Dick and Bain, 1996). *Fusarium circinatum* has been isolated from seed and can survive in soil (Dick, 1998; Viljoen et al. 1994). The pest risk analysis reports an unpublished Forest Research Institute evaluation of the mycoflora contained in dust retained in the air cleaners of three forestry skidders from which the pathogenic *Fusarium solani* was isolated. The primary air cleaners of heavy machinery take in large volumes of air. For instance a Caterpillar D8 Bulldozer with a motor operating at 2200 rpm takes in some 50,600 litres of air every minute without any turbochargers or superchargers (J. Hinton pers. comm.). These large volumes taken from environments in which air-borne pathogens are prevalent, are likely to result in retention of spores in the filters.

There is some evidence that exotic decay fungi have entered New Zealand on wood. For instance laminated root rot *Phellinus weirii* has been intercepted on a totem pole from Canada and imported Douglas fir timber has been found with decay caused by *Phellinus pini* (Ian Hood pers. comm.). The number of imported vehicles and boats with wooden decks is not known. However, in the 18 months to September 2005, 660 trucks (only a proportion of which will have had wooden decks) were imported (MAF Quancargo database). The likelihood of entry via this pathway in comparison with pathways with larger volumes such as imported timber and timber products such as pallets is low. These pathways may also be expected to have wood which is more likely to be contaminated with wood decay than vehicles decks.

Infectious diseases of animals can also be spread by vehicles. In the case of foot and mouth disease the virus can be spread by contaminated transport trucks, and regulations are in place in many countries to disinfect these and the tyres of cars that pass through infected areas. In the major outbreak of swine fever in the Netherlands in 1997/8 transport trucks are believed to have played a major role in disseminating the virus (Elber et al. 1999). However there has never been a recorded or objectively documented case of the virus being spread globally by this method. The likelihood of the virus surviving the voyage is negligible due to the voyage time, the temperatures encountered and the effects of desiccation (Pharo, 2002).

The presence of soil and plant material on second hand machinery imported from overseas has been identified as one of a number of important means of introduction of virulent pathogens into the Australian cotton and wheat industries (Allen, 1995, Murray and Brennan, 1998, Stansbury et al. 2002). The likelihood of spores of *Tilletia indica*, Karnal bunt, lodging in machinery used for harvesting grain and the difficulty of cleaning such machinery effectively, resulted in Australia banning the import of complex agricultural machinery from

the USA (Murray and Brennan, 1998). The movement of military vehicles between countries has long been recognised as a high-risk pathway for the introduction of soil borne pests and diseases into America and risk management measures are required (Department of the Army, 1969). The EU requires imported used agricultural machinery to be cleaned of soil and plant debris in order to prevent the introduction of beet necrotic yellow vein virus (Pietsch, 2005).

Vehicles are specifically included in a list of commodities covered by Canadian phytosanitary measures for soil because of their potential to transport a range of soil borne quarantine pests including nematodes and fungi (Canadian Food Inspection Agency, 2002).

20.2.3 Likelihood of surviving shipment to New Zealand

There is little information on the viability of micro-organisms associated with contaminants, particularly plant material from imported vehicles.

The survival of any particular organism in soil, plant and animal debris contaminating vehicles and machinery will depend on its biological characteristics and environmental factors during shipment to New Zealand. These will include:

- the amount of the contaminant e.g. the size of the clod of soil, which will determine the degree to which the organism is buffered from the environment;
- the delay between contamination of the vehicle and shipment to New Zealand;
- the duration of the voyage and whether the tropics are crossed;
- the location of the contaminant within the vehicle;
- the life stage of the organism – cysts and spores tend to be resistant to adverse environmental conditions;
- the moisture content of the soil and exposure to ultra-violet light. In the case of most animal diseases only spore forming pathogens would survive in dried soil (Mitscherlich and Marth, 1984). The plant pathogen *Phytophthora lateralis* survives and remains infective in the absence of living host tissue in soil and forest litter for at least seven years. However survival is greatly reduced in dry and hot conditions, with no recovery from soil or root fragments exposed to temperatures greater than 25°C (Hansen and Hamm, 1996). In contrast, for some plant pathogens in field conditions, survival is greater in lignified twigs and seed pods with lower moisture content and consequent microbial activity and decomposition (Konam and Guest, 2002). Nematodes can survive many years in a state of anhydrobiosis. For instance, live nematodes have been extracted from infected plant materials stored at room temperature after 28 and 39 years (Fielding, 1951; Steiner and Albin, 1946). Anhydrobiosis has been recognised as a factor aiding dispersal of nematodes in contaminated seed, and plant debris or in dry soil adhering to plants or agricultural machinery (Barrett, 1991). Factors determining survival in this state are not fully understood but may include the rate of water loss and rehydration (Aroian et al. 1993, Barrett, 1991, Wharton, 1986). Not all nematodes are capable of anhydrobiosis.

Microbe survivability is likely to vary according to its location within the vehicle and in particular whether it is exposed to high temperatures. The hottest parts are likely to be:

- under the bonnet, where noise insulation will also have a heat insulating effect and temperatures may range between 38°C (Nomadics, 2000) and 80°C <http://www.dervman.com/kits.htm> in hot conditions;
- in air filters however better designed intakes use heat shields to isolate the air filter from the rest of the engine compartment which reaches 52-57°C at highway driving speeds (Nomadics, 2000);

- the radiator which operates in the region of 90-100°C and can reach up to 140°C (Branquart, 2006), with air exiting at 63-68°C (Nomadics, 2000);
- the exhaust with temperatures of up to 400°C (Branquart, 2006);
- wheel brakes which reach in excess of 150°C (Branquart, 2006).

Thermal tolerances of hazards likely to be associated with soil, plant and animal debris are considered in section 10.7.2 Based on this information, contamination found on the radiator, exhaust and wheel brakes is assumed to be non viable and are therefore not considered to be a hazard.

Survival times will also depend on the organism involved. Table 7 summarises some reported survival periods for the broad groups of pathogens associated with imported vehicle and machinery.

Table 7. Indicative survival times of a range of pathogens associated with vehicle contaminants

contaminant group	bacteria	viruses	fungi	nematodes
soil	months to years for animal pathogens (Sabirovic, 1994); overwinter for plant pathogens (Agrios, 1988)	days to months for animals viruses	40 years for <i>S.endobioticum</i> (Hampson et al. 1996); six months in the laboratory for <i>P. ramorum</i> (Davidson et al. 2005).	years in an anhydrobiotic state as adult, egg or cyst (Aroian et al. 1993; Ferris et al. 2003, Luc et al. 1990)
plant debris	overwinter (Agrios, 1988).	not relevant since transmission of plant viruses require vegetative propagation or direct transfer of sap	months to years as spores (Dick and Bain, 1996)	years in an anhydrobiotic state as adult, egg or cyst (Ferris et al. 2003; Luc et al. 1990)
animal debris/faeces	days to months , but years for anthrax and clostridia (Sabirovic, 1994)	days to weeks	unknown	unknown

The only information available on the actual viability of pathogens entering New Zealand on the vehicle pathway, comes from 78 samples (21 percent of 364 samples) of plant debris and soil that supported fruiting or sporulating fungi, collected from imported used machinery and analysed by the Forest Research Institute between January 1994 and July 1996 (Forest Research Institute, 1996). In contrast less than 1 percent of plant debris intercepted during the Biosecurity Monitoring Group slippage survey had signs of viable fungi. In the latter survey, intercepted plant material was examined by surveyors in the laboratory under a microscope for signs of fungal disease (Wedde et al. 2006). Viable fungi may not always display signs able to be seen through a microscope. As part of a contract to develop methods for the rapid identification of target pathogens in imported wood, the University of Waikato identified fungi on 38 visually compromised wood samples provided by MAF Quarantine Service. These included samples with sporangiophores and fruiting bodies. The reports for 4 of the samples explain that the fruiting bodies produced no viable or ripe spores, or at least they did not grow on the medium used (Janson and Farrell, 2000b).

The range of fungal species in the genera isolated from soil samples from the exterior of sea containers was less than that found in samples of New Zealand field soil. This might reflect the limited survival of the journey by fungal contaminants (Marshall and Varney, 2000). However containers are stowed on the deck of ships and subjected to strong salt winds, whereas vehicles are usually stored inside the vessel and consequently are more protected from the elements. The applicability of this result to the vehicle pathway is therefore questionable.

Nematodes are only likely to enter New Zealand via imported vehicles or machinery in soil or plant material and only in anhydrobiotic form. Other life stages require moisture. Anhydrobiotic stages include cysts in soil, for example *Heterodera* spp. and *Globodera* spp. or in seeds, often in galls e.g. *Anguina tritici* (wheat nematode), and large aggregates of overwintering stages often known as eelworm wool, for instance in *Ditylenchus dipsaci*. These occur either in the soil or sometimes in leaf petioles or tubers. In some species so called dauer larvae have a modified cuticle structure to reduce permeability.

20.2.4 Conclusion on entry assessment

Given that:

- a large proportion of imported used vehicles and machinery are contaminated with soil and plant material and to a lesser extent animal material;
- soil and plant debris on vehicles are known to contain some serious pathogens;
- many pathogens are likely to survive in soil, plant and animal debris for periods greater than the journey time from the major vehicle exporting countries to New Zealand;
- many pathogens often have a resistant form such as a spore or cyst;
- the volume of contamination necessary to transmit pathogens is unknown but likely to be small and within the range found on vehicles and machinery.

It is concluded that the likelihood of exotic pathogens, entering New Zealand on the **used vehicle and machinery pathway is non negligible**. The likelihood of entry is greater for used than for new equipment and machinery and depends on the locations in which they have been used and the nature of that use. There is greater uncertainty about the likelihood of entry on plant material than in soil. For many pathogens, directly infected commodities are likely to be more important pathways for entry to New Zealand.

It is assumed that the majority of new vehicles will only be contaminated with inorganic road film and the dust that accumulates on vehicles during storage and shipping. There is limited evidence of contamination of new vehicles and machinery with plant debris but depending on storage conditions, it is assumed that contamination will occur. The likelihood of pathogens entering New Zealand associated with soil, plant and animal debris on the **new vehicle pathway is considered to be low but non negligible**.

20.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

Assuming that New Zealand has suitable environmental conditions for the establishment of a range of pathogens associated with soil, plant and animal material, the likelihood of establishment will depend on the likelihood of transmission of the pathogens from the vehicle or equipment to a susceptible host. This will depend on:

- the destination of the vehicle/machinery in relation to susceptible hosts. There are no restrictions on their distribution within New Zealand, so the likelihood of transfer to a suitable location is non negligible;
- the use of the vehicle/machinery. Forestry and agricultural machinery is more likely to be used in a location with hosts susceptible to forestry and agricultural pathogens. It is for this reason that Australia has more stringent risk management measures for used machinery than for standard road vehicles (D. Ironside, pers. comm.). Used agricultural equipment is recognised as a major pathway for exotic diseases of rice and wheat entering Australia (Lanoiselet et al. 2001; Stansbury et al. 2002; Wharton, 1986). Regular passenger vehicles are most likely to be used in urban situations. This does not preclude the presence of a susceptible host;
- contact between the contaminants on a vehicle/equipment and susceptible hosts. The type of contact necessary for transmission of a pathogen will depend on the organism concerned.

Transfer from a contaminated vehicle/machine to a suitable environment could occur by:

- faeces, soil or other material being washed off or swept from the vehicle directly into the receiving environment;
- air filters being changed at a garage and disposed of as general municipal waste, and thence transferred to a landfill site. Wind, bird or rat vectored transfer could occur from the land fill site;
- air filters being changed in a back yard situation and tossed directly into surrounding vegetation;
- re-usable air filters of machinery being cleaned and the contents being disposed of directly into the environment at the maintenance yard or in the forest;
- food materials within a vehicle disposed of to municipal waste or more rarely transferred directly to the environment.

Transfer is unlikely to occur from concealed parts of a vehicle's structure which are not accessible without some dismantling of the vehicle. Such dismantling is likely to occur in vehicle repair yards.

In all cases, once in the environment, the pathogen would need to be transferred to a susceptible host through:

- ingestion, inhalation or contact with skin wounds or mucous membranes in the case of animal pathogens;
- being blown by the wind, or carried in water in the case of many plant pathogens except viruses;
- moving directly from the contaminated soil/material into the adjoining soil/host for instance in the case of nematodes;
- transfer by vectors such as birds or invertebrates. For instance, the paucity of suitable vectors may hinder the spread the spread of pine pitch canker if introduced to New Zealand (Dick, 1998).

The likelihood of transfer to a suitable host occurring will depend on a range of organism specific factors such as spatial distribution and abundance of the host, time of year and climatic conditions (Bedding et al. 1993; Jules et al. 2002). Inoculum efficiency or the number of propagules required for successful infection is another important factor (Hampson et al. 1996). The reproductive potential of nematodes for instance is often great, and various

reproductive mechanisms, including parthenogenesis, may facilitate establishment in new areas (Wharton, 1986). However, work on use of nematodes as biological control agents has demonstrated that it is often a considerable challenge to transfer nematodes to a new receiving environment in sufficient quantities to achieve establishment, due to the adverse effects of rapid desiccation and ultra violet radiation (Bedding et al. 1993). Dormant/diapausing stages such as cysts need to be re-activated. The efficacy of this will depend on temperature and moisture levels and in some cases on host root exudates. Survival has been found to be better if rehydration is slow and repeated cycles of drying and wetting are avoided. Extreme states of anhydrobiosis appear to be more common in nematodes in water-stressed environments such as drying, above-ground plant parts (McSorley, 2003).

It is difficult to generalise about the likelihood of establishment of wood rot fungi. There is limited evidence that exotic wood rot species may have established in New Zealand. For instance some species of wood rot fungi are mainly recorded on exotic host species, and some species have only been recorded in recent years and not by the early mycologists (I. Hood pers. comm.).

Vehicles are imported into New Zealand for the long term and are distributed throughout the country. There is therefore a higher likelihood that any contaminants will be transferred to a suitable host than by many other entry pathways. For many pathogens it is impractical to detect an established exotic species at a sufficiently early stage to have any chance of eradicating it. A few cysts introduced into clean land will require several generations of multiplication before cyst numbers are readily detectable by soil sampling (Cotten and Van Riel, 1993).

There have been few quantitative studies on the role of vehicles in spreading pathogens. Jules et al. (2002) determined that 72 percent of infection events of the non-native root pathogen *Phytophthora lateralis* in a 37 km² study area in the USA were caused by dispersal of thick-walled chlamydospores in mud dislodging from vehicles along roads, and the remainder by foot traffic. The maximum observed distance that spores had successfully dispersed off a road surface in this study was 165m. Whilst this study demonstrates the ability of contaminated mud from vehicles to infect new areas at a regional level, there is still uncertainty about whether material contaminated with viable pathogens is likely to remain on a vehicle after international transfer and then become dislodged in a vulnerable location. The likelihood is expected to be much greater for equipment and machinery which is likely to have greater quantities of contamination and is more likely to be taken directly to a vulnerable location, thereby retaining a greater proportion of the soil and plant material. Timber harvesting equipment, which transports more mud and organic material than passenger vehicles, is thought to be particularly important in spreading pathogens (Forest Research Institute, 1996; Hansen et al. 2000; Jules et al. 2002). Whilst there are no data on the frequency of contamination of wire ropes, anecdotal reports indicate that those on most imported four wheel drive vehicles have not been used, whilst those attached to forestry machinery are usually heavily contaminated with soil, plant material and seeds. These are also most likely to be used in locations with suitable hosts for any associated pathogens.

20.3.1 Conclusion of establishment assessment

Given the conditions in which imported vehicles and machinery may be used in New Zealand and the diverse biological characteristics of the micro-organisms associated with soil, plant and animal debris, the likelihood of establishment of an exotic pathogen is considered to be

low but **non negligible**. The likelihood will be **higher for agricultural and forestry machinery** which is more likely to be used in the vicinity of susceptible hosts.

20.4 CONSEQUENCE ASSESSMENT

The rate of spread of pathogens will depend on the availability of vectors (where vectors are a component of the epidemiology), and the biology of the individual organism e.g. (Dick, 1998; Riggs, 1977; Sikora and Greco, 1990). Once established, experience with a number of diseases has shown that pathogens are often not detected for some time and are subsequently very difficult to eradicate or control.

20.4.1 Direct effects

The economic impacts of establishment of a new pathogen in New Zealand could be very high. For instance Branson and Layton (2005) estimated the impacts (in June 2004 NZ dollars) of a *F. circinatum* incursion on the nursery, plantation forest, Christmas tree and urban area amenity planting sectors over a 35 year period would total:

- NZ \$10 million under a low impact scenario (outbreak confined to a single nursery, eradicated within two years);
- NZ \$32 million under a medium impact scenario (pitch canker spreads to all nurseries growing pines, but does not appear in plantation forests or urban area amenity plantings); and
- NZ \$267million under a high impact scenario (pitch canker spreads to all nurseries growing pines, plantation forests and urban areas).

This would be considered a high consequence pest.

The outbreak of foot and mouth disease in England in 2001 was estimated to cost the government £3.1 billion (approximately NZ\$ 9 billion) (Thompson et al. 2002). The number of animals in England is not dissimilar to that in New Zealand and the English economy is less dependent on agriculture than that of New Zealand. In the outbreak of swine fever in the Netherlands in 1997/8 the overall costs and losses were estimated at 2 billion Euros (European Commission, 2001). Note however, that the likelihood of foot and mouth disease entering New Zealand via the vehicle pathway is very low (Pharo, 2002; Sabirovic, 1994).

The economic impact from crop losses alone from the soybean nematode, *H. glycines* based on a conservative 1 percent decrease in production in the U.S.A. was estimated in 1987 as US \$190 million a year (Noel, 1992).

Based on the history of ingress of pathogenic fungi into New Zealand, impacts on indigenous forests are most likely to be caused by organisms from other Gondwanan remnants with a similar floristic and climatic composition (Ridley et al. 2000). On this basis, used forestry equipment from Australia is likely to be of particular concern. During the period 01/01/2004 to 30/09/2005, five vehicles in this category (harvesters) were imported from Australia. The majority of used forestry equipment is imported from the USA. New Zealand's primary plantation species, *Pinus radiata* originates from the USA, where the pitch canker fungus *F. circinatum* has been introduced from central America and is now widespread in several states. Many other serious pathogens of pine are present in North America.

A number of fungi are known to be of medical significance. For instance, the genus *Fusarium* contains important mycotoxin-producing species that have been implicated in human diseases,

such as oesophageal cancer, as well as several animal diseases, including hemorrhagic, estrogenic, emetic, and feed refusal syndromes, fescue foot, degnala disease, mouldy sweet potato toxicosis, bean hulls poisoning, and equine leukoencephalomalacia. *Fusarium* species are present in New Zealand and some of the syndromes mentioned occur here in animals but are not of great economic importance. Therefore it is hard to judge whether any entering via the vehicle pathway are exotic and constitute a biosecurity risk.

The consequences for indigenous biodiversity and ecosystem processes of entry and establishment of exotic species of decay fungi are not known, and there may also be impacts from the effect of decay on wooden houses, and possible health effects (mycotoxins). The impacts of pathogenic species are clearer for species whose host plants are plantation species in New Zealand.

20.4.2 Indirect effects

If a pathogen such as *F. circinatum*, were to become established in New Zealand, it is likely that a number of countries such as Australia and China receiving New Zealand's unprocessed *Pinus radiata* wood exports (e.g. logs, timber, wood chips) would require the wood to be heat treated before export as a phytosanitary measure. This would substantially reduce the profit margin associated with these products (Gadgil et al. 2003). An indication of the possible indirect effects can be gained from consideration of the economic impacts of the pathogen *Nectria fuckeliana*, including the consequences of the imposition of phyto-sanitary regulations to prevent its arrival in some of New Zealand's major export markets – China, Japan and South Korea. Depending on the assumed area affected by *N. fuckeliana*, the net present value of New Zealand's forest sector gross revenue has been assessed as being reduced by US\$34 million to US\$612 million, due to reduced harvest and log exports, following forest stock loss due to the pest. Debarking exported New Zealand logs while holding *N. fuckeliana* on the already affected area was estimated to reduce the present value of New Zealand growers' revenues by US\$1,200 million. If instead China, Japan and South Korea banned New Zealand log exports, and the pest continued to spread at historical rates, the present value of New Zealand growers' revenues would decrease by US\$8,200 million. Estimated losses to growers would be partly offset by increased domestic production of processed wood products, under both trade measures (Turner et al. 2006).

The establishment of some animal diseases would have deleterious effects on trade. In the worst scenario a total ban on the export of New Zealand animal products might be imposed. Since New Zealand's economy is heavily dependant on exporting animal products this could have a significant effect on the economy.

20.4.3 Conclusion of consequence assessment

The likely economic, human and animal health, and environmental consequences of pathogens associated with contamination on the vehicle and machinery pathway becoming established in New Zealand vary with species but in at least some cases will be **non negligible**. Some high consequence pathogens are likely to be associated the pathway.

20.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of a new type of pathogen associated with contamination on the used vehicle and equipment pathway is non negligible; and
- the human and animal health, economic, social and environmental consequences of establishment of at least some such organisms would be non negligible; and
- many countries have recognised the range of risks associated with soil and have put measures in place to manage the risk.

The risk is considered to be non negligible for used vehicles and machinery and risk management measures are justified. The risk is highest for vehicles and machinery that have been used off road or in agricultural or forestry situations and which are contaminated with soil, plant or animal material. These are not readily identified by vehicle type, but are likely to be identifiable during unloading. Relatively few vehicles are likely to present the greatest risk for this group of contaminants. The risk is also likely to be higher for contaminants that are readily detectable through visual inspection, and are more likely to be dislodged from the imported vehicle.

The identification of fungal cultures isolated from wood is very difficult in the absence of fruiting bodies and would require the development of specific cultural/DNA protocols (I. Hood pers. comm.). Therefore, it is not possible to reduce the uncertainty around the risk associated with wood rot in wooden decks in the near future. Given the very low likelihoods of entry and establishment the risk is considered to be negligible and risk management measures are not justified. This conclusion should be reviewed if more information becomes available.

The overall risk for new vehicles is uncertain, although **field tested ‘new’ agriculture vehicles and machinery pose a non negligible risk**

20.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of exotic organisms associated with soil, animal, plant and food debris entering via the vehicle and machinery pathway and establishing in New Zealand.

There is no evidence that inorganic material associated with the pathway is likely to contain potential hazards and the following categories are therefore excluded from the definition of soil as a hazard.

- sand or other material free of plant residues or other organic materials;
- any finely textured particles of dust that may be deposited on a vehicle by air currents during shipment;
- any finely textured particles free of organic material deposited on or under a vehicle from use on hard surfaced roads – commonly known as road film.

There is uncertainty about the volume of soil, plant and animal material that can potentially support viable pathogens, but given the microscopic size of most of these organisms it is assumed to be small. Furthermore, small quantities of soil and plant debris can support other hazards such as exotic ant nests (see Chapter 5). Given these factors all soil, plant and animal

contamination is assumed to be a hazard, except that which is located in such a way that it has effectively been heat treated (see 20.7.3).

Furthermore soil, plant and animal debris located within concealed parts of a vehicle's structure which are not accessible without some dismantling of the vehicle is unlikely to be transferred to a location in which any associated pathogens could establish. Such material is therefore not considered to be a hazard.

20.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

20.7.1 Visual inspection

The Biosecurity Monitoring Group undertook two surveys to look at the effectiveness of visual inspections. These found that visual inspection was not effective at detecting all biosecurity contamination, because there is hidden contamination unable to be detected visually, and also due to inspection failing to detect all visible contaminants. Contamination that was not detected during clearance inspections is referred to as 'slippage'.

Plant material was the most commonly found contaminant of used vehicles in both the slippage survey and videoscope trial, (Biosecurity Monitoring Group, 2006; Wedde et al. 2006). The slippage survey was carried out in different locations and using different biosecurity clearance methods (onshore, offshore and containerised clearances). Due to differences in slippage rates between different port and clearance combinations the results were scaled by incoming volumes and added in a model, rather than being simply calculated cumulatively. Table 8 summarises the estimated slippage of contaminants visible through standard visual inspection, non-visible through standard inspection and in air filters. Table 9 indicates the location in which different visible contaminants were found. Note that the results are only for passenger vehicles, not machinery.

Table 8. Estimated number of vehicles (excluding machinery) with slippage of visible contaminants, non visible contaminants and contaminants in air filters during November 2005, by contaminant type. Source Wedde et al. (2006).

Contaminant type	Visible contaminants		In air filters		Non-visible contaminants	
	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval
Plant material	2 181 (14%)	1 977-2 840	1 862 (12%)	1 601-2 511	6 081 (40%)	5 384-6 802
Soil	480 (3%)	494-1 049	33 (0.2%)	125-457	1 562 (10%)	1 211-2 093
Animal material	181 (1%)	251-734	294 (2%)	298-811	230 (1.5%)	141-534

Note: Since some vehicles may have more than one contaminant type or the same contaminant in multiple locations, the numbers in individual columns and rows should not be added.

Table 9. Estimated numbers of imported used vehicles entering New Zealand during November 2005 with contaminants present after biosecurity clearance, by contaminant type and location in the vehicle. Source: Wedde et al. (2006).

Location	Windshield/ wiper	Cabin	Engine bay/bonnet	Door	Chassis/wheel arch
Initial inspection					
Animal material	0	45	0	0	14
Plant material	19	155	250	85	149
Soil	0	0	17	3	124
After decontamination					
Animal material	0	97	0	0	25
Plant material	70	462	814	349	453
Soil	0	0	40	13	322
Total					
Animal material	0	142	0	0	39
Plant material	89	617	1064	434	602
Soil	0	0	57	16	446

Note: Since some vehicles may have more than one contaminant type or the same contaminant in multiple locations, the numbers in individual columns and rows should not be added.

The extent to which plant material slippage constitutes an actual biosecurity risk is uncertain. Of the slipped plant material examined under the microscope less than 1 percent had observable fungal contamination. Table 9 indicates that slipped plant material was most frequently located in parts of the vehicle that present a relatively hostile environment, particularly the engine bay and bonnet (see paragraph 20.2.3). This supports the suggestion that slipped plant material may be less likely to be contaminated by viable pathogens than material that is readily detected by inspectors, and is therefore of lower risk.

The videoscope survey demonstrated that in the case of machinery, the most prevalent type of non-visible contaminant was soil, whilst in all the other vehicle types the most prevalent contaminant was dried plant material (Biosecurity Monitoring Group, 2006). In the case of road vehicles, the vehicle compliance checking centres are likely to expose some of this hidden contamination. Anything they find is currently disposed of to the municipal waste disposal system (N. Boyd, pers.comm.). These centres could be registered as transitional facilities to enable a proportion of this element of the slippage to be managed. It is considered unlikely that soil and plant debris located in parts of the vehicle not detectable by visual inspection and not uncovered through the compliance centre checks will be transferred to a susceptible environment within the period that any associated pathogens remain viable.

The current regime provides for inspection for gross contamination prior to dis-embarking machinery. Where the level of contamination, principally soil and plant debris is such that it is likely to 'escape' prior to inspection, then cleaning on the ship or wrapping is required (MAF Quarantine Service, 2006). In practice this check can only occur on roll-on-roll off vessels. There are safety considerations and inspection even for gross contamination of a machine on a vessel is difficult. Inspectors estimate that in the order of 20 machines a year are identified as grossly contaminated and decontaminated prior to disembarkation and a similar number are grossly contaminated but are not required to be cleaned on ship due to the lack of ability to inspect on board (Smith and Toy, 2006).

Machinery is much more difficult to inspect and decontaminate than passenger vehicles. Two inspectors are generally necessary because of the complicated nature of the equipment.

Experience is advantageous in knowing where to look for contamination on complex machinery. In some cases it is not possible to see the contamination: if it is possible to feel contamination, dismantling occurs. Machinery is often imported in batches, which puts pressure on inspectors as individual machines frequently take more than a day to clear. Machinery has to be cleared on the wharf as there is no means of securely transporting large items to an off-wharf decontamination facility. Demurrage costs can mount up. For this reason specialised machinery is sometimes pre-cleared as a one off arrangement prior to shipment (Smith and Toy, 2006). Guidance specific to individual items of forestry machinery such as de-barkers and skidders has been produced in the past (Anonymous, Undated). Despite being identified in such guidance, air filters on machinery are not currently routinely checked and cleaned.

There is evidence that pathogens such as potato wart, *S. endobioticum*, can be transmitted on apparently clean vehicles and machinery and that risk management can not be based on visual inspection alone (Jennings et al. 1997; Kakau et al. 2004). Used machinery has been identified as particularly high-risk for this hazard group due to its origins and end use (Allen, 1995; Forest Research Institute, 1996). It has been suggested that the lack of mandatory treatment and the slippage of soil and/or plant material on second-hand machinery constitutes a weak link in the effectiveness of quarantine attempts to prevent the introduction of exotic pathogens into the Australian cotton industry (Allen, 1995). Trucks and vans used for transporting livestock are also a higher risk. These do not form a sub-pathway that can be identified in the same way as machinery. A requirement to declare the prior use of all trucks and vans would enable this identification.

In conclusion visual inspection is not effective at detecting all soil, plant and animal debris. However, soil and plant debris located in parts of the vehicle not detectable by visual inspection and not uncovered through the compliance centre checks is considered unlikely to be a risk. Whilst there is uncertainty, there is evidence that the small quantities of visible plant material missed through visual inspection, is of lower risk and that the risk management objective can be met even with some slippage. However the amount of slippage that is acceptable can not be quantified.

20.7.2 Pressure wash and vacuuming

Vacuuming has been found to remove viable fungal spores in soil from the inside of vehicles (Hampson and Wood, 1997). The authors estimated that at least 600 spores of *S. endobioticum* a year at 80 percent infectivity are present in vehicles leaving Newfoundland.

The videoscope survey demonstrated that steam cleaning and vacuuming are not effective in removing soil and plant debris from locations which are not readily visible. Assuming that these hidden contaminants are not likely to be transferred to a suitable receiving environment, pressure wash and vacuuming is likely to meet the risk management objective.

However, there is variation in the efficacy of these treatment regimes. For instance 95 percent of vehicles inspected in Japan during 12-20 March 2006, were pre-cleaned. The details of the cleaning regime are not fully available and there is variation between facilities (Toy and Glassey, 2006), however 49 percent of these pre-cleaned vehicles retained visible contaminants and required additional treatment (MAF unpublished data). Similarly the Biosecurity Monitoring Group found slippage in decontaminated vehicles that had been steam cleaned and/or vacuumed (Wedde et al. 2006).

Mandatory cleaning would therefore need to be accompanied by stringent compliance checking to ensure that the risk management objective is met.

The surveys could be used to improve the efficacy of treatment through focussing attention on the most frequently contaminated parts of the vehicle (Table 9).

The approved treatment for soil and plant debris on vehicles and equipment is decontamination by sweeping and/or washing off and collection or destruction in an approved manner (Biosecurity New Zealand, 2006). There is no specification for the equipment to be used to achieve this decontamination. The requirements for disposal of washings at on-shore facilities are that they are screened through 2mm sieves to remove any solids, which must be incinerated in an approved facility (Ministry of Agriculture and Forestry, 2003). There are no specifications for disposal or treatment of non-solids.

In conclusion, pressure wash and vacuuming accompanied by stringent compliance checking and provision of enhanced waste water screening at onshore facilities is likely to meet the risk management objective.

20.7.3 Heat Treatment

Table 10 illustrates the range of upper thermal limits for a range of organisms.

Table 10 Approximate upper thermal limits for different groups of organisms (from Brock, 1969)

Group of organisms	Upper thermal limit
Protozoa	45-51 °C
Some, but not all fungi	56-60 °C
Blue-green algae	73-75 °C
Bacteria	>90 °C

Bacteria

The thermal resistance of most bacteria is influenced by a number of factors including the stage of growth and the fat and moisture content of the medium. Thus thermal inactivation experiment results for salmonellae in various foods demonstrate significant variation in heat sensitivities amongst different foods and even within the same food group. Gast (1997) reports that salmonellae are generally quite susceptible to heat but MAF Biosecurity Authority (1999) identifies that an internal temperature of chicken meat of 79-85 °C for an average time of 65 minutes is necessary to deactivate *Salmonella* bacteria. There is also variation between strains, with some such as *S. senftenberg* 775W being particularly thermo-resistant (Gast, 1997). Little information is available on survivability of bacteria such as *Salmonella* in soil at temperatures greater than room temperature. Bollen (1969) reports that with increasing soil temperatures from 60°C to 80 °C, the survival of fungi decreases much faster than bacteria, probably due to spore formation in the heat resistant bacteria. The results of experiments with vegetative cells and spores of bacteria have demonstrated that bacteria are much more resistant to dry heat than to moist heat (Mitscherlich and Marth, 1984). Anthrax spores require autoclave temperatures of approximately 121°C (De Vos and Turnbull, 2004). Assuming that survivability in dry soil on a vehicle will not be lower than that in meat products, the temperatures required for effective treatment of bacteria in contamination of vehicles will be too high for safe use on the vehicle pathway.

Viruses

The heat tolerance of viruses depends on their type. For instance avian paramyxoviruses have a lipoprotein envelope, and their susceptibility to heat rapidly increases at temperatures above 40°C. However Infectious Bursal Disease Virus, a poultry virus which is not present in New Zealand is highly heat-resistant, particularly in meat tissues, which may insulate the virus (Alexander and Chettle, 1998; Lukert and Saif, 1997). Similarly some plant viruses such as tobacco mosaic virus require treatment of soil or compost at temperatures in excess of 68°C for more than 20 days to reduce numbers below detection limits (Noble and Roberts, 2004). It is therefore assumed that the temperatures required for effective treatment of viruses are too high for safe use on the vehicle pathway.

Fungi

Experimental data on efficacy of heat against individual fungal species are sparse. The information available indicates that there is considerable variation in the temperatures required to kill different fungal species. For instance, the temperatures and exposure times to eliminate 10 fungal species in wood range from 40-70°C for 10 – 40 minutes (Ridley and Gardner, 2004). Other studies report treatment times to kill other wood decay fungi ranging from 75 minutes at 66°C to 5 minutes at 100°C (Chidester, 1939; Newbill and Morrell, 1991). In laboratory heating tests of seven species of fungi cultures on agar, four of which were plant pathogens, all species were killed by exposure to 60°C for ten minutes, except *Schizophyllum commune*, which required 70°C for ten minutes (Ridley and Crabtree cited in Hosking, 2001b). The latter species is not pathogenic and is a decay fungus and would therefore be expected to be tolerant of high temperatures and since such fungi are usually associated with self-heating piles of organic matter, they are unlikely to be associated with the vehicle and machinery pathway.

In a study of greenhouse soils, many *Mucor* and *Chaetomium* species in greenhouse soil could not be isolated after treatment at 50°C for thirty minutes, and most of the remaining species were killed by treatment at 55°C. Some *Penicillium*, *Aspergillus*, *Phoma* and *Trichocladium* spp survive maximum temperatures between 60°C and 80°C. However in experimental work on greenhouse soil none of the pathogenic species present survived treatment at 60°C (Bollen, 1969). In a composting situation, 33 fungal pathogens were reduced to below detection limits by a peak temperature of 64 -70 °C for 21 days. Shorter periods and/or lower temperatures may be satisfactory for eradication, but were not examined in detail (Noble and Roberts, 2004). Ridley and Gardner (2004) investigated whether heat tolerance increases with desiccation and found that for some species tolerance decreases. They also found that all species tested could withstand higher temperatures when growing in wood than in agar in a test-tube. Bollen (1969) noted when examining the effect of heat treatment on the microflora of greenhouse soils that species that produced resting structures were more heat tolerant than those that did not.

There is considerable debate about the relative importance of fungal species that can survive exposure to high temperatures. Many have fairly restricted environmental requirements and would therefore be unlikely to become serious pests in a new country. However it is thought that thermal tolerance may be linked to resistant survival structures such as chlamydospores and that some pathogenic species with this characteristic could become serious pests (Morrell, 1995).

Table 11 summarises thermal death data for a range of fungi in genera recorded from the vehicle pathway. Note that the test conditions vary significantly from those found in vehicles.

Table 11. Summary of thermal death data for some species of fungi of genera recorded from the vehicle pathway (see table 1) (Domsch et al. 1980).

Species	Thermal death conditions	Species present in NZ
<i>Alternaria alternata</i>	63°C for 25 minutes in apple juice	yes
<i>Chaetomium globosum</i>	55-57°C for 10 minutes	yes
<i>Cladosporium herbarum</i>	50-60°C for 30 minutes	uncertain
<i>Mucor racemosus</i>	63°C for 25 minutes	no
<i>Paecilomyces variotii</i>	>60°C	yes
<i>Penicillium corylophilum</i>	60°C for 30 minutes	yes
<i>Penicillium expansum</i>	63°C for 23 minutes in apple juice	yes
<i>Penicillium variable</i>	60°C for one hour	no
<i>Penicillium verrucosum</i> var <i>cyclopium</i>	62°C for 20 minutes in apple juice	no
<i>Phoma herbarum</i>	75°C for 30 minutes	yes
<i>Pythium irre.g.ulare</i>	52.5°C for 30 minutes	yes
<i>Pythium ultimum</i>	49.5°C for 30 minutes in soil	yes
<i>Trichoderma viride</i>	49-55°C for 30 minutes	yes

Experimental treatment of soil and plant debris in kiln trials has had inconclusive results. Whilst killing some fungi growing in it, it also triggers the germination of dormant spores. Given the large number of species that make up the assemblage of fungi associated with these contaminants it was not possible to determine whether undesirable species were eliminated by the treatment (Ridley and Crabtree cited Hosking, 2001b).

BNZ-STD- ABTRT requires treatment at a core temperature of 70°C for 4 hours for wood products likely to be contaminated with pathogens including fungi, based on a precautionary sterilisation approach, given that the individual species and strains involved are not known and can not be readily determined. BNZ-STD- ABTRT specifies treatment of 100°C for 25 minutes or 85 °C for 15 hours of soil volumes less than 10 kgs likely to contain micro-organisms including insects, bacteria and fungi. This volume is clearly greater than is likely to be found contaminating vehicles.

On the basis of this evidence, it is likely that treatment at a core temperature of 60°C for 30 minutes would effectively treat some but not all fungal contaminants on the used vehicle and equipment pathway. The likelihood of establishment and associated consequences of the species that would not be treated are not known.

Nematodes

Most plant parasitic nematodes are killed at between 44 and 48°C. Treatment is usually hot water and for a period of 3-4 hours (Hooper and Evans, 1993; Whitehead, 1998). The efficacy of higher temperatures for shorter periods is not recorded since treatment is generally of plant products that can not tolerate higher temperatures. It is assumed that a vehicle treatment at 55-60°C for ten minutes would be likely to be effective. However some species are more thermo tolerant, for instance, citrus nematode, *Tylenchulus semipenetrans*, is killed by treatment at 40°C for twelve hours in soil (Xue et al. 2000) and pinewood nematode, *Bursaphelenchus xylophilus*, in wood is killed by treatment at 60°C for one to four hours depending on the thickness of the wood (Dwinell, 1990). Furthermore, nematodes may be able to tolerate high temperatures for short periods if they are in an anhydrobiotic state (Barrett, 1991; Luc et al. 1990). For instance the anhydrobiotic juveniles of *Anguina tritici* (in galls in seeds) can survive exposure to 105 °C for at least 2 minutes (Bird and Buttrose, 1974). Dry golden nematode cysts are reported to tolerate temperatures as high as 75°C for brief periods, and a

brief wetting does not increase susceptibility. However, treatment for one hour at temperatures of 60°C resulted in 100 percent mortality of all life stages (Brodie and Norris, 2001). Steam treatment has been successfully tested for the decontamination of agricultural equipment moving between infested and uninfested parts of the USA (Brodie and Norris, 2001).

Given this variability, it is likely that treatment at a core temperature of 60°C for 30 minutes would effectively treat most but probably not all nematode contaminants on the used vehicle and equipment pathway. The likelihood of establishment and associated consequences of the species that would not be treated are not known.

A number of arthropods including beetles, ants, mites, bugs, collembola, psocids and phasmatids are often associated with soil, plant and animal material and food debris (see Chapters 5, 7, 8, 9, 21, 26, 29, 30 and 33). A review of the heat tolerance of a range of insects concluded that desert ants have the highest critical thermal maximum of up to 55°C for active life stages, depending on the species (Sherwood, 1996). Since invertebrates associated with soil and plant material are expected to be less thermal tolerant than desert ants, and taking account of the buffering effect of small quantities of soil it is assumed that heat treatment at a core temperature of 60 °C for ten minutes will effectively kill all such organisms.

The temperatures routinely reached during standard operation in the following parts of a vehicle are greater than those required to kill most organisms associated with this group of hazards:

- radiator, operates in the region of 90-100°C and can reach up to 140°C (Branquart, 20006) with air exiting at 63-68°C (Nomadics, 2000);
- exhaust, up to 400°C (Branquart, 20006);
- Wheel brakes reach in excess of 150°C (Branquart, 20006).

Soil, plant (unless still green) or animal debris associated with these locations is not considered to be a hazard.

In conclusion, whilst heat treatment is not likely to be a completely effective measure for this group of hazards, it is likely to kill some of the organisms of concern. BNZ-STD- ABTRT (2006) requires treatment of wire ropes in used forestry equipment at 121°C for 15 minutes or 70°C for four hours. This is likely to be effective in killing micro-organisms associated with soil and plant material, but is not a practical treatment for whole vehicles.

20.7.4 Fumigation

Much of the literature on the efficacy of fumigation against pathogens relates to timber and wood products and it is therefore of limited applicability to the vehicle pathway. Fumigation against pathogens is not commonly used for commodities such as vehicles and consequently there is little evidence on appropriate regimes. Methyl bromide is generally considered effective in treating fungi, e.g. oak wilt fungus at very high rates (United States Department of Agriculture). Treatment at 240g/ m³ and 18°C or equivalent for 72 hours is recommended for fungi such as *Armillaria ostoyae*, *Heterobasidion annosum*, *Lachnellula willkommii* and *Leptographium wageneri* in wood blocks (Rhatigan et al. 1998; U.S. Department of Agriculture, 2001). Less stringent regimes would be required for treatment of vehicles due to the much greater gas penetration. Treatment at 72g/ m³ and >21°C or equivalent for 12 hrs is required by BNZ-STD-ABTRT for contaminated wooden decking.

Much of the work on nematode treatment has been carried out in field conditions. It is recognised that application rates can be as much as 9 to 15 times lower for contained trials than would be required under field conditions to kill nematodes (Xue et al. 2000). This reflects the containment of the fumigant as well as the elimination of invasion and re-colonisation from adjacent infested but sub-lethally treated soil areas that would occur in the field. It is assumed that fumigation rates for treatment in vehicles will be more similar to contained conditions than those required for field situations. For Citrus nematode in contained moist soil, treatment at 7.3 mg/kg (equivalent to 15g/ m³) at 20°C for 24 hours (Xue et al. 2000) is effective. For golden nematode in moist soil in field conditions, treatment is reported to be 240g/m³ at 15.5°C and above or equivalent for 24 hours (Karpati et al. 1983). Complete mortality of pine wood nematode in sawn planks is achieved by treatment in a warehouse at 48g/m³ for 24 hours at 20°C (Kawakami and Mizobuchi, 2005).

Formalin is an effective microbe fumigant but is not practical for the treatment of vehicles, see Chapter 4.

A number of arthropods including beetles, ants, mites, bugs, collembola, psocids and phasmatids are often associated with soil, plant and animal material and food debris (see Chapters 5, 7, 8, 9, 21, 26, 29, 30 and 33). Methyl bromide is widely accepted as having high efficacy against most insects and treatment at the current vehicle fumigation rate of 48g/m³ for 24 hours is expected to kill invertebrates associated with soil and plant material.

In conclusion fumigation with methyl bromide is likely to mitigate the risk from most arthropods and nematodes but not fungi associated with vehicles and machinery.

20.7.5 Removal of High-risk Components

The current risk management regime provides for the removal and destruction of wooden decking material which a quarantine inspector judges to be infected with fungi (MAF Quarantine Service, 2006). However a study of fungal contamination of wooden packaging found that wood which appeared to be clean and free from fungal infection, in fact supported a greater diversity of fungal contaminants than obviously infected wood (Janson and Farrell, 2000a). Such contamination may comprise species of biosecurity concern such as sapstain fungi. The risk posed by wood rot fungi is not known, but is likely to be negligible given the low numbers involved and the removal of decks is not considered justified for the management of the risks associated with fungi.

The risk associated with fungal spores in air filters is not fully understood, but is assumed to be highest in used agricultural and forestry equipment. This could be mitigated by mandatory removal of these filters.

Used wire ropes could be removed as an alternative to heat treatment.

20.7.6 Targeted information

A relatively small proportion of vehicles including agricultural and forestry machinery and specialised machinery such as rubbish trucks are considered likely to represent the biggest risk for this hazard group. Therefore provision of alert information material, on the need for effective treatment prior to importation coupled with deterrent measures in the event of infringement could be an effective process. There is however, no evidence of the efficacy of this approach.

20.7.7 Disinfection

Treatment with disinfectant is effective against many viruses and bacteria. BNZ-STD-ABTRT (2006) requires cleaning followed by disinfection for animal contamination on products not intended for human consumption such as boots and equipment.

Disinfectant is only an appropriate treatment if applied following removal of soil and faecal material, since the presence of dirt may make the disinfectant ineffective. Assuming that the likelihood of bacteria continuing to infect a vehicle once the contaminating soil, faecal or other material has been removed is negligible, disinfection would be an unnecessary treatment, except in cases of gross contamination by faecal and infected material such as garbage lorries, sewerage trucks or vehicles used for transporting livestock.

MAF requires the filtered effluent from incineration/sterilisation facilities that receive refuse from ship and aircraft kitchens to be treated with chlorine in order to mitigate the risk of diseases associated with meat, fish, dairy and poultry products surviving in receiving water and being transmitted to animals in New Zealand (MAF Biosecurity Authority, 2000). A review of diseases, their survival in an aqueous environment and susceptibility to chlorine concluded that effluent treatment is not necessary if the effluent is discharged to a sewer. However, treatment of discharge to fresh water to achieve a minimum concentration of available chlorine of 2 100 mg/l at 30 minutes post treatment at a PH of 5.0 to 7.0 with continuous agitation over the treatment period, was recommended. For discharge to seawater a minimum concentration of available chlorine of 25g/l at 30 minutes post treatment was recommended (Bassett, 1998). If grossly contaminated vehicles are treated onshore there should be similar requirements for treatment of resulting effluent.

In conclusion, disinfection is a recommended treatment of gross contamination by faecal and infected material of vehicles such as garbage lorries, sewerage trucks or vehicles used for transporting livestock, and the wash water of any such vehicles decontaminated onshore should be treated with chlorine.

20.7.8 Onshore versus offshore risk management

The slippage survey found no significant difference in the efficacy of the current risk management regime for vehicles imported break-bulk applied onshore and offshore (Wedde et al. 2006).

The major difference between the current offshore and onshore risk management regimes is that a significant proportion of the vehicles that are inspected offshore have been subject to internal and external cleaning prior to inspection. This cleaning is designed to remove contamination in this hazard group prior to inspection. Tables 4 and 5 indicate that this treatment successfully reduces the quantity of contamination entering New Zealand.

A New Zealand Forest Research Institute report on the risk to New Zealand's forests posed by plant debris and soil on imported second hand vehicles and machinery raised concerns that decontamination onshore may stimulate the release of airborne spores which are impossible to contain (Forest Research Institute, 1996). The scale of this issue can not be measured, but since sporulating fungi have been intercepted on arrival (Table 1), it is likely to occur. Offshore risk management ensures that hazardous material does not arrive in New Zealand and therefore does not need to be disposed of securely.

Whilst there are no data on recontamination rates, it is considered unlikely that vehicles treated offshore would become significantly re-contaminated with soil, animal, plant or food debris prior to shipment, except for specific periods of the year, such as during the autumn. Risk management off-shore is therefore likely to reduce the likelihood of both entry and establishment of pathogens associated with these contaminants and is preferred.

Recommended measures

This risk assessment is based on the assumption that all soil, plant and animal contamination is a hazard, except the following categories which are excluded from the definition of soil as a hazard.

- sand or other material free of plant residues or other organic materials;
- any finely textured particles of dust than may be deposited on a vehicle by air currents during shipment;
- any finely textured particles free of organic material deposited on or under a vehicle from use on hard surfaced roads – commonly known as road film.

Furthermore contamination found on the radiator (unless insulated, or freshly blown in), exhaust and wheel brakes are not considered to be hazards.

It is assumed that any micro-organisms associated with non-visible soil, animal and plant debris inside the structure of a vehicle will not be able to establish in New Zealand and is therefore not considered to be a hazard.

The following measures are recommended:

- 1) **For used passenger vehicles (including recreational four wheel drive):**
 - 100 percent visual inspection followed by internal and/or external cleaning to remove all visible soil and plant debris, followed by re-inspection **and** bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4) **and** improved facility standards. The results of the BMG surveys, identifying the locations of contamination should be used to improve the efficacy of treatment; **or**
 - audited mandatory pressure wash and vacuuming, with stringent compliance checking to ensure that the risk management objective is met.
- 2) **For used machinery and high-risk vehicles such as garbage and sewage trucks and trucks used in transporting animal and plant products:**
 - offshore decontamination and inspection by specialised inspectors. Grossly contaminated vehicles should not be permitted entry. A videoscope survey of used machinery planned for 2006-2007 will provide a measure of slippage for this part of the pathway. It is recommended that this measure is reviewed once the results of the survey are known; **and**
 - mandatory disinfection of all vehicles likely to be contaminated with faecal and other infected material including garbage lorries, sewerage trucks and vehicles used for transporting livestock, agricultural products, food stuffs, etc. Note this requires a means of identifying these vehicles. The effluent from decontamination of any such vehicles onshore should be subject to chlorine treatment as outlined in section 20.7.7; **and**
 - mandatory cleaning or replacement of air filters from all used agricultural and forestry equipment; **and**

- removal and destruction or heat treatment at 121°C for 15 minutes or 70°C for four hours of wire ropes on used agricultural and forestry equipment; **and**.
 - provision of targeted information to importers of high-risk vehicles and machinery. This is likely to increase the level of protection by focussing on the highest risk vehicles.
- 3) **Research** on the viability of micro-organisms entering New Zealand associated with plant debris and soil and the likelihood of establishment.

20.8 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

The identity of organisms associated with soil, plant, animal and food debris associated with vehicles and machinery imported into New Zealand and whether they are already present here is largely unknown. Since it is very difficult to identify these micro-organisms to an appropriate level, this uncertainty can not be cheaply reduced:

- it is assumed that very little fresh, green plant material enters via the vehicle pathway and that entry of plant viruses and other pathogens requiring fresh host plant material is negligible;
- the likelihood of contamination of new vehicles with hazardous organisms is uncertain, but it is clear that the risk associated with field tested 'new' machinery is non negligible;
- the seasonal variation in contamination levels is not known, but is assumed to occur;
- the proportion of organisms entering New Zealand that are viable, especially in association with dry plant material and the significance of the location within the vehicle is not fully understood;
- the likelihood of viable fungal spores occurring in air filters is not known;
- the likelihood of transfer of soil and plant material that is not readily visible, to a sensitive location within New Zealand is not known but assumed to be low.

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21 Mites (Acarina)

21.1 HAZARD IDENTIFICATION

21.1.1 Identity

Category: Taxonomic Group: Order: Acarina

Name: Mites and ticks

21.1.2 Association with pathway

Classification of the Acarina is complex and varies considerably according to source.

The interception records for mites for the period 1994 -2006 are summarised in Table 1.

Table 1. Interception records of mites in association with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status (Scott and Emberson, 1999)	Country of origin & pathway	Lifestage (number of records) and viability
unidentified	Eriophyidae	unknown	Japan used vehicle	adult (1)
unidentified		unknown	USA agricultural machinery	live adult (1)
unidentified		unknown	Japan used vehicle	adult on plant debris (1)
<i>Anystis baccharum</i> , whirligig mite	Anystidae	cosmopolitan species, established and common in NZ	unrecorded	post-border (1).
unidentified	Parasatidae	unknown	Samoa agricultural machinery	live adults (1) on plant debris
unidentified	Pyemotidae	unknown	Samoa agricultural machinery	live adult (1)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Most mite species are relatively host specific. Several species inject a persistent and systemic toxin in their saliva and a few species transmit viruses or fungal spores. Many are not visible to the naked eye. Mites are therefore likely to be under-recorded in the interception records. Some of the more important species of mite occur in the major vehicle exporting countries including Japan, the USA, Australasia and Europe. Some species hibernate or aestivate during adverse periods (Hill, 1994), which would increase the likelihood of their surviving shipment to New Zealand in association with contamination by plant debris. Identification of mites is a specialised task.

21.1.3 Conclusion

Given that many mites:

- are minute and not visible without a hand lens they are almost certainly an under-recorded contaminant on the used vehicle and machinery pathway;
- are difficult to identify, it is not possible to determine whether any individual mite associated with vehicular contamination is already present in New Zealand;
- have the capacity to survive adverse conditions via hibernation/aestivation;
- are associated with plant debris;
- are known to cause adverse effects on host plants.

they are considered a **potential hazard on the used vehicle and machinery pathway**. Given the lack of species level identification, it is not possible to generalise about the likelihood of entry and establishment and potential consequences of establishment and spread. Given the association of mites with plant debris, it is assumed that the risk management measures recommended for the management of plant material (see Chapter 20) will adequately manage the risk associated with mites and no further analysis is undertaken.

Given the association of mites with plant debris, it is assumed that the likelihood of entry on **new** vehicles and machinery is **negligible**.

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22 Mosquitoes (Culicidae)

22.1 HAZARD IDENTIFICATION

22.1.1 Identity

Taxonomic Group: Order: Diptera
Family: Culicidae
Common name(s): mosquitoes

22.1.2 Introduction

There are approximately 3 200 known mosquito species and subspecies distributed among 37 genera worldwide (Service, 2000). Container-breeding mosquitoes are particularly successful bio-invaders, due to their ability to survive long journeys as larvae in water-holding receptacles or as eggs that are desiccation tolerant. Used tyres in particular, are important media for the spread of vector species around the world (e.g. Laird et al. 1994). Tyres are covered by a separate import health standard and are not addressed by this risk analysis.

New Zealand has a relatively species-poor mosquito fauna with 12 native and 4 exotic species (Derraik, 2004). There has never been an outbreak of mosquito-borne disease in humans in New Zealand (Derraik and Maguire, 2005), but it is predicted that it is a matter of time before an arboviral outbreak occurs, most likely of Ross River virus (RRV) (Derraik and Calisher, 2004; Kelly-Hope et al. 2002; Weinstein et al. 1995). Such an outbreak would be more likely under a global warming scenario, which would likely extend the areas of suitable climate for vector species in New Zealand, and increase the rate of pathogen/parasite transmission (Weinstein et al. 1995; Woodward et al. 2001; de Wet et al. 2001). The existing threat to human health would be aggravated by the establishment of other exotic mosquito vectors such as Asian tiger mosquito, *Aedes albopictus* (Derraik, 2006).

The interception data for mosquitoes associated with imported vehicles and machinery is summarised in Table 1. Data are based on Derraik (2004), who carried out a review of mosquito interceptions in New Zealand, including data provided by the Biosecurity Monitoring Group. These data have been updated with further records from 2004 to 2006. Note that interceptions of adults from species already present in New Zealand are excluded, since those species (*Culex pervigilans*, *Culex quinquefasciatus* and *Aedes notoscriptus*)¹ are common, particularly in the North Island, and infestation is likely to have occurred in New Zealand.

The records of mosquito interceptions are likely to be more comprehensive than for most other organisms as a result of strict reporting requirements (MAF's response protocol requires any suspected mosquito life stage to be reported to the Ministry of Health within one hour of

¹ The generic names for Culicidae are abbreviated according to Reinert (1975, 1982a, 1982b). Note that all generic and specific names are as per the traditional nomenclature adopted in the 2001 Systematic Catalog of Culicidae (Walter Reed Biosystematics Unit, 2006). The nomenclature adopted is therefore the one prior to Reinert (2000), as recommended by Russell (2006) and Derraik (unpublished).

the finding so that adequate mitigating action by public health authorities can be carried out). However, the review carried out by Derraik (2004) indicated that records are still incomplete and therefore these cannot be used to provide a quantifiable contamination rate. There have been at least 30 interceptions of 8 species of exotic mosquitoes in association with the pathway, at least 23 of which involve live larvae. Six of these species are not present in New Zealand and are discussed below. The majority of interceptions have been from equipment or machinery rather than from cars.

Table 1. Interception records of exotic mosquitoes in association with used vehicles and machinery (adapted from Derraik, 2004). These records cover the period from the 1950s to 2004.

Species	Life Stage	Number of Interceptions	Pathway	Country of Origin
<i>Aedes aegypti</i>	live larvae	1	dragon boat	Rarotonga
	live larvae	1	used machinery	Tonga
	not recorded	1	used machinery	Wallis & Futuna Is.
<i>Aedes albopictus</i>	live adult & larvae	5	used machinery	Japan
	live larvae & pupae	2	rubbish truck	Japan
	live adult & larvae	1	used concrete truck	Japan
	live larvae, pupa & adults	1	cement machine	Malaysia
<i>Aedes polynesiensis</i>	not recorded	1	used machinery	Wallis & Futuna Is.
<i>Culex</i> sp.	dead adult	1	used cars	England
	dead adult	4	used cars	Japan
<i>Culex quinquefasciatus</i>	live larvae	1	used cherry picker	Australia
<i>Aedes japonicus</i>	live larvae	5	used machinery	Japan
	live larvae	2	used concrete truck	Japan
	live larvae	1	water tanker	Japan
<i>Aedes notoscriptus</i>	live larvae	1	used machinery	Australia
<i>Tripteroides bambusa</i>	live larvae	1	used concrete truck	Japan
<i>Uranotaenia novobscura</i>	live larvae	1	used concrete truck	Japan

Aedes aegypti seems to be the only known vector involved in urban epidemics of yellow fever virus (YFV) (Lounibos, 2002), and is the main vector of the four virus serotypes (DENV 1-4) causing dengue fever. It is also a potential vector of RRV (Russell, 2002), and a known vector of Chikungunya virus (CHIKV) (Mangiafico, 1971).

Aedes albopictus has been listed as one of the world's most invasive species by the World Conservation Union (IUCN) (Lowe et al., 2000), having already invaded many countries around the world (e.g. Knudsen, 1995; Lounibos, 2002; Pan-American-Health-Organization, 1993; Savage et al. 1992). Although *Ae. albopictus* until recently had only been identified as an arbovirus vector of dengue viruses, this species is remarkably susceptible to oral infection with numerous arboviruses, most of which can be transmitted in laboratory conditions with varying degrees of efficiency (Mitchell, 1995). An outbreak of CHIKV virus in the Reunion Islands in 2006 demonstrates that this species poses a threat to human health (Derraik and Slaney, 2007). Although it had never been recorded as a field vector of CHIKV anywhere else in the world, the recent isolation of the virus from wild-caught females has incriminated the species as the vector of the outbreak involving tens of thousands of people (Derraik and Slaney, 2007). *Aedes albopictus* has also been found to be a very efficient laboratory vector of WNV (Sardelis et al. 2002), and the virus has been isolated from this species in nature (Turell et al. 2001). *Aedes albopictus* is also a competent laboratory vector of Eastern equine

encephalitis virus (EEEV) (Turell et al. 1994), and EEEV has been isolated from *Ae. albopictus* in Florida (Niebylski et al. 1992). In Italy, this mosquito was shown to be a natural vector of *Dirofilaria immitis* (canine heartworm) (Cancrini et al. 2003). *Aedes albopictus* could also pose a public health risk also as a competent vector of YFV and RRV (Knudsen, 1995; Russell, 2002), La Crosse encephalitis virus (LAC) (Gerhardt et al., 2001), and possibly Japanese encephalitis virus (JEV) (Hawley, 1988).

Aedes japonicus utilizes invasion pathways similar to *Ae. albopictus*. Although *Ae. japonicus* does not appear to be particularly anthropophilic, it is a laboratory vector of JEV (Takashima and Rosen, 1989) and it is an efficient laboratory vector of WNV (Fonseca et al. 2001).

Aedes polynesiensis is a vector of lymphatic filariasis (*Wuchereria bancrofti*) (Zagaria and Savioli, 2002); RRV (Marshall and Miles, 1979) and DEN (Lardeux et al. 2002).

The other species intercepted, *Tripteroides bambusa* and *Uranotaenia novobscura* are not anthropophilic (Tanaka et al. 1979) and are not known to be vectors of human disease. However, no information seems to be available on their host preferences and these species may be of environmental concern in New Zealand.

22.1.3 Conclusion

Given the interceptions of at least four significant exotic mosquitoes that are known disease vectors and are not present in New Zealand, in association with imported vehicles/machinery, mosquitoes are considered to be potential hazards associated with the pathway. Exotic species already present in New Zealand entering via the vehicle and machinery pathway are also considered to be potential hazards. There are known variations in vector competence between populations of the same mosquito species, therefore new genotypes could pose a greater risk than those already present in New Zealand. In addition, arriving specimens could be carriers of arboviruses, which may have been acquired via vertical transmission.

22.2 ENTRY ASSESSMENT

22.2.1 Current distribution

The known distribution of the exotic mosquito species found in association with imported vehicles and machinery is given in Table 2. Most have a worldwide distribution and are present in several vehicle exporting countries including Japan, USA, Australia and Singapore.

Table 2. Known distribution of exotic mosquitoes associated with imported vehicles/machinery.

Species	Distribution ¹
<i>Aedes aegypti</i>	Cosmopolitan in tropical regions, but also in other areas in the South Pacific, Europe, Africa and Asia. Present in Australia, Japan, Singapore and USA.
<i>Aedes albopictus</i>	Widespread, including many countries in the Americas, Africa, Europe, Asia and the South Pacific. Present in Japan, Singapore, USA, Papua New Guinea, and recently discovered in the Torres Strait of Australia (Russell <i>et al</i> 2005).
<i>Aedes polynesiensis</i>	American Samoa , Australia, Cook Islands, Fiji, French Polynesia, Samoa, Tuvalu, United Kingdom
<i>Culex quinquefasciatus</i>	Cosmopolitan throughout the world, and established in New Zealand.
<i>Aedes japonicus</i>	China, Japan, Korea, Russia, Taiwan, United States
<i>Aedes notoscriptus</i>	Australia, Indonesia, New Caledonia, PNG, Solomon Islands, it is established in New Zealand
<i>Tripteroides bambusa</i>	China, Japan, Korea, Taiwan
<i>Uranotaenia novobscura</i>	Southeast Asia, including Japan

¹ As per the Systematic Catalog of the Culicidae (Walter Reed Biosystematics Unit, 2006).

22.2.2 Likelihood of association with the pathway

Aedes aegypti thrives in human-modified environments and breeds readily in all types of artificial container habitats, i.e. any artificial receptacle capable of harbouring stagnant water, in close association with humans (Laird and Mokry, 1983). Only small volumes of water are required for breeding. Similar habitat preferences are described for *Ae. japonicus* and *Ae. albopictus*, although the latter species has preference for areas close to forest cover (Hawley, 1988). Container breeders, such as the three above cited species are capable of breeding in almost any container that harbours water. Therefore, any receptacle that can impound water is a potential breeding habitat for these and other mosquito species.

The data in Table 1 indicate that most interceptions of mosquitoes have been from the water receptacles on used trucks and used machinery. The types of machinery most frequently contaminated with water are reported to be concrete mixers, cherry picker baskets, sewage trucks, garbage trucks, spare buckets in vehicles, construction equipment and boat bilges (Matthews, undated). It seems that a similar situation occurs in Australia in relation to *Ae. albopictus* (Ritchie et al. 2001).

It is not possible to get an accurate indication of the frequency of contamination of imported vehicles with mosquitoes. Vehicles are not fumigated for mosquitoes, so these records are not available. The snapshot contaminant survey over the period 12-20 March 2006, during which MAF Quarantine Service officers recorded the contaminants found in inspected vehicles, by hazard group (MAF unpublished data) only included four items of machinery so provides only limited additional data. The results of the survey, summarised in Table 3 indicate that mosquitoes are regularly found in association with vehicles. However these were all dead adults which are assumed to have been trapped in the vehicle and in the absence of any pooled water will not have laid eggs. Dead adults do not constitute a biosecurity risk. Note that no specimens were identified.

Table 3. Mosquito related contamination recorded on imported used vehicles by MAF Quarantine Service officers 12-20 March 2006.

	number vehicles inspected in Japan	number vehicles inspected in New Zealand
number of vehicles inspected both internally and externally	1509	1469
number of vehicles partially inspected	628 internal only 998 external only	0
percentage of vehicles cleaned prior to biosecurity inspection	95%	0
number vehicles inspected found to contain pooled water	18	14
number of vehicles inspected with dead adult mosquitoes	10	10

The majority of vehicles inspected in Japan are cleaned prior to biosecurity inspection. This cleaning often results in the presence of small amounts of water inside the vehicle. When the vehicle is inspected immediately afterwards, this water is not considered by the inspectors to be evidence of mosquito contamination and is dried with a towel prior to a green sticker being issued. Note that this survey was a brief snapshot and there may be differences in levels of contamination during different seasons, which are not reflected in these figures. Records from all the Terminal Receiving Facilities in Japan have been amalgamated, as have the records from all ports of entry into New Zealand. It is assumed that there are no significant differences in contamination rates or detection rates between facilities and ports.

There are no interception records for mosquitoes from imported new vehicles and machinery. However, it is not the age of the vehicle/machinery that determines the likelihood of contamination, but rather the manner in which it was stored prior to export. Any receptacle capable of harbouring water can harbour mosquito larvae. Therefore, in relation to external contamination, if new and used vehicles/machinery are equally exposed to rainfall, and water is held for the same length of time, the likelihood of contamination by mosquito larvae would be identical for both types. However, for new cars, such as sedans and station wagons, internal contamination with larvae is likely to be negligible as these would be unlikely to have damaged bodies that would allow water leakage, and would also be unlikely to be left exposed to rainfall with the boot open for example.

Crash damaged vehicles are sometimes imported into New Zealand for restoration (Toy and Glassey, 2006; Wards, 2006). Numbers vary, but up to 20 vehicles a week are exported from one facility in Japan (Toy and Glassey, 2006). These vehicles are more likely to leak and have water containing cavities and be infested with mosquito larvae or eggs.

22.2.3 Likelihood of surviving shipment to New Zealand

Eggs of most aedine species are laid on moist surfaces immediately above the waterline of flooded receptacles. Following a rainfall event, the water level rises and the eggs will hatch when submerged.

Larval survival for *Aedes albopictus* with suboptimal food may be up to 58 days, with some larvae emerging after more than 80 days (Mori, 1979). However, with sufficient food, they may develop to adults within a fortnight. The Ships' Atlas gives the transit time from Yokohama to Auckland as 12.5 days (at 16 knots) (Shipping Guides Ltd., 1998). There are newer ships that travel faster and at 20 knots the journey would take approximately 10 days. In practice journey times usually range from 12 days (Kawasaki direct to Auckland) to 28

days (Osaka to Nelson via 11 intermediate ports) (Toyofuji Shipping Company Ltd, 2006). The journey time from San Francisco is 15.4 days, from Singapore is 13.2 days and from Australia is 4 days. Therefore, exotic vector mosquitoes can survive the journey into New Zealand at the larval stage. Moreover, eggs of species such as *Aedes aegypti* and *Aedes albopictus* are desiccation tolerant (Lounibos, 2002) and may remain viable for many months.

The situation for adults differs. A female *Aedes albopictus* would be likely to survive 5-7 days in an enclosed environment with no nourishment other than water (Hien, 1976). It is therefore possible for adult mosquitoes to survive the journey from Australia locked inside a vehicle or the cab of machinery. The same would be unlikely to occur from distant countries such as Japan, but some species over-winter at the adult stage (e.g. Bailey et al. 1982) and could potentially survive the journey.

22.2.4 Conclusion on entry assessment

Given that:

- six intercepted exotic species occur in countries from which vehicles and machinery originates;
- several species of exotic mosquitoes are urban pests and are thus likely to be in a position to contaminate vehicles;
- mosquitoes can survive long journeys in association with the commodity at the larval and egg stage;
- live life-stages of exotic mosquitoes have been intercepted on imported vehicles and machinery at the border;
- adult mosquito may over-winter and survive long-distance journeys.

it is concluded that the likelihood of exotic mosquitoes entering New Zealand via **used** vehicles and machinery is **non negligible**. Used equipment, trucks and other vehicles with open areas that could trap water are more likely to be contaminated than passenger cars.

The likelihood of entry via **new** passenger vehicles without water holding areas is **negligible**, but **non negligible for machinery or vehicles with open areas that can hold water**.

22.3 ESTABLISHMENT ASSESSMENT

22.3.1 Environmental suitability in New Zealand

Derraik (2006) discussed some factors affecting the likelihood of *Ae. albopictus* establishment in New Zealand. Climate is a key constraint to the establishment of exotic vectors in New Zealand, but the Auckland and Northland regions have been identified as having favourable conditions for *Ae. albopictus* (de Wet et al. 2001). The latest work using the *Hotspots* computer model (de Wet et al. unpublished data) confirmed previous results, indicating that most areas of the Northland and Auckland regions provide suitable climate, in terms of both temperature and rainfall requirements, for *Ae. albopictus* (Derraik and Slaney, 2007). This species' cold hardiness also means that other North Island areas are likely to be suitable (Laird et al. 1994; Weinstein et al. 1995), and a number of studies in the United States have shown that *Ae. albopictus* is capable of over-wintering in cold climates (Barker et al. 2003; Hawley, 1988; Swanson et al. 2000). Russell et al. (2005), using the model Climex, estimated that *Ae. albopictus* could potentially become established in most coastal areas of Australia, including colder areas such as Melbourne and Perth. Although climatic limitations may be an

important constraint for the establishment of *Ae. albopictus*, overseas this species shows an evident evolution of locally adapted life history traits that can overcome such limiting factors (Juliano and Lounibos, 2005).

Temperature requirements for *Ae. aegypti* are higher than those for *Ae. albopictus*, but suitable climate may occur for *Ae. aegypti* at the northern tip of New Zealand (de Wet et al. 2001). However, more recent work using the Hotspots model suggests that *Ae. aegypti* would be unlikely to establish in New Zealand under current climatic conditions (de Wet et al. 2005). *Aedes japonicus* is also considered to be cold-hardy (Laird et al. 1994) and is likely to be able to establish in New Zealand, being adapted to colder conditions and snowy winters of Japan (Tanaka et al. 1979). De Wet et al. (2005), based on the findings of the Hotspots model, concluded that “for most of the North Island, especially its northern and warmer coastal areas, climate will not be likely to preclude this mosquito [*Ae. japonicus*] surviving and breeding if it were introduced. The regions most at risk are Northland, Auckland, Waikato and Bay of Plenty. Some of the warmer and northern coastal areas of the South Island have climate that is compatible with *Oc. japonicus* [sic] infestation” (p.72). For *Ae. polynesiensis*, according to de Wet et al. (2005) “the northern coastal areas of the North Island and especially the Northland and Auckland regions have climates that are tolerable and at times possibly close to optimal for *Ae. polynesiensis*” (p.59).

The climate in Auckland and Northland is considered the most suitable for the establishment of exotic mosquitoes in New Zealand. The majority of used vehicles and machinery enters New Zealand, at the Port of Auckland, see Chapter 3. Therefore arriving exotic mosquitoes would be likely to find suitable environmental conditions at their point of entry.

22.3.2 Biological characteristics

Immature mosquito life-stages can arrive in considerable numbers in a water-filled receptacle. For example, Laird et al. (1994) recorded about 100 *Aedes albopictus* larvae in a single used tyre imported from Japan. Although there is some variation between species or due to environmental conditions, the sex ratio of hatching cohorts is likely to be close to 1:1.

The likelihood of establishment following the arrival of adult mosquitoes would be considerably lower than following arrival of eggs or larvae, since these tend to consist of one or few individuals arriving at any given time. Lounibos (2002) pointed out that adults arriving in aircraft for instance, rarely lead to an established population. However, a single gravid female mosquito could potentially lead to a viable population. In addition, numerous species are autogenous (able to produce a batch of eggs without ingestion of blood meals). Also, most female mosquitoes are able to store sperm (Clements, 2000; Service, 2000), so the female only needs to mate with a male once in its lifetime. As a result, a single female mosquito, which mated prior to entering a vehicle, could potentially lead to a viable population without being gravid at the time of arrival and without necessarily feeding on blood.

While as a general rule it is considered that the larger the founder population size, the greater the likelihood of establishment, there is unlikely to be a precise threshold above which establishment is certain and below which it is impossible (Simberloff, 1989). Successful establishment of arthropods (from studies on the release of biocontrol agents) has been recorded from introduction of fewer than 20 individuals (eg Berggren, 2001; Simberloff, 1989; Hee et al. 2000). In terms of optimising gorse thrips (a biological control agent) releases, Memmott et al. (1998) suggested that a larger number of smaller introductions would be more likely to lead to successful establishment than a smaller number of larger

introductions. In the case of mosquitoes the likelihood of establishment is increased by a greater number of individuals hatching from any one entry event and repeated entries of contaminated vehicles in the port area.

22.3.3 Likelihood of transfer to a suitable environment

Adult mosquitoes are highly mobile and on emergence can readily disperse from an imported vehicle to nearby habitat.

22.3.4 Conclusion on establishment assessment

Given that:

- at least parts of New Zealand and in particular areas around the main entry point for imported vehicles have a suitable climate and range of habitats for some exotic mosquitoes;
- large numbers of eggs or larvae can arrive in a single contaminated vehicle or machine and that a single gravid adult female or a batch of eggs or larvae may lead to a viable population;

it is concluded that **the likelihood of establishment** of exotic species of mosquitoes in association with the new and used vehicle and machinery pathway is **non negligible**.

22.4 EXPOSURE AND CONSEQUENCE ASSESSMENTS

The establishment of new exotic mosquito vectors in New Zealand would be reason for major public health concern. Six species listed in Table 1 are known vectors of the diseases described in section 22.1.2. Of particular concern would be the introduction of mosquitoes that are vectors of Ross River virus, the most likely mosquito-borne virus to cause a disease outbreak in New Zealand. It has been predicted that in a worst case scenario a virgin-soil epidemic of Ross River virus in the Auckland region could affect tens of thousands of people (e.g. Kelly-Hope et al. 2002).

Larvae of exotic mosquito species may also introduce exotic arbovirus into New Zealand. Experimental vertical transmission of a number of arboviruses has been shown to occur for some of the intercepted species such as JEV by *Ae. japonicus* (Takashima and Rosen, 1989), WNV by *Ae. aegypti* and *Ae. albopictus* (Baqar et al. 1993) and *Cx. quinquefasciatus* (Goddard et al. 2003), DENV by *Ae. albopictus* (Mitchell and Miller, 1990) and *Ae. aegypti* (Joshi et al. 2002), and YFV by *Ae. aegypti* (Diallo et al. 2000). However, this does not seem to be particularly common within a given population, and thus unlikely to occur in the small number of individuals entering via the vehicle pathway (S. Ritchie, pers. comm. 2006).

The economic costs of medical treatment and lost productivity associated with the spread of a mosquito-borne disease are expected to be very high. The economic costs resulting from a mosquito incursion response are also high. For instance the New Zealand government is spending approximately \$59 million in the attempt to eradicate the southern saltmarsh mosquito *Aedes camptorhynchus* (Sarah Clinehens, pers. comm. 2007).

In addition, there are likely to be social impacts from the establishment of species such as *Ae. albopictus* which is a particularly aggressive biter that could become a serious nuisance, as happened in Italy where this species seems to have become the most serious pest mosquito through most of its range (Gratz, 2004).

Whilst adult mosquitoes have a low likelihood of entry and establishment, particularly in comparison to the amount of habitat for hitchhiking adult mosquitoes aboard a vessel, impacts on human health may occur without establishment from infected females vectoring disease. Nonetheless, the likelihood of such occurrence in association with this particular pathway would be very low. Depending on the pathogen/parasite and the presence of a suitable vector in New Zealand, such cases could potentially escalate to an outbreak.

Mosquitoes also pose a threat to New Zealand's native fauna, and to domestic animals. Numerous pathogens/parasites can be transmitted to non-human hosts by mosquitoes which could be introduced into the country with the arrival of an infected vector. Species such as *Aedes albopictus* feed on a very wide range of hosts, including mammals, birds, amphibians and reptiles (Hawley, 1988), and due to their aggressive behaviour would at the very least become a serious nuisance to exposed animals in New Zealand. Furthermore, animal diseases, such as canine heartworm (*Dirofilaria immitis*) can be transmitted by *Ae. albopictus* (Cancrini et al. 2003)

22.4.1 Conclusion of consequence assessment

There are likely to be significant human health, economic and environmental consequences from the entry, establishment and spread of exotic mosquito species. The consequences are therefore non negligible.

Container breeding mosquitoes are considered high consequence hazards.

22.5 RISK ESTIMATION

Given that:

- the likelihood of entry into New Zealand and establishment of a new species of mosquito, in particular species such as *Aedes albopictus* and *Aedes japonicus*, associated with the used vehicle and machinery pathways is non negligible; and
- the economic, human health and environmental consequences of establishment would be non negligible;

The risk is considered to be non negligible for used vehicles and machinery, and risk management measures are justified.

The risk of entry for **new vehicles (except passenger cars) and machinery is non negligible** and, therefore, the overall risk is non negligible and risk management measures are justified.

22.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of exotic mosquitoes entering New Zealand via the vehicle and machinery pathway and becoming established.

22.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

22.7.1 Visual inspection

There are no data on the efficacy of visual inspection in detecting mosquito contamination.

Mosquito eggs are not detectable by visual inspection. Therefore, all items that have evidence (such as a visual waterline) that they have held water at some stage or have exposed cavities which could hold water, should be treated to kill any eggs that would not be detected by visual inspection and could hatch when flooded. There has been a reported instance of a tyre in a vehicle being exposed to water when the imported vehicle was pressure washed and on subsequent biosecurity inspection live exotic mosquito larvae were found in the tyre (Matthews, undated).

Water holding cavities should be detectable through visual inspection. The current risk management regime based on visual inspection is likely to be effective in mitigating the likelihood of entry for mosquitoes associated with pooled water. However, the same does not apply for potential larval mosquito habitats that are dry or nearly dry on which eggs may have been laid.

Adult mosquitoes are unlikely to be detected through visual inspection on arrival in New Zealand, since they are highly mobile and will have plenty of opportunity to exit the vehicle or machine during its transfer from the ship and to a lesser extent container. External inspections are undertaken prior to interior inspections, extending the time available for escape prior to detection. MAF Quarantine Service officers are able to look for mosquitoes when doing an on-vessel check of large machines. Stevedores could be advised of the need to contain any mosquitoes found in other vehicles during unloading.

Conclusion: Visual inspection coupled with appropriate treatment will reduce the risk from mosquitoes but is unlikely to reduce the risk to a negligible level.

22.7.2 Heat treatment

Heat treatment has the advantage of treating both internal and external contaminants and those that are not detectable through standard inspection procedures. Limited data are available on the thermal tolerances of mosquito life stages. Unpublished results of small scale laboratory thermal death tests, using larvae of *Culex rotoruae* and adults of *Culex pervigilans* and *Ae. notoscriptus* established 100 percent mortality following treatment at 50°C for 5 minutes (Crabtree, 2002). However, these results cannot be necessarily extrapolated to tropical species such as *Ae. aegypti*. In addition, it is possible that desiccation-tolerant eggs may be resistant to short bursts of relatively high temperature. Nonetheless, based on the lack of any evidence to the contrary, it is assumed that heat treatment at a core temperature of 60°C for 10 minutes would effectively manage the risks associated with eggs, larvae and adults of exotic mosquitoes. However, trucks and machinery with water retaining receptacles are the highest risk components of the pathway for mosquitoes. The practicality of treating large vehicles at an operational scale has not been established. Furthermore it is likely that any large bodies of water (e.g. within a concrete mixer or vessel refuse drum) and recessed cavities may be insulated from the heat, decreasing efficacy of the treatment.

Conclusion: Heat treatment at 60°C for 10 minutes is likely to effectively mitigate the risk from mosquitoes associated with passenger vehicles but not for machinery and vehicles likely to hold water.

22.7.3 Fumigation with methyl bromide

Methyl bromide is effective against all life stages of mosquitoes (Table 4). However, it is not soluble in water and is therefore ineffective against submerged un-hatched eggs (Ritchie, 2001). However, since most submerged eggs would hatch (and the emerging larvae killed), unhatched submerged eggs that could give rise to viable larvae would likely be rare. Its use is unlikely to be practical against adult mosquitoes, which in many cases would likely to be flushed out of the vehicle during preparation for fumigation.

Conclusion: fumigation with methyl bromide is not likely to be the most appropriate treatment method, although it may be adopted for high risk vehicles when needed (e.g. severely crash-damaged vehicles).

22.7.4 Treatment of pooled water and/or receptacles with chlorine

The current treatment for pooled water is to drain it and treat the cavity with 1 percent solution of a range of chlorination solutions (Biosecurity New Zealand, 2006). This is similar to the Australian requirements. The results of tests of the quarantine procedures adopted by the Australian Quarantine and Investigation Service against mosquitoes including the efficacy of chlorine treatment against the life stages of *Ae. aegypti* (Ritchie, 2001) are summarised in Table 4. A 1 percent solution of sodium hypochlorite was 100 percent effective against eggs laid on paper and larvae, but only 30 percent of pupae were killed within one hour (although they were dead after 24 hours). 5 percent solution was 100 percent effective against pupae within one hour. This is not a suitable treatment for adults. However, in subsequent trials using *Ae. aegypti* eggs laid on plastic, Ritchie and Montgomery (unpublished data) found that chlorine ran off the plastic, and the residual amount evaporated resulting in less than 100 percent kill for 5 percent sodium hypochlorite. Use of a 10 percent active ingredient solution (pool chlorine) provided 100 percent kill, and addition of detergent (4 percent by weight or volume) improved wetting ability of the solution and decreased evaporation, increasing efficacy (Sherman et al. 1998; Shortus and Whelan, 2006). The recommendation of Shortus and Whelan (2006) is that the treated receptacle should be left to stand for 30 minutes. Note that since chlorine is potentially corrosive, treated parts of vehicles and machinery should be adequately flushed with water at the end of the required treatment period.

Conclusion: treatment of cavities that can contain water with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes is an effective treatment against mosquito eggs, larvae and pupae, but not adults. The current treatment for pooled water is unlikely to reduce the risk to a negligible level.

Table 4. Efficacy of different treatments against the life stages of *Aedes aegypti*. Source: (Ritchie 2001) and Ritchie & Montgomery (unpublished data).

Treatment	Eggs ¹	Larvae	Pupae	Adults
1% sodium hypochlorite	100%	100% (< 30 min) ²	30% (1 hr)	n/a
5% sodium hypochlorite	100%	100% (<10 min) ²	100% (1 hr)	n/a
10% sodium hypochlorite + 4% detergent	100%	-	-	n/a
Methyl bromide at 48g/m ³ for 24 hr	100% of exposed eggs	100%	100%	100%
2% Permethrin spray - 1 sec	100%	100%	100%	100%

¹ These were dipped for 1 second within the respective solution

² The author does not provide the exact time it took to kill them, but states that for 5 percent solution “larvae were affected within minutes”, and that the 1 percent solution resulted in “fast kill of larvae”. The figures used in the table are estimates erring on the side of caution.

22.7.5 Treatment with Synthetic Pyrethroids

Permethrin is a pyrethroid contact insecticide that is water soluble, and has been found to yield 100 percent mortality of mosquito larvae and pupae for 16 weeks when applied as a surface spray to water-containing habitats (in a formulation of 0.7 and 2.0 g/kg of imiprothrin and cypermethrin, respectively) (Ritchie et al., 2001). Permethrin is recommended by the World Health Organization to control mosquitoes in aircraft, and is described as a safe compound (Aitio, 2002). A 2 percent permethrin spray was found to provide 100 percent control of eggs, larvae, pupae and adults (Ritchie, 2001), but its long term action was not assessed. It is therefore unclear whether this solution would be effective over the same time-period as the formulation tested by Ritchie et al. (2001), although Ritchie (2001) states that mosquito control using synthetic pyrethroid aerosols “can extend for several months”.

Nonetheless, the formulation treatment experiment was carried out in containers in the shade (Ritchie et al. 2001), and the effect of exposure to sunlight on the long-term action of the formulation was not assessed.

If cavities capable of containing water in a vehicle/machine were treated with a pyrethroid insecticide offshore, it is assumed that the longest period of time that it would take between the treatment and its arrival in New Zealand would be 8 weeks. Therefore, for offshore treatment with a pyrethroid to be effective it would have to remain effective against all mosquito life stages in larval habitats as surface spray for no less than 8 weeks even when exposed to sun and rain.

Synthetic pyrethroids stick to the surfaces on which they are applied and allowed to dry, unless these are flushed immediately after treatment (Scott Ritchie, pers. comm. 2006). Since this would not happen in the case of vehicles, even if larval habitats on vehicles or machinery were exposed to torrential rainfall after treatment, the efficacy of the treatment would be unlikely to be affected.

Since synthetic pyrethroids degrade in sunlight, it would be necessary to use formulations specifically designed to resist sunlight degradation. Such formulations have ‘encapsulated’ pyrethroids (Scott Ritchie, pers. comm. 2006), and are commercially available as outdoor surface sprays, for example, containing both imiprothrin and deltamethrin.

The challenge with this measure is identifying vehicles with cavities capable of holding water. The majority will be machines or open backed trucks and utility vehicles where the cavities are obvious. However, a vehicle with a leaking boot or containing a used tyre will not be identifiable by vehicle type. Such vehicles would need to be identified through visual

inspection which could be linked to a requirement for vacuuming as a measure for other hazards.

Synthetic pyrethroids are contact insecticides, and would kill any adult mosquitoes that come into contact with a treated surface, such as adults resting within a concrete mixer. However, adults may be disturbed during application and consequently fly away without prior contact with the chemical.

Pyrethroids have very low water solubility so they are not readily dispersed through the water column. As a result, they also tend to be rapidly and strongly adsorbed to particulate material (Hill, 1989). Although they are effective in eventually killing the aquatic stages of mosquitoes Zeichner & Perich (1999) and Ritchie et al. (2001), death of larvae does not appear to be promptly induced. The short term exposure that would be required for onshore treatment of water-filled cavities would therefore be unlikely to be effective.

Conclusion: Surface spray of cavities capable of containing water with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than 8 weeks, is likely to be an effective offshore treatment to mitigate the likelihood of exotic mosquitoes arriving in New Zealand. This treatment would render onshore measures against these organisms unnecessary.

22.7.6 *Bacillus thuringiensis* var. *israelensis* (Bti)

Bacillus thuringiensis is a naturally occurring bacterium in the New Zealand environment, where strains similar to *Bti* are present (Glare and O'Calaghan, 1998; Stark, 2005). The aquatic larvae of mosquitoes will die following ingestion of *Bti*, which affects the larvae's mid-gut cell walls (Glare and O'Calaghan, 1998). Larval mortality does not occur immediately, and, for example, the exposure of *Cx. quinquefasciatus* larvae to lethal concentrations of *Bti* caused approximately 65 percent mortality after 4 hours with 100 percent mortality observed after nearly 10 hours (Lacey and Lacey, 1981). The time from ingestion of *Bti* until death of mosquito larvae will depend on the amount of the bacteria ingested, which at high doses may lead to 100 percent mortality of *Ae. aegypti* larvae in 1.5 hours (Khawaled et al. 1988). However, *Bti* is only effective against larvae which ingest the bacteria while feeding. Therefore, it is not an effective measure against mosquito eggs, pupae or adults.

Conclusion: *Bti* treatment of pooled water is only an effective treatment against mosquito larvae that are exposed to it for a few hours. It will not manage other mosquito life-stages.

22.7.7 S-methoprene

S-methoprene is an insect growth regulator (a juvenile hormone analogue) that disrupts the normal development of insects (WHO 2006). In New Zealand, it has been used in the *Ae. camptorhynchus* eradication programme (Glare and O'Calaghan 1999). However, it is primarily a larvicidal compound (WHO 2006), and is not effective against mosquito eggs or pupae. The information provided in Glare & O'Calaghan's (1999) review, indicates that S-methoprene does not provide a sufficiently high efficacy level against all life stages to meet the risk management objective.

22.7.8 Mosquito Exclusion Zone

Article 19 of the International Health Regulations, requires that all signatories carry out surveillance for mosquitoes at ports of entry. As part of World Health Organisation

recommendations, a 400 m exclusion zone should be maintained at national entry ports, in which all larval mosquito habitats must be eliminated or effectively managed and intensive adult mosquito trapping carried out. Routine surveys for mosquito breeding sites should be carried out several times a year with removal or treatment of all habitats suitable for mosquito breeding. These measures will support the primary risk mitigation measures in minimising the likelihood of exotic mosquitoes becoming established in the immediate vicinity of where vehicles are discharged, and subsequently dispersing further afield, should they escape.

Note these programmes are currently mandated to the Ministry of Health.

22.7.9 Offshore versus onshore treatment

Given the mobile nature of mosquitoes, and the large number of eggs/larvae that can arrive in a single vehicle or machine, offshore risk management is preferable to onshore management.

Mosquitoes can breed in a wide range of habitats and are likely occur in the urban areas in the main vehicle exporting countries. The breeding areas may not be in the immediate vicinity of the port or could be underground, so surveillance and storage yard maintenance measures will not be sufficient to prevent recontamination of vehicles inspected and treated offshore if they are stored in areas exposed to rainfall. Therefore, treatment with residual effect is necessary for offshore risk management, and the use of specific residual synthetic pyrethroid formulations on all vehicles with cavities capable of holding water would render onshore mitigation unnecessary.

22.8 RECOMMENDED MEASURES

2) For used passenger vehicles that have no cavities that could hold water:

Offshore/Onshore treatment:

- heat treatment at a core temperature of 60°C for 10 minutes; **and**
- stevedores advised of the need to contain any adult mosquitoes found during unloading/devanning; **and**
- reporting and thoroughly treating with a synthetic pyrethroid spray any cavities containing or likely to contain likely to have contained water, that are found during internal vacuuming; **or**
- continue the current regime of 100 percent visual inspection, followed by treatment with a residual synthetic pyrethroid spray of any cavities containing or likely to have contained water.

3) For new and used machinery, boats, trucks, utility vehicles and similar vehicles with potential larval mosquito habitats (as defined below):

Offshore treatment:

- all water-filled cavities must be drained; **and**
- all potential larval mosquito habitats must have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation resistant to sunlight degradation for no less than 8 weeks; **or**

Onshore treatment:

- visual inspection for adult mosquitoes immediately on arrival. Any found must be killed immediately with a synthetic pyrethroid spray. If the specimen is found inside a vehicle, the interior of the vehicle must be treated with a synthetic pyrethroid spray and sealed for an hour; **and**
- within 12 hours of the ship berthing in New Zealand all water-filled cavities:
 - a. filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
 - b. must be treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **and**
must be drained; **and**
have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

and

- within 12 hours of the ship berthing in New Zealand all cavities capable of impounding water, whether or not they contain evidence of having held water, but which are dry:
 - a. must be filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
 - b. have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

4) For crash damaged vehicles, where the damage may have created potential larval mosquito habitats.

Offshore treatment:

- all water-filled cavities must be drained; **and**
- all potential larval mosquito habitats must be thoroughly sprayed with a residual synthetic pyrethroid formulation resistant to sunlight degradation for no less than 8 weeks; **or**

Onshore treatment:

- all potential larval mosquito habitats must be thoroughly treated with a synthetic pyrethroid spray.

Note that similar issues are likely to arise in relation to imported vehicle parts which are managed through a separate import health standard. It is recommended that this standard is reviewed to provide a consistent approach to the management of potential larval mosquito habitats.

- 5) **In addition** an exclusion zone for mosquitoes should be maintained at all ports of entry, where used vehicles and used machinery are unloaded. Active anti-mosquito measures must be maintained within a protective area extending for a distance of at least 400 metres around the perimeter, as per WHO recommendations, to include:
- a. the elimination or effective treatment of all potential mosquito larval habitats within the exclusion zone; **and**
 - b. active and comprehensive trapping of adult mosquitoes.

These programmes are currently mandated to the Ministry of Health.

When any suspected mosquito life stage is discovered onshore, MAF's response protocol based on the existing Memorandum of Understanding with the Ministry of Health, must be activated. The Ministry of Health must be informed within one hour of the finding so that adequate mitigating action by public health authorities can also be carried out.

Note: 'potential larval mosquito habitats' are defined as any receptacles capable of harbouring water, irrespective of whether or not they are water-filled at the time of inspection. This may vary from small containers such as jars and cans, to concrete mixers and excavating buckets.

'Passenger vehicles' are defined as completely enclosed vehicles with no open areas capable of holding water.

22.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- The frequency of entry of exotic mosquitoes via the vehicle pathway is uncertain – the data for this group of hazards are limited. It is assumed that machinery, boats, trucks, utility vehicles and similar vehicles are more likely to be contaminated as they have greater potential to hold water.
- It is assumed that new vehicles and machinery is with cavities capable of holding water and stored in open conditions are as likely to be contaminated with mosquitoes as used vehicles or machinery stored in similar conditions.
- The efficacy and practicality of heat treatment of large vehicles/machinery has not been tested on an operational scale.
- The efficacy of heat treatment against mosquito eggs and larvae in pooled water is not known.

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23 Plant seeds (Angiospermae)

23.1 HAZARD IDENTIFICATION

23.1.1 Identity

Category: Plants

Taxonomic Group: Class, Angiospermae

Name: flower producing plants

23.1.2 Introduction

Plant debris as a contaminant is assessed in Chapter 20. This chapter assesses the risks associated with plant seeds. Whilst seeds are often mentioned anecdotally as a significant internal and external contaminant of the vehicle and machinery pathway, they are generally not identified to species level or recorded as specific contaminants by quarantine staff, as there is no requirement to do so (Smith and Toy, 2006). Table 1 summarises the information on seed contaminants associated with imported vehicles available from the following sources:

- A small scale investigation of seeds in air-filters of imported Japanese cars (MAF Quarantine Service, 2005).
- Biosecurity Monitoring Group videoscope and used vehicles monitoring surveys (Biosecurity Monitoring Group, 2006; Wedde et al. 2006). Seeds were the most frequent contaminant of air filters, the second most common contaminant found elsewhere in vehicles after clearance and the third most frequent contaminant type not detectable through visual inspection in the videoscope survey. Wherever possible a sample of seed contaminants found during these surveys was collected by the surveyor and sent to the National Seed Laboratory, AgriQuality Ltd for identification and germination/viability testing. In some cases it was not possible to collect seeds for testing and in many cases only a sample, rather than all seeds from each vehicle were sent for testing. In order to avoid false negatives resulting from germination failure due to dormancy, any seed that had not germinated within 10 days and was not obviously decayed, was tested for viability using tetrazolium. A dilute solution of 2,3,5 triphenyl tetrazolium chloride will change colour in the presence of hydrogen ions which are a by-product of seed respiration.
- Historical interception records from the Biosecurity Monitoring Group's interceptions database.

Since most intercepted seeds have not been identified to species level, factors indicating the impact of other species in the family or genus have been considered. These include whether there are restrictions on their allowable level of contamination in seeds imported for sowing; whether they are known to carry disease, whether they are included in formal pest management strategies and whether they have a known history of invasiveness in other countries.

Table 1. Identity, viability, status and factors influencing potential impact of seeds intercepted from imported vehicles.

Organism	Family	Country of origin of vehicle	Viable seeds recorded	Status in New Zealand (Edgar and Connor, 2000; Webb et al. 1988)	Potential impact factors (MAF Biosecurity Authority, 2004; http://www.biosecurityperformance.maf.govt.nz/ ; M. Newfield pers. comm.)
<i>Acer</i> sp.	Aceraceae	USA, Canada	no/uncertain	200 species in genus, 2 naturalised in NZ	Entry conditions on import of <i>Acer</i> seed to prevent entry of disease. Some species are invasive in NZ & overseas
<i>Andropogon virginicus</i>	Poaceae	Japan, unrecorded	yes	naturalised from USA	Managed in 3 Regional Pest Management Strategies
<i>Betula</i> sp.	Betulaceae	Japan USA	yes	60 species in genus, 1 naturalised in NZ	
<i>Bromus willdenowii</i>	Poaceae	Japan	no	naturalised from South America	Entry conditions on import of <i>Bromus</i> seed to prevent entry of disease.
<i>Casuarina</i> sp.	Casuarinaceae	Japan	no	5 species in genus, 2 naturalised in NZ from Australia	Some species regarded as invasive overseas.
<i>Chloris truncata</i> *	Poaceae	Unrecorded	unrecorded	naturalised in NZ from Australia	
<i>Conyza</i> sp.	Asteraceae	Japan Unrecorded	yes	50 species in genus, 5 naturalised in NZ	Many species are regarded as weeds (mostly agriculture and disturbed ground).
<i>Cortaderia</i> sp.	Poaceae	Japan	yes	25 species in genus, 5 endemic and 2 naturalised in NZ	Two species invasive in NZ and also overseas.
<i>Crepis</i> sp.	Asteraceae	Japan Unrecorded	yes	200 species in genus, 4 naturalised in NZ	Some weedy species
<i>Digitaria</i> sp.	Poaceae	Japan	yes	220 species in genus, 6 naturalised in NZ	Many species in the genus are weeds
<i>Epilobium</i> sp.	Onagraceae	UK	yes	163 species in genus, 37 species native to NZ and 5 naturalised	Some weedy species, although mostly minor weeds
<i>Echinochloa</i> sp.*	Poaceae	Japan	unrecorded	30 species in genus, 4 species naturalised in NZ & 2 transient	Many species in the genus are weeds
Fabaceae	also known as Leguminosae	Japan	unrecorded	18000 species in 650 genera,	

Organism	Family	Country of origin of vehicle	Viable seeds recorded	Status in New Zealand (Edgar and Connor, 2000; Webb et al. 1988)	Potential impact factors (MAF Biosecurity Authority, 2004; http://www.biosecurityperformance.maf.govt.nz/ ; M. Newfield pers. comm.)
				109 naturalised in NZ	
<i>Hordeum</i> sp.	Poaceae	USA	uncertain	31 species in genus, 1 species naturalised in NZ.	Entry conditions on import of <i>Hordeum</i> seed to prevent entry of disease. Some species are weedy
<i>Hypochoeris</i> sp.	Asteraceae	Japan	yes	100 species in genus, 3 naturalised in NZ	some species are minor weeds
<i>Imperata cylindrica</i>	Poaceae	Japan Singapore Unrecorded	yes	naturalised from palaeotropics	
<i>Lactuca</i> sp.	Asteraceae	USA Japan	no/uncertain	100 species in genus, 4 naturalised in NZ	
<i>Medicago</i> sp.	Fabaceae	Japan	no/uncertain	50 species in genus, 8 naturalised in NZ	Entry conditions on import of seed to prevent entry of disease.
<i>Miscanthus</i> sp.	Poaceae	Japan	no/uncertain	20 species in genus, 2 naturalised in NZ from Asia	Many species in the genus are invasive weeds
<i>Oryza sativa</i>	Poaceae		unrecorded	rice	food spill in vehicle
<i>Oxalis</i> sp.	Oxalidaceae	Japan	no	800 species in genus, 3 species native to NZ and 15 naturalised	Some weedy species
<i>Pennisetum</i> sp.*	Poaceae	Unrecorded	unrecorded	130 species in genus, 7 naturalised in NZ, 1 transient.	A number of serious weeds in this genus. All but 2 of the species present in NZ are unwanted organisms for the purposes of preventing sale, propagation and distribution within NZ. Included within 14 Regional Pest Management Strategies
<i>Phalaris</i> sp.	Poaceae	Japan	uncertain	20 species in genus, 5 naturalised in NZ, 1 transient.	Entry conditions on import of seed to prevent entry of disease. Some species are weedy
<i>Phleum pratense</i>	Poaceae	Japan	uncertain	naturalised from Eurasia.	Entry conditions on import of seed to prevent entry of disease.
<i>Picris hieracioides</i>	Asteraceae	Unrecorded	unrecorded	cosmopolitan species native to NZ and most other temperate regions	
<i>Platanus</i> sp.	Plantanaceae	Japan	uncertain	8-10 species in	

Organism	Family	Country of origin of vehicle	Viable seeds recorded	Status in New Zealand (Edgar and Connor, 2000; Webb et al. 1988)	Potential impact factors (MAF Biosecurity Authority, 2004; http://www.biosecurityperformance.maf.govt.nz/ ; M. Newfield pers. comm.)
				genus, 2 species & a hybrid naturalised in NZ.	
<i>Poa</i> sp.	Poaceae	Japan	uncertain	Some 500 species in genus, 37 species endemic in NZ, 10 species naturalised & 2 transient species.	Entry conditions on import of seed to prevent entry of disease.
<i>Polygonum</i> sp.	Polygonaceae	Japan	uncertain	300 species in genus, 1 species native to NZ and 12 naturalised	
<i>Puccinellia</i> sp.	Poaceae	Japan USA	yes	80 species in genus, 4 species native to NZ, 3 of which are endemic and 3 naturalised species	
<i>Senecio</i> sp.	Asteraceae	Japan Unrecorded	yes	1500 species in genus, 18 species native to NZ and 16 naturalised	Many species in genus are serious weeds in NZ and overseas.
<i>Setaria</i> sp.*	Poaceae	Japan	unrecorded	140 species in genus, 7 species naturalised in NZ, 1 transient species.	Entry conditions on import of seed to prevent entry of disease. Many weedy species in genus.
<i>Sonchus asper</i>	Asteraceae	Japan	yes	naturalised from Europe, North Africa, Asia	
<i>Sonchus oleraceus</i>	Asteraceae	Japan	yes	naturalised from Europe, North Africa, Asia	
<i>Taraxacum officinale</i>	Asteraceae	Japan USA	yes	naturalised from Europe	
<i>Taraxacum</i> sp.	Asteraceae	Japan USA	no/uncertain	150 species groups in genus, 1 species native to NZ and 1 naturalised	
<i>Torilis nodosa</i>	Apiaceae	Japan	uncertain	naturalised from Europe, west Asia and north Africa	

Organism	Family	Country of origin of vehicle	Viable seeds recorded	Status in New Zealand (Edgar and Connor, 2000; Webb et al. 1988)	Potential impact factors (MAF Biosecurity Authority, 2004; http://www.biosecurityperformance.maf.govt.nz/ ; M. Newfield pers. comm.)
<i>Tribulus terrestris</i> *	Zygophyllaceae	Unrecorded	unrecorded	Not established in NZ. Recorded in vehicle from USA	A widespread & notorious weed of temperate and sub-tropical regions.
<i>Typha</i> sp.	Typhaceae	Japan Unrecorded	yes	10 species in genus, 1 native	2 species have been declared unwanted organisms, one to prevent entry and one to prevent sale, propagation and distribution within NZ.
<i>Ulmus</i> sp.	Ulmaceae	Australia USA	no	45 species in genus, 1 hybrid naturalised in NZ	Entry conditions on import of seed to prevent entry of disease.
<i>Urochloa</i> sp. (previously <i>Bracharia</i> sp.)	Poaceae	Japan	yes	120 species in genus, 1 naturalised and 1 transient in NZ	
<i>Zelkova serrata</i>	Ulmaceae	Japan	yes	Not naturalised	Entry conditions on import of seed to prevent entry of disease.
unidentified	Asteraceae	Japan Unrecorded	no	About 1100 genera, many naturalised in NZ	
unidentified	Poaceae	Japan USA Unrecorded	no/uncertain	188 species native to NZ and 226 naturalised	
unidentified	unidentified		no/uncertain		

*historical records from Biosecurity Monitoring Group interceptions database.

Note since Table 1 is derived in large part from slippage interceptions the results are not necessarily indicative of contamination by seeds prior to intervention on the pathway, nor can they be used quantitatively.

There are records of 37 genera in 14 families.

Table 2 lists historical seed identifications from used vehicles imported from Japan held by the National Seed Laboratory (National Seed Laboratory, pers. comm.). There is no quantitative or viability information for these records.

Table 2 Additional plant seeds identified historically from imported Japanese vehicles (National Seed Laboratory, pers. comm.)

Organism	Family	Status in New Zealand (Edgar and Connor, 2000, Webb et al. 1988)	Potential impact factors (MAF Biosecurity Authority, 2004), M. Newfield pers. comm.
<i>Agropyron</i> sp.	Poaceae	6 endemic species, 1 indigenous species, 1 naturalised species	Entry conditions on import of seed to prevent entry of disease.

<i>Aster</i> sp.	Asteraceae	250 species, cosmopolitan, 4 species naturalised in NZ and 1 hybrid group	
<i>Bidens</i> sp.	Asteraceae	230 species, cosmopolitan, 3 species naturalised in NZ	Some weedy species
<i>Carthamus tinctorius</i>	Asteraceae	has been collected twice from bean crops near Blenheim. Originates in west Asia.	Entry conditions on import of seed to prevent entry of disease.
<i>Chondrilla juncea</i>	Asteraceae	1 persistent population in NZ, originates in temperate Eurasia	Serious weed overseas.
<i>Coix lacryma-jobi</i>	Poaceae	naturalised in NZ	Entry conditions on import of seed to prevent entry of disease.
<i>Cortaderia</i> sp.	Poaceae	25 species, mainly in South America, 2 naturalised in NZ and 5 endemic	The 2 species naturalised in NZ are serious weeds, declared unwanted organisms to prevent deliberate, sale, propagation and distribution in NZ.
<i>Cyperus brevifolius</i>	Cyperaceae	naturalised in NZ	
<i>Lagurus ovatus</i>	Poaceae	naturalised from the Mediterranean	
<i>Miscanthus sinensis</i>	Poaceae	naturalised from eastern Asia	
<i>Pennisetum</i> poss. <i>clandestinum</i>	Poaceae	naturalised in NZ from north Africa	Serious weed in NZ, entry conditions on import of seed to prevent entry of disease.
<i>Phragmites australis</i>	Poaceae	naturalised in NZ, originates in temperate zones.	All known sites under control by Regional Councils. Declared an unwanted organisms to prevent deliberate, sale, propagation and distribution in NZ
<i>Zelkova serrata</i>	Ulmaceae	Not naturalised in NZ.	Entry conditions on import of seed to prevent entry of disease.

The majority of vehicle seed contaminants have not been identified to species level. Most of those that were identified are either grasses or plants with composite flower heads. Both these groups are characterised by the production of large numbers of small, wind blown seeds. Most of the identified seeds are of cosmopolitan species already present in New Zealand. However species that are not present in New Zealand are less readily identified, so this picture may be misleading. Most of the seeds found to be viable were of species already present in New Zealand.

About one hundred viruses of plants have been reported to be transmitted by seed, although generally less than 30 percent of the seeds derived from virus-infected plants transmit the virus (Agrios, 1988). A large number of bacterial and fungal diseases may also be transmitted by seed. Disease inoculum, in the form of fungal spores, resting structures and dried bacterial exudates, may even adhere to milled rice (Lanoiselet et al. 2001). Nematodes in an anhydrobiotic state can also be carried in seeds (Barrett, 1991; Maas, 1987), as can arthropod life stages. Due to the large number of pests and diseases associated with seed, the importation of seed for sowing for many species is subject stringent entry conditions (MAF Biosecurity Authority, 2004). For instance, *Hordeum*, one of the genera intercepted from imported vehicles has 32 listed regulated pests associated with it and import requirements include mandatory fungicide treatment and phytosanitary certification declaring freedom from specified pests (MAF Biosecurity Authority, 2004). Thus seeds in vehicles, including those of

species already present in New Zealand or food products such as rice, may also be vectors for plant pests and diseases.

23.1.3 Conclusion

At least some of the seeds contaminating the pathway are from species not present in New Zealand. Furthermore even seeds of plants present in New Zealand may vector exotic pests and pathogens. Seeds may be associated with soil contamination and may be trapped in various locations in the vehicle both internally and externally. Seeds of plants are therefore considered a potential hazard on the vehicle and machinery pathway

Common cattail, *Typha latifolia*, and Johnson Grass, *Sorghum halepense*, are used as examples of the hazard group to illustrate the likelihood the entry and establishment and the consequences that may result from seeds entering New Zealand on imported vehicles and machinery. These species have been selected since they occur in some of the main vehicle exporting countries, are known to be significant weeds and have been declared unwanted organisms in New Zealand. They are also difficult to manage once established. Unidentified *Typha* seeds have been intercepted from vehicles and there are anecdotal reports of *S. halepense*.

23.2 ENTRY ASSESSMENT

23.2.1 Current Distribution

Typha latifolia has a nearly worldwide distribution occurring in North America, Central America, Great Britain, Eurasia, Africa, Australia, and Japan. It is not established in New Zealand, although it occurs in one contained site near Auckland and is listed under Biosecurity New Zealand's Plant Biosecurity Index as entry prohibited (Champion and Clayton, 2001). It is also listed under the National Pest Plant Accord to prevent sale, propagation and distribution within New Zealand.

Sorghum halepense is native to the Mediterranean region but is now widely distributed worldwide including Japan, Australia and the USA (Holm et al. 1977). It is present in limited areas of New Zealand, and since it is subject to control at all known localities it is considered a potential hazard.

23.2.2 Likelihood of association with the pathway

Typha latifolia produces a flowering spike containing up to 222 000 tiny seeds with bristly hairs that aid in wind dispersal (Finlayson et al. 1995). At maturity, the spike bursts under dry conditions, releasing the seeds. Any vehicle parked in the vicinity of wetlands containing *T. latifolia* at a time when it is producing mature seed is likely to become contaminated with seeds. In addition, many seeds including those of *T. latifolia* are stored in soils. Mean seed bank densities, of 84 000/m³ have been recorded in Baltic delta soil (Jutila, 2001). Wind-blown seed as well as produce and machinery contaminated with seed have previously been identified as possible paths of entry for this species into New Zealand (Champion and Clayton, 2001).

S. halepense is also a prolific seed producer with large panicles (Holm et al. 1977). More than 1kg of seed can be produced by a single plant over one growing season (Warrick and Black, 1983). The seeds are large in comparison with those of *Typha*, (3 by 1.5 mm in size) and have awns which aid dispersal in the fur of animals (Edgar and Connor, 2000). They are also transported by wind, in water, in mud or in contaminated grain or agricultural machinery

(Warrick and Black, 1983). The species has been reported growing close to vehicle exporting port areas in Japan (Alexander, 1997).

MAF Quarantine Service officers report that seeds are commonly intercepted inside the bonnet lid, inside the boot and trapped in cobwebs under the vehicle. Air filters are not routinely inspected or decontaminated, since they sometimes require dismantling with tools (MAF Quarantine Service, 2006). However inspectors report that large numbers of seeds occur in the filters and filter containers as well as soil, pine needles, leaves, dead insects and occasional live dermestid beetles. They report that generally cars from Japan have never had an air filter change and so can have the accumulation of contaminants from between 500 and 200 thousand kilometres of driving being drawn through the airfilter (Y. Fletcher pers. comm.; Smith and Toy, 2006). There are also anecdotal reports of seeds in air conditioning filters.

A survey of 300 imported vehicles, using a videoscope to find contamination in parts of the vehicle not visible through routine visible inspections recorded seeds in the following locations after decontamination: truck deck struts, inside chassis, radiators, interior - under seats, above exhaust pipe, around petrol tank, door sills, front wheel arches, inside the front bumper, behind rear mudguard, rear wheels, engine compartment and inside the bonnet. The full range of vehicle types were contaminated with seeds including sedans, trucks, vans and machinery (Biosecurity Monitoring Group, 2006).

Information on the frequency of contamination of imported used vehicles with seeds is available from the following sources:

1. The Biosecurity Monitoring Group survey of air filters. The survey did not include air conditioning filters. Just over half of the vehicles surveyed, or 620 vehicles had air filters accessible without the use of tools. Of these, 40 percent were contaminated and some vehicles had more than one contaminant type. The filters were not checked for fungal spores or other non-visible contamination. Differences in slippage rates between ports of entry and vehicle group (break-bulk and containerised) mean that the overall survey results can not be pooled and applied to the entire pathway. Estimated numbers of contaminated vehicles are therefore derived by calculating the estimated numbers by port and vehicle group and weighting them by the proportion of vehicles in that part of the pathway (Wedde et al. 2006). Numbers of vehicles entering with different contaminant types in air filters estimated in this way are given in Table 3. Note that since air filters are not inspected under the current risk management regime, unlike other contaminants which were recorded as slippage in the survey, this number provides an indication of contamination prior to intervention. It is based on the assumption that the inaccessible air filters had similar levels of contamination to the accessible ones.

Table 3. Estimated numbers of imported vehicles with air filters containing different contaminants entering New Zealand during November 2005. Source: Wedde et al. (2006)

Contaminant type	Estimated vehicles with contamination	95% confidence interval
Seeds	5 053	4 521 - 5 765
Plant material	1 862	1 601 - 2 511
Live arthropods	380	372 - 900
Animal material	294*	298 - 811
Soil	33*	125 - 457

*While the point estimates are based on a binomial distribution, when sample sizes are small the mean of the beta distribution deviates from the point estimate, particularly when '0' counts are recorded in the same categories.

2. In a survey of 500 new vehicles imported from Japan in 1999, 6 vehicles (about 1 percent) were contaminated with seeds which were not identified or tested for viability (Whimp and Moore, 1999).
3. During the period 12-20 March 2006, MAF quarantine officers recorded the contaminants found on inspected vehicles, excluding air filters, by hazard group (MAF unpublished data). The results for seed contaminants are summarised in Table 4. Seeds were not identified or tested for viability.

Table 4. Seed contaminants recorded on imported used vehicles 12-20 March 2006

	number vehicles inspected in Japan	number vehicles inspected in NZ
number of vehicles inspected both internally and externally	1509	1469
number of vehicles partially inspected	628 internal only 998 external only	0
percentage of vehicles cleaned prior to biosecurity inspection	95%	0
number & percent of vehicles cleared through assisted cleaning at the time of biosecurity inspection	624 (20%)	13 (1.0%)
number & percent of all vehicles inspected with plant seeds	349 (11%)	453 (31%)
number & percent of the vehicles that had plant seeds, that had 10 or fewer seeds	280 (80%)	298 (66%)

Many vehicles imported from Japan are subject to vacuuming and pressure wash immediately prior to MAF inspection. This is called pre-cleaning. In some instances where an inspector finds a very small quantity of contamination it is removed from the vehicle either by the inspector or by a non-MAF assistant, enabling clearance of the vehicle without further treatment and inspection. This is called assisted cleaning. These processes are reflected in the lower percentages of vehicles inspected in Japan with seed contaminants in comparison with those inspected in New Zealand.

Note the percentage contamination figures are based on all vehicles inspected even if only partially. Consequently a proportion of internal contaminants will be under-recorded. Only four items of machinery were inspected during the recording period 12-20 March. The results are therefore not representative of this sub pathway. Records from all the Terminal Receiving Facilities in Japan have been amalgamated, as have the records from all ports of entry into New Zealand. It is assumed that there are no significant differences in contamination rates or detection rates between facilities and ports.

These results are likely to be an understated estimate since the slippage and videoscope surveys indicate that not all seeds are found through visual inspection.

In addition to occurring in vehicles as individual contaminants, seeds also occur in soil which is itself a frequent contaminant of imported vehicles (see Chapter 20). There is no information on the frequency with which soil on vehicles is contaminated with seeds. However a Better Border Biosecurity (B3) research project lead by AgResearch looked at the biosecurity risk of soil associated with the footwear of international passengers arriving in New Zealand, and found plant seeds in 35 out of 60 samples (58 percent) (McNeill et al. 2006). Seed banks in

soil, are a means by which plants are able to survive adverse conditions. Seeds can occur in high densities in soils, for instance a mean density of 84 000 seeds/m³ have been recorded in coastal grasslands (Jutila, 2001) and blue grass, *Poa annua* seeds occurred at densities of between 2 000 and 20 000/m³ in vegetable fields (Shem Tov and Fennimore, 2003). Tsuyuzaki and Kanda (1996) recorded species-poor seed banks comprising 10 species at densities of 542 to 2 957 seeds/m³ in abandoned pasture in Japan. The highest seed bank densities often occur in early successional habitats (Grandin, 2001). It is assumed that these are likely to be situations in which vehicles will pick up soil contamination and also situations where soil from a vehicle may be transferred to the receiving environment in New Zealand.

There is limited literature on the association between vehicles and seeds. Schmidt (1989) germinated 124 species from the mud washed off one car in Germany. Annuals, perennials, herbs and phanerophytes with a variety of seed sizes and forms were all represented. In general grass species with small seeds were more common than herbs with large seeds, and ruderal plant community species were most common.

A survey of 1 960 seeds collected from 304 tourist vehicles entering Kakadu National Park in Australia also found that grasses were the most likely species to be carried by vehicles. Type of vehicle was the best predictor of seed numbers on vehicles, with four-wheel drive vehicles having the greatest number of seeds. Nearly half the vehicles surveyed carried no seeds (Lonsdale and Lane, 1994). Off-road vehicles have been identified as being of particular concern in the spread of weeds (Space and Imada, 2004). Soil associated with dirty, heavy machinery is considered to be the main pathway of introduction for a number of weed species to new locations for instance *Miconia calvescens* to Tahiti (Meyer, 2001) and spread of *Solanum elaeagnifolium* seed and root fragments (European Plant Protection Organisation, 2006).

Wace (1977) found no clear concentration or grouping of species with any particular biological characteristics in 224 species of vascular plants germinated from car-wash sludge in Canberra, although grasses were again abundant. Relatively few species made up the majority of seedlings germinated, and a large number of species were represented by small numbers of seedlings. The sludge from a single urban car-wash facility generated 15 645 seedlings over a two year period. It is thought that the number would be higher from a facility in a more rural area. This study also found that the vacuum sweepings from inside vehicles produced a yield of seedlings of the same order as that derived from the outside of vehicles.

A New Zealand school experiment, involving glasshouse germination of mud samples collected from 20 Department of Conservation trucks around Northland, in a glasshouse, found 495 plants of 29 different species germinated. Most of the species were not native to New Zealand (Department of Conservation web page). The number of seeds associated with mud on vehicles shows seasonal variation. One study found 100 seeds per 1000g dry mud early in the rainy season in Nigeria compared with 180 seeds per 1000g dry mud later in the rainy season. Plants with small seeds predominated (Clifford, 1959).

These studies together with the available identifications of seeds from imported vehicles indicate that the plants whose seeds are most likely to be associated with the vehicle pathway are predominantly small-seeded ruderal species. Given the long history of deliberate and accidental release of plant species into New Zealand, many but not all of these species are likely to be present in New Zealand already.

Taken together, this evidence indicates that imported vehicles are an important entry pathway for seed. The data for machinery is very limited but even higher levels of contamination can be expected given their nature and use. It is assumed that given the likely nature of its past use, used machinery is more likely to be contaminated with species that are not ruderal and may not already be present in New Zealand.

23.2.3 Likelihood of surviving shipment to New Zealand

S. halepense seeds can lie dormant for a couple of years in soil and seven years in dry storage (Holm et al. 1977), although viability in soil drops off from 60-75 percent after 2.5 years burial (Warrick and Black, 1983). Any viable seeds associated with soil are likely to be able to survive shipment to New Zealand in association with a vehicle, depending on their location within the vehicle.

T. latifolia seeds require moist conditions to germinate (Bonnewell et al. 1983; Jutila, 2001; Spencer and Bowes, 1990). It is assumed that they will remain dormant in the absence of such conditions.

The longevity of seeds varies according to species. Many seeds can survive in a seed-bank for a considerable period. For instance, seeds in the grass family Poaceae have recorded longevities ranging from one year to fifteen years (Shem Tov and Fennimore, 2003) and there are reports of seeds germinating following exposure of soil buried for several hundred years (Odum, 1974). Early-successional species often have numerous, small, long lived seeds while late-successional species tend to have fewer, larger and short-lived seeds (Grandin, 2001; Jensen, 2004; Odum, 1974). Plants with persistent seed banks tend to have small or very small seeds (Thompson and Grime, 1979) and these are the types of seeds most commonly found on vehicles. Seeds in soil which are buffered from the environmental conditions during transit may have a greater likelihood of surviving shipment. Longevity in seed banks will depend on a range of factors including time of year of soil collection. For instance Shem Tov and Fennimore (2003) found that weed emergence and germination from soil samples collected in the spring and germinated in both autumn and spring was less than 1%, whereas samples collected in the autumn had greater than 95 percent emergence under both spring and autumn conditions.

Information on the viability of seed associated with imported vehicles is very limited. The number of seeds collected and sent for viability testing during the Biosecurity Monitoring Group air filter and used vehicle slippage surveys was small, and since not all seed from any one contaminated vehicle were tested, there is no information on the average proportion of seeds on any one vehicle that were viable. However the results provide an indication that seeds in air filters had a lower viability than seeds found elsewhere in a vehicle. An estimated (after modelling) 13 percent of vehicles with seed contamination found in the air filters carried at least one viable seed, whilst an estimated 45 percent of vehicles with seed contamination found elsewhere in the vehicle, carried at least one viable seed (Wedde et al. 2006). This may reflect the higher temperatures and dryer conditions that seeds are exposed to in the engine bay.

These surveys looked at contaminants that were missed by the current biosecurity management system. Whilst most of the viable seeds were of genera already present in New Zealand, insufficient seeds from the surveys were able to be identified to species level to draw any conclusions about the association between viability and whether the species are already

present in New Zealand. There is no information on the viability of the wider population of seeds contaminating vehicles prior to biosecurity intervention, but the studies discussed above indicate that large numbers of seeds on vehicles can germinate.

This evidence of variable seed viability is expected given the range of temperature and moisture conditions within a vehicle. Seed survivability is likely to be lower in parts of the vehicle that experience the hottest operating temperatures:

- under the bonnet, where noise insulation will also have a heat insulating effect and temperatures may range between 38°C (Nomadics, 2000) and 80°C (<http://www.dervman.com/kits.htm>) in hot conditions;
- in air filters, although some air intakes use heat shields to isolate the air filter from the rest of the engine compartment which reaches 52-57°C at highway driving speeds (Nomadics, 2000);
- the radiator, which operates in the region of 90-100°C and can reach up to 140°C (Branquart, 2006) with air exiting at 63-68°C (Nomadics, 2000);
- the exhaust reaches temperatures up to 400°C, (Branquart, 2006);
- wheel brakes reach in excess of 150°C (Branquart, 2006).

23.2.4 Conclusion on entry assessment

Given that:

- There are large numbers of potential weed species not present in New Zealand with seeds capable of contaminating the vehicle and machinery pathway;
- Any vehicle or machinery parked in the vicinity of plants with wind blown seeds such as *T. latifolia* is likely to be contaminated with seeds;
- Seeds will also be carried in soil on vehicles;
- Large numbers of vehicles are contaminated with seeds of which the proportion belonging to species already present in New Zealand is not known;
- Seed contamination has been reported on imported new vehicles;
- Seeds are found in a wide range of locations in imported vehicles;
- The seeds of at least some potential weed species are able to survive in a dormant condition for periods greater than the journey time from the major exporting countries to New Zealand.

It is concluded that the likelihood of *S. halepense* and *T. latifolia* and of other exotic plant species entering New Zealand on the **new and used vehicle and machinery** pathway is **non negligible**. The likelihood of entry on used vehicles will be higher than on new vehicles given their past use and the likelihood of machinery being contaminated with non-ruderal species may be higher than on passenger vehicles.

The likelihood of viable seeds entering via air filters appears to be much lower than seeds elsewhere in the car. However there is considerable uncertainty around both the identity and viability of these seeds and no firm conclusions can be drawn.

23.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

23.3.1 Environmental suitability of New Zealand

Environmental suitability for establishment will depend on the species. Many plant seeds require exposure to moisture and cold (Jensen, 2004) or ingestion by animals or birds to facilitate germination. Since a number of countries from which vehicles and machinery are imported have similar climatic conditions to New Zealand, it is assumed that environmental conditions would be suitable for the establishment of at least some plant species entering as seeds on the vehicle pathway. The paucity of native 'weedy' species able to occupy continually disturbed habitats is a particular feature of the native flora of New Zealand (Ullman et al. 1995). This may increase the likelihood of establishment of new ruderal species.

T. latifolia grows in most places where the soil remains wet, saturated or flooded for most of the growing season. In North America it occurs in arctic, temperate, subtropical and tropical regions. Substantial amounts of tissue occur below the hydrosol where it is protected from freezing and new plants can arise from the meristematic tissue of buried rhizomes even after killing frosts. It grows mainly in freshwater but can tolerate slightly brackish conditions. It can grow in a range of soils from those with a high organic content to mineral soils. *T. latifolia* seed germination requires high temperatures, low oxygen concentration and relatively long exposure to light. In laboratory tests no germination occurred at 10°C, less than 10 percent seeds germinated at 15°C, but high levels germinated at 35°C. Shallow water and open mud flats around lakes and marshes provide appropriate conditions (Bonnewell et al. 1983; Jutila, 2001). It is likely that conditions in New Zealand's wetlands would be suitable for it to establish. Seeds are considered the main means whereby *T. latifolia* colonises new locations. Once established it spreads through vegetative reproduction from subterranean rhizomes (Spencer and Bowes, 1990). Whilst *Typha* seeds germinate readily in appropriate conditions, there is a high level of mortality and few seedlings reach a stage that enables them to reproduce vegetatively (Finlayson et al. 1995).

S. halepense occurs in the moist tropics, sub-tropics and Mediterranean climatic zones. It is generally frost sensitive but is able to over-winter in the warm temperate zones of Europe, the United States and Canada. It can grow in a variety of sites including arable land, waste land, and road sides, and has many ecotypes (Holm et al. 1977). Climatic modelling has shown that extensive areas of the North Island and parts of the northern and eastern coasts of the South Island are suitable for *S. halepense* to establish (Panetta and Mitchell, 1991) and it has already established in New Zealand in these areas in both the North and South Islands. Once established, it spreads through vegetative growth, with a single plant reportedly able to produce 60-90m of rhizome per season (Warrick and Black, 1983).

23.3.2 Biological characteristics

On the basis of past establishments, it has been estimated that in the absence of border controls, for every 100 new plant taxa introduced into New Zealand, at least one and probably nearer two will become a significant environment and /or agricultural weed. For some combinations of plant families and habitats the likelihood will be higher (Williams et al. 2000).

Of the 140 terrestrial weeds of public conservation land, 85 percent have been reported as weeds in other countries (Williams et al. 2000). Such weeds are more likely to contaminate the vehicle pathway than species without weedy characteristics.

The number of plant species accidentally introduced into New Zealand, via imported vehicles, is likely to be small in comparison with the thousands of plant species deliberately brought into New Zealand in recent decades which are still only cultivated, and have neither escaped into the wild nor passed through the 'break out' phase of establishment. However, small wind-borne seeds are most likely to be associated with the vehicle pathway. These characteristics are often associated with a large number of seeds on an individual plant. These are all characteristics likely to enable a new species to spread and become established from a founder population.

The number of seeds necessary to be introduced for a population to become established will depend on the species. The number of seeds of any one species entering New Zealand on the vehicle pathway is not known, but is potentially high depending on the conditions in which the vehicle was used and stored prior to shipment. The likelihood of establishment will increase if a significant number of seeds of a particular species are transferred to a suitable location together, and this is more likely to occur with instances of gross contamination than from releases of individual seeds.

23.3.3 Likelihood of transfer to suitable environment

In order for a species to establish the seeds will need to be transferred from a contaminated imported vehicle to an appropriate receiving environment. This could be through:

- seeds in mud being washed off the vehicle directly into a suitable habitat; or
- seeds in mud being washed off the vehicle at a decontamination facility, entering the waste water disposal system and ultimately being transferred to wetlands. The required screen size for washdown water is 2mm. Many seed contaminants are likely to pass through this; or
- seeds inside the vehicle being brushed out or blown out into a suitable habitat; or
- seeds dropping of a vehicle while in transit; or
- used air filters being disposed of either in general landfill or being dumped in a back yard. In many cases disposal will be in an urban environment but in the case of used agricultural or forestry equipment or off road vehicles transfer to more remote rural environments are also possible. There is no industry norm for servicing newly imported used vehicles and replacing air filters, each dealer or importer has their own level of preparation and servicing prior to putting cars on the sale yard. The air filter could remain in the vehicle for two years before being removed or cleaned by an owner or mechanic (Glasse, pers. comm.).

Road sides are well documented sites for exotic plant invasion (Parendes and Jones, 2000; Tyser and Worley, 1992). Small seeded ruderal plant species are likely to be able to establish in disturbed conditions associated with road and track margins to which they may be transferred by vehicles. Thus, vehicles are likely to be used in conditions where seed contaminants are more likely to establish.

A comparison of the species found on vehicles, with road side flora in Kakadu National Park, Australia concluded that nine of the weed species found on cars were found on three times as many sites within the National Park as other weeds (Lonsdale and Lane, 1994). This suggests

that cars may be partly responsible for weed infestations in the park, although mammals and birds could also have been responsible for the introduction of those species.

Germination of *T. latifolia* seed requires exposure to light, low oxygen levels and high temperatures, parameters characteristic of shallow water and bare mudflats (Bonnewell et al. 1983; Spencer, 1990). The likelihood of transfer of seeds from a vehicle to such an environment is small. However, once a population of a new plant species has become established it may be spread further through the activities of vehicles, birds, wind and other vectors. Champion and Clayton (2001) identified wind-dispersed *Typha* as one of the potential aquatic weeds of greatest concern because of its potential to spread.

The likelihood of transfer of *S. halepense* seeds from an imported vehicle to an appropriate receiving environment is much higher, given the species broad tolerances. It is reported as a serious weed in more than 50 countries (Warrick and Black, 1983).

23.3.4 Conclusion on establishment assessment

Given that:

- used vehicles and machinery can be taken to and used anywhere within New Zealand;
- used trucks, vans and four wheel drive vehicles as well as agricultural and forestry machinery are likely to be used in rural situations;
- ruderal plant species are most likely to be associated with vehicles and more likely to be able to establish in the environments to which they may be transferred from an imported vehicle.

And taking account the high mortality of many seedlings, it is concluded that the likelihood of establishment of a new species of weed in association with the vehicle and machinery pathway **non negligible but lower than for some other hazard groups**. *Sorghum halepense* has already demonstrated its ability to establish in New Zealand.

The likelihood of new weed species establishing via other pathways, notably naturalisation from plants already present in a garden environment, and the importation of seed and nursery stock is likely to be higher.

23.4 CONSEQUENCE ASSESSMENT

23.4.1 Direct effects

T. latifolia can form monocultures in wetlands. It forms dense rhizome mats and litter layers which can block water courses and interfere with wetland functioning. In Australia it has naturalised in Tasmania and Victoria where it is now an important weed of irrigation and drainage channels. It also reduces the storage capacity of small water reservoirs (Finlayson et al. 1995). Although there are already native and introduced species of this erect type of vegetation associated with wetland margins in New Zealand that are known for their competitiveness (e.g. *Typha orientalis*, *Zizania latifolia*, *Phragmites australis*), further problematic species of *Typha* could still have a marked impact if they became established (Champion and Clayton, 2000).

S. halepense is considered a serious agricultural pest, out-competing many pasture grass species through its stature and high rates of growth and spread, as well as reducing the yield of many crop species such as sugar cane, soyabean and maize. The economic costs of lost

production and of control are significant (Holm et al. 1977; Warrick and Black, 1983). Whilst the impact on arable crops is likely to be less significant in New Zealand than in some places it has established, the consequences of its spread for the livestock and dairy sectors could be significant, despite it being a reasonably high quality forage species (Warrick and Black, 1983).

23.4.2 Indirect effects

T. latifolia has an effect on wetland species diversity through direct competition and alteration of habitat. Given the absence of water stress which allows stomata to remain open and photosynthesis to proceed unhindered throughout the daylight hours, *T. latifolia* is highly productive and can achieve an above-ground productivity of 45 tonnes per hectare per year (Spencer and Bowes, 1990). Establishment and spread would result in social and cultural impacts associated with loss of wetland recreation opportunities and change in species composition. It could possibly hybridise with the native species, *Typha orientalis*. It is difficult to control given its rhizomal growth and aquatic nature. Control costs should it become established would likely be significant.

S. halepense is believed to produce allelopathic chemicals capable of inhibiting the germination and seedling development of a number of crop species including maize, wheat, and even citrus crops. It has also been an alternate host for many insect, fungal, viral, bacterial and nematode pathogens that attack crops (Panetta and Mitchell, 1991; Warrick and Black, 1983). Stress, or mechanical damage can cause the plant to produce hydrocyanic acid which can be toxic to grazing livestock (Holm et al. 1977).

The impacts of a new species of weed in general will depend on the species involved, but they have been summarised by (Williams et al. 2000) as:

- changes to vegetation structure occurring primarily when one life form dominates a community where it was previously absent;
- change in vegetation composition and reduction in the number of native species;
- suppression of natural regeneration of native species;
- facilitation of invasion by other weed species e.g. by collapsing canopies and allowing entry of light demanding weeds;
- changes to animal biodiversity as a result of habitat change;
- changes to animal behaviour such as the provision of cover or food for predators of native species;
- change to hydrological and /or fire and/or nutrient regimes.

The number of known invasive weeds in New Zealand has grown steadily since the 1960's, as new species have naturalised. Much of the introduction of new species in the past has been associated with the importation of seed and nursery stock for gardening and horticultural purposes. Currently there are approximately 20 000 introduced plant species present in New Zealand, of which approximately 2 000 have become established in the wild (Webb et al. 1988). New weed species have the potential to cause production losses and threaten New Zealand's natural heritage if they become established and able to maintain invasive populations. However, the impacts in New Zealand are not always easily predicted from their behavior in their native range (Randall, 1999). Historically, the majority of plant introductions have not become serious weeds (Panetta and Mitchell, 1991).

In addition as discussed earlier, seeds including those of species already present in New Zealand, may also be vectors for plant pests and diseases.

23.4.3 Conclusion of consequence assessment

The economic, social and environmental consequences of the establishment and spread of non-native plant species and of diseases introduced with seeds in association with the new and used vehicle and machinery pathway is **non negligible**. Both *T. latifolia* and *S. halepense* have been listed on the global invasive species database <http://www.issg.org/database/species> as being highly invasive global pest species. They are considered to be high consequence hazards.

23.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of a new species of plant associated with imported vehicles and equipment is non negligible; and
- the economic, social and environmental consequences of establishment would be non negligible.

and taking into account the non-visible micro-organisms that may be associated with seed, the risk is considered to be non negligible for new and used vehicles and machinery and risk management measures are justified. The risk is lower for new vehicles, and will depend on the conditions in which they are stored prior to export. The risk for used machinery and vehicles that are used off road is likely to be higher than it is for other types of used vehicle.

The risks associated with seeds in air filters are uncertain, but lower than seeds occurring elsewhere in imported vehicles.

23.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of seeds of exotic plant species and of pests and pathogens associated with seeds entering via imported vehicles and machinery and establishing in New Zealand.

23.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

23.7.1 Visual inspection

Seeds were one of the main contaminant types found by the Biosecurity Monitoring Group's used vehicle survey, in vehicles after biosecurity clearance had been issued. Differences in slippage rates by port and vehicle group mean that the overall results can not be pooled and applied to the entire pathway. The results were therefore calculated by port and vehicle group and weighted by the proportion of vehicles in that part of the pathway in November 2005. Numbers of vehicles entering with seed contaminants after biosecurity clearance, estimated in this way are given in Table 5. Some vehicles may have visible, air filter and non-visible seeds (or any combination of these), so these figures do not sum to the total number of vehicles with seeds slipping into New Zealand.

Table 5. Estimated number of vehicles with slippage of visible seed contaminants, non visible seeds and seeds in air filters during November 2005. Source: Wedde et al. (2006).

Visible seed contaminants		Seeds in air filters		Non-visible seed contaminants	
Estimated number of vehicles	95% confidence interval	Estimated number of vehicles	95% confidence interval	Estimated number of vehicles	95% confidence interval
873	205-1471	5 053	4 521-5 765	839	601-1273

Air filters are not inspected under the current risk management regime. Whilst visual inspection by experienced inspectors will detect many seeds, these results indicate that visual inspection is not able to reduce entry to a negligible level. Formally incorporating the Land Transport New Zealand compliance checking process into the biosecurity management process (see Chapter 4) would be likely to reduce the risk to a negligible level.

23.7.2 Vacuuming and pressure wash

Many of the instances of seed contamination found during the Biosecurity Monitoring Group survey were in vehicles that had been subject to decontamination by vacuuming and or pressure wash. This suggests that these decontamination regimes do not reduce the likelihood of entry to a negligible level. However, seeds remaining in a vehicle after thorough vacuuming/ pressure washing are considered less likely to be transferred from the vehicle to a suitable location for germination within the time period during which they remain viable than seeds which are readily removed. The likelihood of establishment of such seeds is therefore likely to be lower.

The approved treatment for soil and plant debris on vehicles and equipment is decontamination by sweeping and/or washing off and collection or destruction in an approved manner (Biosecurity New Zealand, 2006). There is no specification for the equipment to be used to achieve this de-contamination. The requirements for disposal of washings at on-shore facilities are that they are screened through 2mm sieves to remove any solids which must be incinerated in an approved facility (Ministry of Agriculture and Forestry, 2003). There are no specifications for disposal or treatment of non-solids. The seeds of some of the genera intercepted on imported vehicles, for instance *Typha*, *Conyza* and *Miscanthus* are less than 2mm in diameter (Edgar and Connor, 2000; Webb et al. 1988). Onshore pressure wash may therefore not effectively mitigate the entry of small seeded species.

23.7.3 Heat treatment

Little information is available on the tolerance of seeds to heat. Given that many seeds are protected by resistant coats and have the capacity for lengthy dormancy, it is assumed that a high temperature heat treatment regime would be required for effective devitalisation of seed contaminants. This is supported by the USDA requirement of treatment of imported niger seed, *Guizotia abyssinica* at 120°C for 15 minutes to minimise the entry of noxious weed species (United States Department of Agriculture). Strasser (1988) reports four percent germination of niger seed, after treatment for four hours at 100°C. These temperatures are higher than can be safely applied to vehicles, so this is not considered a practical risk management measure.

23.7.4 Fumigation

Methyl bromide is regularly employed as a fumigant to control pests associated with seeds because of its ability to penetrate large consignments of sacks and bags, and its general lack of

effect on seeds. Treatment with a concentration time product of 400 mg/h/l at 18°C reduces germination efficacy by less than five percent (Powell, 1975). Treatment of soft seeded species, has resulted in unspecified loss of viability, germination may be delayed or the vitality of young plants impaired (Bond, 1984). Cassells et al. (1994) found that after treatment with methyl bromide at five times the dosage and twice the exposure period normally specified by AQIS for disinfestation of consignments, more than 10 percent of the treated maize germinated. Fumigation is therefore not considered a practical treatment of seed contaminants.

23.7.5 Removal of air filters

Air filters are not currently routinely inspected for contamination as a degree of dismantling is sometimes required. The Biosecurity Monitoring Group found they were accessible in just over half the vehicles surveyed (Wedde et al. 2006). However, since they are designed to suck in air, they are likely to contain air-borne seeds and spores and this is supported by the results of the 2005 vehicle slippage survey. Although the data are limited, there are indications that the viability of seeds in air filters is lower than that of seeds occurring elsewhere in imported vehicles (Wedde et al. 2006).

Easily accessible air filters were inspected in Japan prior to 2006. Where pre-cleaning with an air gun had not occurred, contaminants were generally found. These were not systematically recorded, but reportedly included litter, including pine needles, soil, dead insects and on a couple of occasions live dermestid beetles (Y. Fletcher, pers.comm.).

The air filters of agricultural and forestry machinery are likely to contain larger numbers of seeds as well as other contaminants of concern such as fungal spores. As a result of their use, they are also more likely to be contaminated with species of biosecurity concern and are more likely to be emptied in locations in the vicinity of suitable receiving environments than air filters in passenger vehicles. Agricultural and forestry machinery is generally recognised as being of higher risk for the transmission of seeds. The Australian Quarantine and Inspection Service requires the air filters of military equipment such as diggers to be replaced prior to return to Australia (AQIS, 2000).

Replacing or cleaning used air filters prior to import or clearance would overcome this uncertain risk. Formally incorporating the Land Transport New Zealand compliance checking process into the biosecurity management process (see Chapter 4) could provide a practical opportunity to achieve this, for all vehicles, including those with less accessible air filters.

23.7.6 Onshore versus offshore risk management

The slippage survey found no significant difference between slippage of seeds on vehicles with offshore biosecurity management and those with onshore management. Whilst there are no data on recontamination rates, recontamination of vehicles treated offshore prior to shipment could occur if the storage area is in the vicinity of exotic plant species with wind blown seed. The likelihood of re-contamination will be reduced, but not eliminated through maintenance of storage facilities free from vegetation.

If decontamination occurs onshore the management of waste water from decontamination facilities needs to be reviewed to ensure that small seeds are not transferred to wetlands following decontamination. Offshore risk management ensures that hazardous material does not arrive in New Zealand and therefore does not need to be disposed of securely.

23.8 RECOMMENDED MEASURES

There is considerable uncertainty about the level of risk associated with seeds in air filters of passenger vehicles. Removal or cleaning of air filters is an effective and easy way of removing this uncertain risk for about half the imported used vehicles. Given the uncertainty there is a strong recommendation for further research in this area. Seed contamination on the radiator (unless insulated), exhaust and wheel brakes are not considered to be hazards, since they are exposed to sufficiently high temperatures to devitalise them.

The following measures are recommended for **used vehicles and machinery**:

- 1) 100 percent visual inspection followed by internal and/or external cleaning to remove all visible soil and seed contamination, followed by re-inspection; **and**
- 2) bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4); **and**
- 3) encourage voluntary replacement/cleaning of air filters for passenger vehicles as an interim measure but **mandatory** replacement or cleaning for **machinery**

In addition

- 4) If risk management occurs offshore, the exporting facilities must be maintained free from vegetation and measures adopted to prevent re-contamination by wind blown seed;
- 5) If risk management occurs onshore, the specification for treatment of waste water and should be reviewed to avoid small seeds entering the aquatic environment;
- 6) Research to clarify the identity and viability of seeds in air filters and air conditioning filters of passenger vehicles to determine whether mandatory cleaning or replacement is justified.

An alternative package of measures involving audited mandatory pressure wash, vacuuming and encouraging voluntary air filter cleaning/replacement would also reduce the risk from plant seeds but not as much as the recommended package of measures.

The risk associated with seeds contaminating imported used machinery is unclear given the low levels of information. A videoscope survey of used machinery planned for 2006-2007 will provide a measure of slippage for this part of the pathway. It is recommended that this measure is reviewed once the results of the survey are known. Requiring offshore decontamination and inspection by specialised inspectors for any classes of machinery found to have particularly high levels of contamination with seeds would reduce the level of risk associated with these machines.

For imported **new** passenger vehicles a systems approach incorporating surveillance, appropriate storage yard maintenance measures and decontamination where necessary should be investigated.

23.9 UNCERTAINTY/ ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- Few of the seeds entering via the vehicle pathway have been able to be identified to species level. As a result the proportion of seeds that are of species not present in New Zealand and therefore of biosecurity concern is not known. Since it is very difficult to identify seeds and seedlings from exotic locations, this uncertainty can not be easily reduced;
- The viability of seeds, particularly those located in the air filters is based on only a few samples, and has a wide margin of error; as a result seed viability is uncertain;
- It is assumed that given the likely nature and location of its use, used machinery is more likely to be contaminated with species that are not ruderal and may not already be present in New Zealand.
- The likelihood of transfer of exotic seeds from an imported vehicle, particularly seeds that are not readily visible, to a suitable receiving environment is not known, but assumed to be relatively low;
- The likelihood of contamination of new vehicles is unknown but will depend on the conditions and length of storage and is assumed to be non negligible.

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24 Lizards and snakes (Reptiles)

24.1 HAZARD IDENTIFICATION

24.1.1 Identity

Category: Taxonomic Group: Class: Reptilia; Order: Squamata

Name: lizards, snakes

24.1.2 Introduction

The Order Squamata comprises some 28 families of lizard (around 4470 species) and 18 families of snake (around 2980 species). Some species of snake and lizards occur in all the main countries from which vehicles are imported. Two families of lizard occur naturally in New Zealand, geckos (Diplodactylidae) and skinks (Scincidae) comprising some 88 endemic species. New Zealand lizard species, with one exception, are almost unique in giving birth to live young rather than laying eggs. There are no terrestrial snakes native to or established in New Zealand but two marine snakes are indigenous (Gill and Whitaker, 1996).

Most intercepted reptiles are sent to Whitaker Consultants Limited for identification. Table 1 summarises the records from imported vehicles, boats and machinery from their database.

Table 1. Interception records of Squamata up to April 2006, associated with imported vehicles and machinery. Source: A.H. Whitaker.

Organism	Family	Status (Gill and Whitaker, 1996)	Country of origin	Pathway	Lifestage & viability (number of records)
<i>Gehyra dubia</i> Australian house gecko	Gekkonidae	Australian species not present in NZ	Australia	used vehicle	border dead adult (1)
<i>Hemidactylus brookii</i>	Gekkonidae	widespread in the old world tropics. Not present in NZ	Singapore	used vehicle	border live adult (1)
<i>Hemidactylus frenatus</i> , Asian house gecko	Gekkonidae	widely distributed in Asia including Japan (Bonin and Ryukyu Islands), Australia, USA, South America. Not present in NZ	Singapore	used vehicle	border live adults (6, 1 record was of 2 geckos), post-border live adult (1), border viable eggs(1 record of 3 eggs), adult unrecorded viability (1)
				new vehicle	border live adult (1 of 5 geckos) post-border non-viable eggs(1),
				used vehicle	post-border live adult (2) ** post-border live adult (1)
			Japan	break-bulk yacht	border live adult (1) post-border live adult(2)

Organism	Family	Status (Gill and Whitaker, 1996)	Country of origin	Pathway	Lifestage & viability (number of records)
			French Polynesia	used vehicle new car	border live adult (2) post-border live adult (1)
			Thailand	used vehicle	border live adult (1)
			Australia	used vehicle used vehicle	border live adult (2) post-border live adult (1)
			Malaysia		
			not recorded		
<i>Hemidactylus turcicus</i> Mediterranean gecko ****	Gekkonidae	native to Europe introduced to many countries including USA. Not present in NZ	not recorded	vehicle	border live adult (1 of 2 geckos)
<i>Lepidodactylus lugubris</i> , mourning gecko	Gekkonidae	Native to Asia & the Pacific. Not present in NZ.	Fiji	vehicle	post-border live adult (1) adult viability not recorded (1)
<i>Tarentola mauritanica</i> Moorish gecko	Gekkonidae	native to Mediterranean regions. Introduced to Uruguay & USA. Not present in NZ.	Tonga Spain	yacht freighted yacht	post-border live adult (1)
unidentified	Gekkonidae	unknown	Singapore	used vehicle	border dead adult (1)
<i>Cryptoblepharus carnabyi</i> , spiny palmed shining skink*	Scincidae	Australian species not present in NZ	Australia	used machinery	live juvenile (1)
<i>Lampropholis delicata</i> , rainbow skink	Scincidae	Australian species present in northern NZ	Japan	new vehicle	post-border live adult (1)***
<i>Dendrelaphis punctulata</i>	Colubridae	Australia & New Guinea. Not present in NZ	Australia	vehicle	border live adult (1)
<i>Elaphe climacophora</i> Japanese rat snake	Colubridae	Japan. Not present in NZ	Japan	used vehicle	post-border dead adult (1) border dead adult (1)
<i>Elaphe obsoleta</i>	Colubridae	North America. Not present in NZ	USA	used vehicle	border discarded snake skin (1)
<i>Elaphe quadrivirgata</i> Japanese four lined rat snake	Colubridae	Japan. Not present in NZ	Japan	vehicle	live adult (1)
unidentified snake	unknown	Not present in NZ	Japan	used vehicle used machinery	post-border dead adult (3), border dead adult (2) border dead adult (1)

*This record is from the Biosecurity Monitoring Group interceptions data base, the specimen was identified by the Lynfield Plant Protection Centre in 1995.

** One record was from a vehicle imported from Yokohama, discharged at Laem Chabang (Thailand), transhipped and discharged at Auckland five weeks later. It was inspected, steam-cleaned and later selected for a random re-inspection. The lizard was found through the use of a videoscope inside one of the door panels, together with assorted plant material. This illustrates one of the limitations of the interception data. Vehicles that have been transhipped may have become contaminated with organisms from a third country and this will most often not be evident from the records.

*** The record of a live adult rainbow skink *Lampropholis delicata* from a new vehicle imported from Japan is thought to have been a local contamination. This species is native to Australia and established in parts of northern New Zealand, particularly around Auckland: it does not occur in Japan. The vehicle was stored outside for four months on an asphalt surface in Auckland prior to distribution and is likely to have been contaminated during this period (Whitaker, 2006).

**** It is doubtful whether this record is associated with the vehicle pathway since the three vehicles in question came from California and Texas but were loaded into the container at Long Beach, California, where the species does not occur. The container was transhipped at Pusan (Korea) and again at Sydney (where it was ashore for seven days). The geckos were found on the **outside** of the container on arrival at Christchurch (A. H. Whitaker pers. comm.). This record will not be considered further in the analysis, but it serves to illustrate the difficulties in interpreting interception records.

There are records for 11 species of reptile in association with the pathway (excluding *Hemidactylus turcicus*), only one of which is established in New Zealand. The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Whilst the high proportion of live interceptions recorded (73 percent) is not likely to represent the proportion of reptiles surviving shipment, since live reptiles are more likely to be both intercepted and recorded than dead ones, it is nonetheless noteworthy in comparison with other hazard groups. 41 percent of records are post-border. There are three records for live reptiles (*Hemidactylus frenatus*) that are not present in New Zealand, from imported **new** vehicles. In October 2006 a monitor lizard (*Varanus salvator*) was found alive in a used vehicle imported from Singapore. This is the first record of this species from NZ and is a large animal (total length 38 centimetres) relative to other organisms intercepted on the pathway (A.H. Whittaker pers. comm.). Its survival of the journey is noteworthy.

24.1.3 Conclusion

Given the records for live reptiles intercepted on imported vehicles, Squamata are considered a potential hazard on both new and used imported vehicles and machinery.

The risks of introduction of exotic Squamata into New Zealand via imported vehicles and machinery are assessed using Asian house gecko, *Hemidactylus frenatus* which is the mostly commonly intercepted member of this group, and the brown tree snake, *Boiga irregularis* as examples. Whilst *Boiga irregularis* has not been intercepted from imported vehicles and machinery, it is a well known high consequence pest in this group which has a reported association with vehicles and machinery elsewhere (Rodda et al. 1992).

24.2 ENTRY ASSESSMENT

24.2.1 Current Distribution

Hemidactylus frenatus has a worldwide tropical and sub tropical distribution, including Japan and has been introduced to a number of countries including the USA, parts of central America, the Pacific Islands and Australia (Case et al. 1994; Galina Tessaro et al. 1999). In

Japan it occurs only in the Bonin and Ryuku islands. Its global range has increased dramatically as a result of inadvertent movement by humans and is still expanding (A.H. Whitaker, per comm.).

Boiga irregularis is native to eastern Indonesia, the northern part of Australia, Papua New Guinea, and the Solomon Islands. The species was introduced to Guam, probably as stowaways on vehicles and other salvaged war material transported via ships in the late 1940's or early 1950's (Rodda et al. 1992).

24.2.2 Likelihood of association with the pathway

Both species can survive in urban and agricultural surroundings and have the potential to hide in very small spaces in vehicles and machinery. Radiotelemetry data shows that *B. irregularis* will cross substantial expanses of asphalt (Rodda et al. 1999). Both species are nocturnal and therefore not likely to be readily detected entering a vehicle. The likelihood of association will depend on:

- the location in which vehicles have been used prior to shipment;
- the location in which vehicles are stored prior to shipment;
- the prevalence of reptiles in these locations.

There are records (border and post-border) for 52 species of reptiles and amphibians accidentally imported into New Zealand over the period 1929 to 2000 (Gill et al. 2001). *Hemidactylus frenatus* made up 22 percent of all the interceptions while most other species were intercepted only infrequently. The most frequent pathway of introduction of reptiles was personal effects (21 percent). Motor vehicles were also an important pathway (11 records, 9 percent) along with bananas and timber. There appears to be an increase in the proportion of reported interception records made up of *H. frenatus*. Over the last 12 months, 69 percent of interceptions across all pathways were of *H. frenatus* (A.H. Whitaker, pers. comm.).

MAF quarantine officers verbally report finding reptiles in approximately 1 in 100 vehicles (Smith and Toy, 2006). This is a surprisingly high figure which cannot be verified since there is no routine recording of contaminants found on the vehicle pathway. It is assumed to be a high level estimate. There have been 51 reptile interceptions from vehicles sent to Whitaker Consultants Limited for identification over the last 4 years (A.H. Whitaker, pers. comm.). Since not all interceptions, particularly specimens that are found dead are sent, and since the videoscope survey has shown that not all reptile contaminants are detected through visual inspection, this is assumed to be an under-recording.

24.2.3 Likelihood of surviving shipment to New Zealand

Little is known about the critical thermal limits of many reptiles. *Boiga irregularis* can tolerate temperatures of up to 36°C (Rodda et al. 1999) but is susceptible to desiccation given the high surface area to volume ratio caused by its slender morphology. Snakes do not need to eat regularly, for instance the Japanese pit viper, *Trimeresurus flavoviridis*, can survive several years without food so long as water is available (Nakomoto et al. 1981). It is assumed therefore that a hitch hiking snake would be able to survive the 4 day shipment from Australia to New Zealand. This is supported by a live record of *B. irregularis* arriving in New Zealand on timber from Papua New Guinea (Gill et al. 2001) and the two records of live snakes from the vehicle and machinery pathway, one on a vehicle from Japan.

Hemidactylus frenatus has been intercepted alive on imported vehicles at the border and is clearly able to survive shipment from Singapore to New Zealand.

24.2.4 Conclusion on entry assessment

Given that:

- *H. frenatus* and *B. irregularis* occur in countries from which used vehicles are regularly imported;
- they occur in suburban areas and are thus likely to be in a position to contaminate vehicles;
- live geckos are intercepted at the border on imported vehicles;

and assuming that *B. irregularis* would be able to survive the relatively short journey between Australia and New Zealand, it is concluded that the likelihood of exotic reptiles including *H. frenatus* and *B. irregularis* entering New Zealand on imported **used** vehicles and machinery is **non negligible**.

Given that snakes and geckos are able to infest **new** vehicles, the likelihood of contamination of new vehicles is considered to be **non negligible**. It is interesting that in the year prior to December 2004, 20 184 new cars were imported from Australia, which is a likely source of hitchhiking reptiles, compared with only 1 057 used cars (New Zealand Customs, 2004).

24.3 ESTABLISHMENT ASSESSMENT

This potential hazard group differs from ones like ants in that despite the long history of international trade, and the potential for introduction, so far no amphibian or reptile has established in New Zealand by accidental importation in cargo, except for the Australian rainbow skink *Lampropholis delicata*. This skink is assumed to have arrived accidentally in cargo (Gill et al. 2001).

24.3.1 Environmental suitability of New Zealand

Hemidactylus frenatus thrives around human dwellings and in second growth forests and habitats with rocks or other debris and large trees (McKeown, 1996). It is a tropical/sub-tropical species. However it has become established inside artificially-heated city buildings elsewhere in its range (Gill et al. 2001). It has a large temperature range from 19° C to 34.3° C to facilitate nocturnal activity. During the day, *H. frenatus* raises its body temperature to levels higher than that found in diurnal species. Its body temperature on emergence from diurnal retreats is higher than most nocturnal environmental temperatures available to the animal, and this enables it to remain active at colder temperatures (Marcellini, 1976). The species has spread, probably via cargo to Pacific Islands, east Africa, Mexico and southern USA in recent years (Case et al. 1994; McKeown, 1996). It has been steadily expanding its naturalised range down the east Australian seaboard in recent years and is now established as far south as Coffs Harbour in central New South Wales. It has recently naturalised on Norfolk Island. This expanded range brings it close to being able to cope with some local microclimates in the northern North Island. What is not yet known is how temperature dependent sex determination might affect its ability to establish in cooler climates where it might otherwise be able to survive (A.H. Whitaker, pers. comm.). The diet of *H. frenatus* is broad and invertebrate dominated (Galina Tessaro et al. 1999). The relative abundance of prey items appears to reflect their abundance in the area occupied by the gecko (Tyler, 1961).

B. irregularis is considered to be a tropical species, however its distribution in Australia roughly coincides with the frost line (Rodda et al. 1999) and it occurs nearly as far south as

Sydney, suggesting it would be capable of surviving in northern New Zealand (Gill et al. 2001). It is thought that humidity greater than 60 percent is necessary to enable skin shedding. Mean monthly relative humidity exceeds 60 percent in all months of the year in virtually all of New Zealand (NIWA Science, 2006). It occurs in a range of habitats from forests and mangroves to grasslands, shrublands, gardens, garages, and roofs of houses and feeds on a wide variety of birds, lizards, small mammals, eggs (bird and reptile) and small common household pets (Rodda et al. 1999).

24.3.2 Biological characteristics

H. frenatus is an opportunistic egg layer with nest sites under loose bark, holes in trees, in houses or almost any protected elevated location. Generally multiple clutches of two eggs are laid throughout a breeding period and take 45-90 days to hatch, depending on the incubation temperature (McKeown, 1996; Zug, 1991). Gravid females occur in all months in tropical areas, whereas in temperate areas, males' maximum spermatogenesis occurs in late spring (Zug, 1991). Females can store sperm for more than nine months and produce viable eggs (Murphy-Walker and Haley, 1996). There have been interception records of more than one gecko entering New Zealand in a vehicle.

Reproduction of *B. irregularis* starts around age three with up to 12 eggs deposited once or twice a year in caves, hollow trees, and other areas protected from drying and overheating. The eggs are then abandoned, and hatch about 90 days later. On the island of Guam population densities estimated to reach several thousand per square kilometre are reached (Savarie and Bruggers, 1999).

Snakes, including *B. irregularis* are renowned for their ability to store sperm, with reports of females producing viable young after being in isolation for six years (Rodda et al. 1999). It is therefore assumed any adult female that has mated could potentially start a new population.

A significant uncertainty in predicting the likelihood of establishment of a new species is the impact of predation, parasitisation and competition in a new environment. For about 35 years after its introduction to Guam, *B. irregularis* had a limited distribution, but in the 1960s a sharp population growth occurred with peak levels attained a decade or more after each area was colonized (Rodda et al. 1992). This typical colonisation pattern has also been demonstrated by *Lampropholis delicata* in Auckland and *H. frenatus* in Australia (A.H. Whitaker, pers. comm.).

24.3.3 Likelihood of transfer to suitable environment

Given that reptiles are mobile, and that *B. irregularis* and *H. frenatus* can survive in urban environments and that Auckland, the main port of entry for vehicles (see Chapter 3) is in the north of New Zealand where environmental conditions are likely to be most suitable, it is likely that at least some snakes and geckos that survive the journey to New Zealand would be transferred to a suitable environment. It is assumed that the high rate of entry of geckos across all pathways (Gill et al. 2001) will increase the likelihood of establishment.

The rate at which exotic reptiles would spread in New Zealand is uncertain. However the human assisted means by which the species arrive in New Zealand are also pathways for domestic spread. None of these pathways have any biosecurity measures or restrictions on them.

A recent incident in which a live adult rainbow skink *Lampropholis delicata* entered a vehicle stored on an asphalt holding area in Auckland and was transported to New Plymouth (Whitaker, 2006) demonstrates that reptiles can be readily transported around the country once they have become established. Individual brown tree snakes have been recorded travelling up to 450 metres a night (Rodda et al. 1999).

24.3.4 Conclusion on establishment assessment

Given that:

- new and used vehicles and machinery can be taken to and used anywhere within New Zealand;
- the northern part of New Zealand has a suitable climate and range of habitats for *B. irregularis* and *H. frenatus*, although *H. frenatus* is likely to be restricted to urban environments;
- snakes can store sperm and a single gravid female can produce several broods;

and taking account of the uncertainty over the effect of temperature dependent sex determination on establishment, it is concluded that the likelihood of establishment of exotic species of reptile including *B. irregularis* and *H. frenatus*, in association with the new and used vehicle and equipment pathway is lower than organisms in some other hazard groups, but **non negligible**.

24.4 CONSEQUENCE ASSESSMENT

24.4.1 Direct effects

New Zealand is free of terrestrial snakes and has a naive native fauna that would be vulnerable to predation if snakes establish. At least 12 native terrestrial species are thought to have been extirpated on Guam by *B. irregularis* (Rodda et al. 1999). The impacts have been greatest on the island's native bird fauna, because introduced bird species are able to nest and roost in locations that *B. irregularis* seldom reaches (Wiles et al. 2003). *B. irregularis* has been observed foraging on birds, eggs, small mammals and lizards (McKeown, 1996). The precise effects are difficult to determine as population declines are often the result of multiple factors (Rodda and Fritts, 1992). Nonetheless, New Zealand's endemic bird, lizard and frog fauna would be very vulnerable to a snake that includes these organisms in its diet.

On islands across the Pacific the invasion of the gecko *H. frenatus* has caused a decline in the abundance of a resident gecko *Lepidodactylus lugubris* through competitive displacement (Hanley et al. 1998). The exact mechanism is not fully understood, but it is thought that the combination of insect-rich patches associated with artificial lights and structural simplicity of buildings may allow behavioural exclusion of the smaller *L. lugubris* in the urban environment but not in more natural forest habitats (Case et al. 1994). *Hemidactylus frenatus* has also been implicated in gecko extinctions on Indian Ocean islands (Cole et al. 2005) and on various Pacific Islands, where the impact is not just around lights and on buildings, but also in natural habitats (A.H. Whitaker pers. comm.). New Zealand's endemic reptiles which are principally forest dwellers (Gill and Whitaker, 1996), and may thus be unlikely to come into contact with *H. frenatus* if it became established. New Zealand lizards would be expected to be at a competitive disadvantage since they tend to lay fewer eggs than most overseas geckos and skinks (Cree, 1994) and develop maturity late. In contrast *H. frenatus* matures rapidly, is fecund and short-lived.

The most vulnerable native bird, reptile and amphibian populations are currently largely located on off-shore islands which have rigorous biosecurity regimes in operation to prevent transfer of harmful predators such as rats and mice. However mainland islands and sanctuaries are being established to increase the range and populations of New Zealand's endemic fauna. Preventing transfer of a newly established species of reptile to such areas would be much more difficult than on offshore islands and experience of designing and maintaining snake proof barriers on Guam has highlighted the difficulties in maintaining nature reserves free from exotic snakes (Rodda et al. 2002). It is undesirable to restrict New Zealand's endemic fauna to intensively managed sanctuaries and the impacts of an introduced snake in the wider environment would be severe.

24.4.2 Indirect effects

Along with the disappearance of most of Guam's native vertebrates from predation by *B. irregularis*, ecological processes that are important to the remaining components of the ecosystems, such as seed dispersal by flying foxes have been affected (Rodda et al. 1999). The long-term consequences of establishment of a species such as the brown tree snake are therefore likely to be complex and far-reaching. Whilst it is recognised that the effects of *B. irregularis* on Guam are extreme, it is assumed that severe impacts could occur in New Zealand. For instance, native New Zealand lizards pollinate and disperse the seeds of some native plants, which appear to have evolved fruits specifically to attract them (Wilson, 2004).

Regular power outages on Guam are a significant economic burden to the island and have been attributed to the brown tree snake, which frequently scales power lines and transformers. Aside from the inconvenience, and direct impact on local businesses such outages are becoming an impediment to Guam's tourist industry. *Hemidactylus frenatus* also commonly occupy electrical installations and electronic equipment with consequent failures and increased maintenance and cleaning costs. In buildings, particularly those where hygiene is an issue (medical sites, food preparation areas) contamination is a big issue requiring increased pest management and cleaning costs (A.H. Whitaker pers. comm.).

The social effects of a species of snake establishing as a major new component of the New Zealand fauna may be considerable, given fear of snakes based on many species being venomous. Ophidiophobia (fear of snakes) is a common form of specific phobia, and the experienced irrational fear can cause functional impairment and severely affect the quality of life of the sufferers (Wu et al. 2006). Even non-venomous snakes pose a threat to humans as they can bite if threatened. For example Silveira and Nishioka (1992) reported some cases of painful bites by non-venomous snakes. As in the case of all animal bites, infection may occur. In one extreme case, a human death was induced by multiple bites from a non-venomous snake (Chroni et al. 2005).

Reptiles are known carriers of a range of ticks (Burrige, 2001) and other parasites. Information on rates of infestation is sparse, but 28 percent of reptile shipments imported into Florida over a three month period in 1995 were tick infested (Burrige, 2001) 17 percent of geckos historically intercepted in New Zealand were recorded to have ectoparasites (Gill et al. 2001).

Hemidactylus frenatus is known to be affected by a broad range of 30 helminth parasites, one virus and 10 ectoparasites. There is a lack of knowledge of ectoparasites and the diseases they

may vector, both of native reptiles and of commonly intercepted species. However the acarine parasite *Ophionyssus natricis* is of particular concern. It has entered New Zealand on an exotic reptile on at least one occasion. It has established among wild skink populations in Australia and is known to have pathogenic effects on its hosts. The naive indigenous reptiles of New Zealand are likely to be particularly susceptible (Reardon and Heath, 2004). Since the majority of New Zealand's herpetofauna is listed as threatened (Hitchmough, 2002), such impacts on the indigenous fauna are likely to be serious. Adverse consequences from the introduction of new parasites may occur without establishment of *H. frenatus*. Repeated one off incursions may have the same effect. Geckos also transmit diseases that can affect humans, such as salmonella.

24.4.3 Conclusion of consequence assessment

There are likely to be significant environmental, economic and social consequences from the entry and establishment of new reptile species including *B. irregularis* and *H. frenatus* into New Zealand. The consequences are therefore **non negligible**.

B. irregularis is considered a high consequence pest. It is unlikely that it would be acceptable for any species of snake to establish in New Zealand and the measures recommended below will address the risk from all species likely to be associated with the pathway.

24.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of reptiles associated with the new and used vehicle and machinery pathways is non negligible;
- the environmental, economic, social and human health consequences of establishment would be non negligible;

and taking into account, that adverse consequences from the introduction of new parasites may occur from repeat incursions without establishment of *H. frenatus*, the risk is estimated to be **non negligible for new and used vehicles and machinery** and risk management measures are justified. The risk is lower for *B. irregularis* than for *H. frenatus* because *B. irregularis* does not occur in Singapore which exports a greater volume of vehicles. The risk associated with used machinery is likely to be higher than it is for other types of vehicles, due to its more complex construction which allow more hiding places.

Furthermore, reptiles in at least nine additional taxa which are not present in New Zealand have been recorded from the vehicle pathway. Whilst they have not been subject to risk assessment, it can not be assumed that the risk associated with them is non negligible.

24.6 RISK MANAGEMENT

The objective is to reduce to a negligible level, the likelihood of exotic reptiles entering New Zealand via the vehicle and equipment pathway.

24.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

24.7.1 Visual inspection

Reptiles were not encountered during the 2005 slippage survey. This is not surprising given that they are not intercepted very frequently. Based on the number of vehicles surveyed, there was a 95 percent chance of detecting visible contamination affecting 1 in 182 vehicles (Wedde et. al. 2006). Reptiles are relatively large in comparison with other live hazards associated with the vehicle pathway, and so could be expected to be detected relatively easily. Their rapid motion would also draw the attention of the inspector. However, since many species, including *B. irregularis* and *H. frenatus* are nocturnal, and are able to hide in small crevices, it is likely that they may hide within the structure of the vehicle where they will not be detected by visual inspection. A live gecko was found by videoscope in this way in a survey of 300 vehicles (Biosecurity Monitoring Group, 2006). The high proportion of post-border interceptions also indicates the limitations of visual inspection.

In conclusion, visual inspection is not likely to meet the risk management objective.

24.7.2 Pressure wash

No information is available on the efficacy of this treatment, but it is assumed that it would not be effective against external reptile contaminants, if they are able to move into crevices inaccessible to water blasting.

24.7.3 Heat Treatment

Reptiles often rely on behavioural thermoregulation to control their body temperature.

Thermal death temperatures of around 41°C have been reported for snakes, although temperate zone snakes are reported to have thermal preferences between 30 and 35°C (Winne and Keck, 2005). The desert dragon, *Amphibolurus inermis* (now called *Ctenophorus nuchalis*) is one of the most heat resistant species known. It has a lethal temperature of 49.3°C, and thermoregulates through a variety of means including colour change, burrowing, basking and panting (Heatwole, 1970). *H. frenatus* is a nocturnal species with a maximum recorded cloacal temperature of 34.3°C (Marcellini, 1976).

Without the opportunity for access to thermal refuges, reptile body temperatures in heat treated vehicles are likely to exceed the critical thermal maximum, even for species adapted to live in very hot environments. The efficacy of heat treatment against reptiles will depend on the speed with which the temperature can be raised to avoid the reptile escaping.

Whilst there is a lack of experimental evidence of heat treatment on reptiles, given the reported thermal death temperatures of 41°C, treatment at a core temperature of 50°C or higher for ten minutes is assumed to be effective in killing reptiles associated with a vehicle.

24.7.4 Fumigation

The ability of reptiles to withstand adverse conditions may mean that they are less susceptible to fumigation than other organisms (Williams et al. 2002). However, fumigation with methyl bromide at 24g/m³ for 2 hours resulted in all treated *B. irregularis* dying within 18 hours (Savarie and Bruggers, 1999). Williams et al. (2002) recommended a concentration time product of 160 g.h/ m³ at temperatures greater than 16°C for treatment of snakes. It is assumed that fumigation with methyl bromide at 48 g/m³ for 24 hours at 21°C (concentration time product of 1152 g.h/ m³) will kill any reptile contaminants.

24.7.5 Offshore versus onshore risk management

Whilst there are no data on recontamination rates, the likelihood of infestation of new vehicles, or re-contamination of vehicles treated offshore prior to shipment can be reduced through maintenance of vehicle storage yards and surrounding areas free from vegetative cover. However this is unlikely to have much effect on commensal geckos. The current risk management regime requires a minimum of 3 metres to be maintained between biosecurity inspected vehicles and surroundings containing vegetation and un-cleared vehicles. This separation between cleared and un-cleared vehicles extends to storage on the ship. Separation by this distance will have no deterrent effect on the movement of reptiles or amphibians. It is likely that populations of geckos may be established on the ship itself, and that contamination of vehicles could occur from such populations during shipment to New Zealand. However no definitive evidence has been found for this.

Reptiles are mobile and fast moving. Their nocturnal habits may increase the likelihood of them leaving a vehicle on arrival in New Zealand without being detected. Offshore treatment is therefore preferable to onshore treatment.

24.8 RECOMMENDED MEASURES

1. for **used** vehicles and machinery, heat treatment at a core temperature of 50°C or higher for ten minutes or fumigation with methyl bromide at less than 48 g/m³ for 24 hours at temperatures greater than 21°C. For offshore treated vehicles, storage yards should be maintained free from vegetation to reduce the likelihood of recontamination for at least some reptiles after treatment.
2. For **new** vehicles, a systems approach incorporating surveillance and storage measures should be investigated.

An alternative package of measures comprising:

- visual inspection and fumigation/heat treatment where necessary; **and**
- bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4);

would reduce the risk to a lower level than that associated with the current risk management regime but would not meet the risk management objective.

24.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- The frequency of entry of exotic reptiles via the vehicle pathway is unknown, but estimate to occur on less than 1 percent of imported vehicles.

- The frequency of contamination of new vehicles is unknown, but considered to be non negligible if vehicles are stored for extended periods in appropriate conditions;
- It is assumed that the high rate of entry of geckos across a range of pathways will increase the likelihood of establishment of exotic species.
- It is assumed that establishment of geckos is not necessary for the occurrence of adverse consequences from associated parasites and diseases.
- The efficacy of some risk management measures, particularly pressure wash against reptiles is not known.

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25 Scorpions (Scorpiones)

25.1 HAZARD IDENTIFICATION

25.1.1 Identity

Category: Taxonomic Group: Class: Arachnida; Order: Scorpiones

Name: Scorpions

25.1.2 Association with pathway

The scorpion interception records for the pathway are summarised in Table 1.

Table 1. Interception records of scorpions in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Association with pathway
<i>Centruroides sp.</i>	Buthidae	1 post-border interception of a live adult on a truck imported from unknown country of origin

The Buthidae are a widespread family of some 740 species occurring in all continents except Antarctica. No species occur in New Zealand. Several species in this family are highly toxic, but fewer than 20 can be lethal to man. There are more than 50 species of *Centruroides* including some of medical significance (Rein, 2005).

Most species are relatively inactive and spend most of their time in their burrow, although some tropical species are associated with trees. Some species can go as long as a year without food and some can live indefinitely without water, deriving all the moisture they need from their prey. Many scorpions are ideally suited to surviving in a habitat where food may be come available only infrequently. Life-spans are generally more than two years. Some species can store sperm (Ramel, 2005). Given their habitats scorpions are unlikely to be associated with the vehicle pathway but have a good likelihood of surviving shipment should they hitchhike on a vehicle.

25.1.3 Conclusion

Given that scorpions:

- are relatively visible and yet are rarely reported to have been intercepted on the vehicle pathway;
- habitat preferences mean that they are unlikely to be associated with the vehicle pathway.

They are **not considered to be a hazard** on the new or used vehicle or machinery pathway.

25.1.4 References

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26 Silverfish (*Thysanura*)

26.1 HAZARD IDENTIFICATION

26.1.1 Identity

Category: Thysanura

Taxonomic Group: Class: Insecta; Order: Thysanura

Name: Silverfish or Bristletails

26.1.2 Association with pathway

The silverfish interception records for the pathway are summarised in Table 1.

Table 1. Interception records of silverfish in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status (Scott and Emberson, 1999)	Country of origin & pathway	Lifestage & viability (number of records)
<i>Ctenolepisma longicaudata</i>	Lepismatidae	present in NZ	Japan used vehicle	live adult (1)
unidentified	Lepismatidae	unknown	Pakistan new machinery	live adult (1)

There are 5 families of Thysanura and some 550 species. They are small flightless insects, 5-20 mm in length, primarily found in leaf litter or domestic premises and warehouses. They are omnivores. A few are pests of plants, while others are pests in human habitations where they feed on paper, glue and scraps (Hill, 1994). They are likely to enter vehicles in association with plant debris.

Given their small size and association with plant material which is not routinely inspected for individual organisms associated with it, it is likely that silverfish are under-recorded on the vehicle and equipment pathway.

26.1.3 Conclusion

Given that:

- the only recorded silverfish interception identified to species level is present in New Zealand;
- silverfish are likely to have few adverse consequences;

they are **not considered a potential hazard** on the new and used vehicle and machinery pathway.

26.2 REFERENCES

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27 Snails (Gastropoda)

27.1 HAZARD IDENTIFICATION

27.1.1 Identity

Category: Gastropod Molluscs

Taxonomic Group: Class: Gastropoda

Common name: Snails

27.1.2 Introduction

The taxonomy of molluscs is under revision and at present, it is not possible to give a classification of the Gastropoda that has consistent ranks and also reflects current usage. The gastropods are the largest class of molluscs, with 60 000-75 000 extant species known, comprising terrestrial snails and slugs as well as marine and freshwater species. Snails that have been intercepted at the border on imported vehicles and machinery are summarised in Table 1.

Table 1 Snail interception records between 1994 and April 2006, associated with the vehicle and machinery pathway. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Present in New Zealand *	Country of origin	Vehicle type	Life-stage & viability (number of records)
<i>Achatina fulica</i> , giant African snail	Achatinidae	No	Korea Japan	new vehicle	live (1) **
				used vehicle	live (1)
<i>Asperitas</i> sp. land snails	Ariophantidae.	No	Japan	used vehicle	live adult (1)
<i>Bradybaena similis</i>	Bradybaenidae	No	Japan	used vehicle	live adult (1) dead adult (1)
<i>Capaea nemoralis</i>	Helicidae	No	Japan	used vehicle	live adult (1)
			Germany	machinery	live adult (1)
<i>Ceruella virgata</i> , white snail	Helicellidae	No	Australia	boat	adult (2)
<i>Euhadra sandia</i>	Bradybaenidae	No	Japan	used vehicle	live adult (3)
<i>Helix aspersa</i>	Helicidae	Yes	UK	used vehicle	live juvenile (1)
			UK	new machinery	live adult (1) live juvenile (2)
<i>Hygromia</i> sp.	Hygromiidae	No	Hong Kong	used vehicle	1 unspecified record
<i>Lymnaea</i> sp.	Lymnaeidae	Unknown, 4 species in this genus present in NZ (Climo and Pullan, 1972)	Japan	used vehicle	live adult (4) dead adult (1)
<i>Megalacron</i> sp.	Camaenidae	No	Japan	used vehicle	live adult (10)
			Fiji	used machinery	live adult (1)
<i>Monacha</i> sp.	Helicellidae	No	Japan	used vehicle	live adult (2)

Organism	Family	Present in New Zealand *	Country of origin	Vehicle type	Life-stage & viability (number of records)
<i>Naninia</i> sp.	Ariophantidae	No	Japan	used vehicle	live adult (3)
<i>Oxychilus</i> sp.	Zonitidae	Unknown, genus is present	Japan	used vehicle	live adult (1)
<i>Stylominatophora</i> sp.	Succinidae	No, this genus not present in NZ	Japan	used vehicle	live adult (1)
<i>Succinea putris</i>	Succinidae	No	Japan	used vehicle	live adult (1) dead adult (1)
<i>Vitrea</i> sp.	Vitrinidae	Unknown, 1 species in genus is present in NZ.	Japan	used vehicle	live adult & juveniles (1)
unidentified	Bradybaenidae	unknown	Japan	used vehicle	live adult (3) dead adult (1)
unidentified	Helicidae	unknown	Japan	used vehicle	live adult & juveniles(6)
			UK	used vehicle	dead adult (2) live adult (1)
unidentified	Pupillidae	unknown	Japan	used vehicle	dead adult (2)

* Spencer et al. (2002)

** *A. fulica* interceptions are not recorded on the interceptions databases they are anecdotal records from MAF Quarantine inspectors (Smith and Toy, 2006).

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. There are interception records for snails in 16 genera and 12 families. Only one of the intercepted taxa is known to be present in New Zealand. 80 percent of interception records were on vehicles from Japan. 74 percent of intercepted snails were alive.

27.1.3 Conclusion

Given that there are interception records for 15 snail taxa not currently known to occur in New Zealand, associated with the vehicle and machinery pathway, snails are considered potential hazards. The giant African Snail, *Achatina fulica* and Asian tramp snail, *Bradybaena similaris* are considered in the risk assessment below as examples of this group of potential hazards. These species have been selected as examples for analysis because they are recognised pest species included on the New Zealand unwanted organism register. *B. similaris* occurs in Japan, the most significant country of origin of imported vehicles by volume, whilst *A. fulica* occurs in countries such as Singapore, which currently export fewer vehicles to New Zealand.

27.2 ENTRY ASSESSMENT

27.2.1 Current Distribution

A. fulica is believed to have originated in eastern coastal Africa. It has been accidentally and purposefully (for food, medicinal and research purposes) moved around the world and now occurs throughout sub-Saharan Africa, Pacific and Indian Ocean and Caribbean islands, Asia, including Malaysia, Singapore, India, and Brazil. It is not established in Europe and has been successfully eradicated from USA, Australia and Japan except for the Ryukyu peninsula, and

southern islands, (Dundee, 1974; Mead, 1961; Raut and Barker, 2002; Tomiyama, 1992). The volume of imported vehicles from countries in which it is established is currently relatively low, but growing from Singapore (see Chapter 3).

The Bradybaenidae family is predominantly Asian. *B. similaris* has been spread widely throughout the world, including Japan (Komai and Emura, 1955), probably mainly on plants (Dundee, 1974).

27.2.2 Likelihood of association with the pathway

As discussed in Chapter 2, it is not possible to estimate the frequency of any particular group of potential hazards on the vehicle pathway with accuracy. However, fumigation treatment records give an indication of the relative frequency of different contaminant groups. Of the 68 600 vehicles imported via Auckland wharf between 01/01/2004 and 30/09/2005 snails were recorded as the reason for fumigation for 11 vehicles, which is less than 0.1 percent of vehicles and less than 1 percent of fumigated vehicles. This figure is derived from the inspectors' recorded comments. These do not follow a prescribed format and there is no requirement for inspectors to record the reason for fumigation, so it is possible that additional vehicles had snails which were not recorded by the inspectors. There may also have been snails that were not detected through the visual inspection process.

Whilst there are only two records for *A. fulica* on the vehicle pathway, it has been intercepted from baggage and cargo pathways in the USA (Venette and Larson, 2004) and is intercepted on containers in New Zealand (MAF interception records). It often occurs in inhabited areas (Mead, 1961), and has a propensity for crawling into recesses. It typically only travels between 1m and 14 m a night (Raut and Barker, 2002), but juveniles may disperse up to 500m. Reproductively mature adults are least active (Tomiyama, 1992).

B. similaris typically inhabits humid areas rich in tall grasses such as vacant parking lots, areas along railroad tracks or roads, etc. It is also common in gardens and greenhouses. It is active mostly at night (Dundee, 1970). Eggs are laid in a cluster in depressions in the soil. It is unlikely that soil containing eggs would become attached to a vehicle.

The likelihood of association of snails with vehicles and machinery will depend on

- the location in which vehicles have been used prior to shipment;
- the location in which vehicles are stored prior to shipment;
- the prevalence of snails in these locations.

In the case of *A. fulica*, cross-contamination may also occur if the vehicle is transported in a container contaminated with *A. fulica*. Most vehicles imported from Singapore arrive in containers.

27.2.3 Likelihood of surviving shipment to New Zealand

Under adverse conditions such as in cold winters or in dry periods, snails crawl under rocks, wood and leaves, and seal their shell with several layers of mucus. *B. similaris* can survive desiccation and lack of food for an average of 122 days (Dundee, 1970). Large *A. fulica* snails can survive up to ten months in a state of hibernation or dormant aestivation (Raut and Barker, 2002). This species is sensitive to high rates of evaporation. Under moisture stress, it is reported to become inactive and begin aestivating within 24 hours. Snails may aestivate as

they cling to objects, aiding in their inadvertent spread to new areas on cargo, vehicles or machinery (USDA/APHIS, 2005). This trait is likely to enable adult snails hidden in crevices in used vehicles or machinery to survive periods of inclement conditions associated with shipment of the vehicle. This assumption is confirmed by the fact that live adult snails have been intercepted from vehicles at the border. The Mediterranean snails, *Cochlicella barbara* and *Theba pisana* have been reported to survive 18 months of warm, dry storage without food or water (Richardson and Roth, 1965).

Eggs of *B. similaris* are approximately 2 mm long and are laid in a cluster in a concavity in the soil and have an incubation time in the field of 10 -15 days (Dee, 1970). *Achatina fulica* eggs are several millimetres in diameter and hatch in anything from a few hours to 17 days (Raut and Barker, 2002). They have a transparent shell and are vulnerable to desiccation (Richardson and Roth, 1965). It is unlikely that the eggs or small immature snails would survive shipment, unless buffered in a clod of soil.

The 10 species of exotic mollusc that have become established in New Zealand since 1940 are thought to have been introduced either as eggs or post-embryonic stages with soil and plant material, or as snails aestivating in household goods and heavy machinery (Barker, 1992). Plant products and containers are generally considered the most significant entry pathways for snails (Dundee, 1974).

27.2.4 Conclusion on entry assessment

Given that:

- *A. fulica* and *B. similaris* occur in countries from which used vehicles are imported;
- they occur in inhabited areas and are thus likely to be in a position to contaminate vehicles;
- adult snails are able to withstand adverse conditions and live snails have been intercepted on imported vehicles.

It is concluded that the likelihood of snails and *A. fulica* and *B. similaris* in particular, entering New Zealand on the **used** vehicle and machinery pathway is **non negligible**. The likelihood of entry of *A. fulica* is lower than that of *B. similaris* given the smaller number of vehicles imported from host countries.

Given that snails are likely to be able to infest **new** vehicles parked near vegetation for a sufficient period, the likelihood of contamination of new vehicles is considered to be **non negligible**, but lower than for used vehicles and machinery.

27.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

27.3.1 Environmental suitability of New Zealand

A. fulica is most closely associated with tropical and subtropical moist and dry broadleaf forests, although over much of its introduced range it has a predilection for modified environments such as plantations and gardens (Raut and Barker, 2002). High humidity, a lack of frost and cover from direct exposure to the sun appear to be environmental requirements. Eight to twenty one days at a minimum temperature of 15 °C are required for eggs to hatch. Adults remain active at temperatures ranging from 9°C to 29°C and survive temperatures of 2°C by hibernation and 30°C by aestivation (Mead, 1961; Raut and Barker, 2002). Activity is largely restricted to areas with at least 80 percent relative humidity.

Overlay mapping of mean annual temperature, mean minimum temperature, vapour pressure deficits (as a measure of humidity), relative soil calcium levels and land cover has shown that optimum conditions for establishment of *A. fulica* do not occur anywhere in New Zealand. However much of the North Island, the west coast of the South Island and Stewart Island have been assessed as potentially suitable (Cooling, 2005). It is assumed that *A. fulica* is likely to be able to establish at least in the northern part of the North Island.

A. fulica feeds on decayed vegetation and animal matter, with the juveniles feeding primarily on plants. It has been recorded feeding on more than 500 different kinds of plants from a wide range of families including eucalyptus and most species of vegetables as well as feeding on the bark of relatively large trees such as citrus (Venette and Larson, 2004). It is therefore likely to be able to find appropriate food sources in New Zealand. A source of calcium is required for hatchlings.

The large, heavy shell and the generous supply of mucus of a mature giant African snail affords considerable protection both from the adverse physical factors in the environment and from natural enemies. For instance, ducks and geese are unable to handle the snails if the specimens are more than a few months old (Mead, 1961). However omnivores such as the red crab, *Gecarcoidea natalis* and the fire ant *Solenopsis geminata* have been shown to control the spread of *A. fulica* in undisturbed habitats on Christmas Island (Lake and O'Dowd, 1991).

The temperature tolerances for *B. similaris* in the laboratory are reported to be 12-38°C (Dundee, 1970). However field activity has been reported at air temperatures as low as 5-10°C in Louisiana (Dundee and Cancienne, 1978). Adults feed on a wide range of plants, but predominantly on monocots (Dundee, 1970). Given these factors it is likely that *B. similaris* is able to establish at least in the northern parts of New Zealand.

27.3.2 Biological characteristics

Being hermaphroditic, each individual snail is an egg producer, although reproduction requires cross fertilisation between two individuals. A single mating of *A. fulica* at six months of age can result on in several batches of 100 to 400 eggs being laid. *A. fulica* has been shown to become sexually mature much earlier and at a much smaller size when introduced into new habitats, e.g. St. Lucia. This means it can reproduce faster under these circumstances (G.Fowler pers. comm.). Egg production can occur up to 380 days after mating. Fecundity lasts approximately 400 days even though snail lifetimes of up to nine years have been recorded (Raut and Barker, 2002). Thus a single externally fertilised adult snail can establish a population if it is transferred to a suitable environment. The frequency of fertilisation and thus the likelihood of a gravid individual contaminating the vehicle pathway is not known, but immature snails disperse more widely and are thus more likely to be associated with the pathway. Whilst the interception records for *A. fulica* and *B. similaris* are of single individuals there are several records of two or three snails of other species being intercepted on the same vehicle. The likelihood of more than one snail being transferred together, to a suitable location via the vehicle pathway is considered to be low.

B. similaris is also hermaphroditic but less productive, with clutches of up to 38 eggs being laid in laboratory conditions. Each snail produces 100-250 eggs. Incubation takes 7-10 days in summer but 20-60 days in winter. Adult snails rarely live longer than a year (Chang, 2002; Komai and Emura, 1955).

A significant uncertainty in predicting the likelihood of establishment of a new species is the impact of predation, parasitisation and competition in a new environment and the consequences of this for the size of founder population necessary for establishment. Once established in a new location, introduced snails often go through a phase of rapid population expansion followed in some cases, by a decline. The reasons for the decline are not fully understood. Introduced biological control agents may be a reason, but disease has also been implicated. Both *A. fulica* and *B. similaris* have a history of long-term successful establishment over a wide geographic area (Cowie, 1998; Mead, 1979).

Despite the large size of *A. fulica*, virtually all the incursions in the Miami area of USA were in existence for two or more years before they were discovered and reported. Transfer by humans is thought to have contributed to their spread. There are several cases of apparent eradications followed by renewed outbreaks (Mead, 1979).

Improved agricultural pasture in New Zealand has proved to be vulnerable to invasion by exotic molluscs with eighteen introduced species, most significant of which are slugs. Exotic terrestrial molluscs have a long and ongoing history of establishment in New Zealand with on average, a new species becoming established every five years over the past 150 years (Barker, 1992; Barker and Watts, 2002).

27.3.3 Likelihood of transfer to suitable environment

Both *A. fulica* and *B. similaris* have broad diets and are not restricted to particular habitats. It is therefore likely that snails could be transferred to suitable habitat by any vehicle delivered to the northern part of the North Island. Both species are nocturnal. *Achatina fulica* typically only travels between 1m and 14 m a night (Raut and Barker, 2002, Tomiyama, 1992). Transfer from the vehicle would therefore require suitable habitat within close proximity to the vehicle.

The rate at which exotic molluscs would spread in New Zealand is uncertain. However the human assisted means by which the species arrive in New Zealand are also pathways for domestic spread. In addition, *B. similaris* is thought to have been transferred most frequently in association with plants, plant material and particularly through ova in soil associated with plants. None of the domestic pathways have any biosecurity measures or restrictions on them. Having entered New Zealand, both species could be transported to suitable habitat either by the imported vehicle or by secondary means from a temporary location.

27.3.4 Conclusion on establishment assessment

Given that:

- used vehicles and equipment can be taken to and used anywhere within New Zealand;
- The habit of aestivation would enable both species to survive until transferred to a suitable environment;
- *A. fulica* and *B. similaris* have a wide host range and the northern part of New Zealand has a suitable climate;
- both species are hermaphroditic, so each individual can lay eggs and a single gravid individual can produce a large number of eggs;
- there are few predatory organisms able to cope with the defences of *A. fulica*.

It is concluded that the likelihood of establishment of a new species of snail and of *A. fulica* and *B. similaris* in particular, in association with the used vehicle and machinery pathway is

lower than some other hazard groups but **non negligible**. Having entered New Zealand, *A. fulica* is more likely to establish than *B. similaris* given its prolific powers of reproduction.

27.4 CONSEQUENCE ASSESSMENT

27.4.1 Direct effects

Economic impacts associated with damage to crops from *A. fulica* and associated control attempts are likely to be high. The estimated annual losses in Florida based on a 2002 dollar value, if *A. fulica* had become established are some US\$ 54,000,000 (Venette and Larson, 2004). The extent of possible damage in New Zealand would not be of this order and would depend on the extent of spread, the crops affected and the population size of the snails. It is however likely to be significant.

Bradybaena similaris is a significant pest of citrus plantations in Louisiana. It rasps through the skin of the fruit and makes holes in the leaves of the trees, which lead to attacks by other organisms (Dundee and Cancienne, 1978). It is also a problem in greenhouses and nurseries in the USA. Similarly, it has been reported as a cosmopolitan garden pest feeding on ornamental plants wherever it has established. In Hong Kong, it is an agricultural pest feeding mainly on Chinese white cabbage, flowering cabbage, watercress and beans (Lee, 1973). In Taiwan it has recently emerged as a pest of grapevines, which can be severely damaged through destruction of leaf and flower buds, defoliation and spoilage of the fruit (Chang, 2002).

27.4.2 Indirect effects

The introduction of *A. fulica* and *B. similaris* presents possible public health hazards through the spread of diseases such as angiostrongylosis and eosinophilic meningoencephalitis. The snails are a host in the life cycle of the rat lungworm parasite *Angiostrongylus cantonensis* (Aguilar et al. 1981; Alicata, 1991; Rambo et al. 1997). The parasite is passed to humans eating raw or improperly cooked snails or freshwater prawns. Humans are accidental hosts, which become infected due to ingestion of an infected intermediate host. Eosinophilic meningitis or meningoencephalitis is particularly serious, and in south-eastern Asia for example, fatal and chronic cases frequently occur (Dorta-Contreras and Reiber, 1998). Other snail species are involved in the cycle of other human diseases, being for example the intermediate hosts of the trematodes *Schistosoma* spp. which are the causative agents of schistosomiasis (bilharziasis).

Plant diseases such as black pod disease caused by *Phytophthora palmivora* are also spread in the faeces of snails (Mead, 1979).

Social impacts are likely to arise from the establishment of both species due to the susceptibility of garden flowers and ornamental plants to the snails at any stage of development (Mead, 1961).

Given its wide range of host plants it is likely that environmental consequences of the establishment of *A. fulica* in particular, would include damage to native plant species through herbivory and through disruption of vegetation regeneration. Resource competition with native snails is also likely to be a significant impact given the high biomass of *A. fulica* populations. New Zealand has a high diversity of endemic snails, most of which are dependent on undisturbed forest or tussock grassland as habitat. The New Zealand indigenous terrestrial mollusc fauna is among the richest in the world per unit land area, with an

estimated 1350 species (Barker, 1999). There are 21 species of threatened land snail whose distribution is restricted to Northland (McGuinness, 2001). Many have very localised distributions which are more vulnerable to competition or disease impacts than more widespread species. Impacts on native snail populations have already been attributed to the brown garden snail, *Cantareus asperus*, which is a common exotic species in coastal areas of northern New Zealand (Barker, 2002). Many of the 29 introduced terrestrial molluscs already present in New Zealand, brought with them a range of parasites including mites, ciliate protozoa, microsporidia and nematodes (Barker, 1999). It is likely that *A. fulica* and *B. similaris* could also introduce parasites which could potentially be transmitted to indigenous species. Hawaii has a diverse native mollusc fauna which has undergone significant decline. The extent to which this is due to competition from the large number of non-native molluscs that have been introduced is difficult to determine, since the declines could be caused by a wide range of other factors such as habitat modification (Cowie, 1998).

Control of exotic species once they have become established is likely to be hampered by the susceptibility of indigenous snail species to molluscicides.

27.4.3 Conclusion of consequence assessment

There are likely to be significant economic, environmental and possible human health consequences from the entry and establishment of a new type of gastropod snail and, in particular, *A. fulica* and *B. similaris* into New Zealand. The consequences are therefore **non negligible**. The consequences arising from the introduction of *A. fulica* are likely to be more significant than those from *B. similaris*. *A. fulica* is considered a high consequence pest.

27.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of an exotic snail and of *A. fulica* and *B. similaris* in particular, associated with the new and used vehicle and equipment pathways is non negligible; and
- the economic environmental and possible human health consequences of establishment would be non negligible.

The risk is considered to be **non negligible for new and used vehicles and machinery** and risk management measures are justified. The risk is lower for new vehicles than for used vehicles and machinery. The risk is also lower for *A. fulica* than for *B. similaris* because *A. fulica* occurs in fewer of the main vehicle exporting countries. *A. fulica* is much more likely to enter New Zealand on pathways such as sea containers which have higher volumes from affected countries. *Bradybaena similaris* is more likely to enter in association with nursery stock.

Furthermore, snails in at least 13 additional taxa which are not present in New Zealand have been recorded from the vehicle and machinery pathway. Whilst they have not been subject to risk analysis, it cannot be assumed that the risk associated with them is negligible.

27.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of exotic snails entering on imported vehicles and machinery and establishing in New Zealand.

27.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

27.7.1 Visual inspection

Terrestrial snails are mainly nocturnal and because of their tendency to hide in crevices and crawl into small openings, visual inspection may not meet the risk management objective. No snails were found in either the videoscope or vehicle slippage surveys of 300 and 541 vehicles respectively. This might have been because the snails were removed by pressure washing prior to the survey, or it might have been that the sample sizes were too small. Based on the sample of 541 vehicles there is a 95 percent chance of detecting visible contamination affecting 1 in 182 imported used vehicles (Wedde et al. 2006). However the videoscope survey highlighted that a number of contaminants are located in parts of the vehicle that are difficult to see with standard visual inspection (Biosecurity Monitoring Group, 2006). Given the large size of *A. fulica*, adults may exceed 20 cm in shell length (Mead, 1979) it is much more likely to be detected through visual inspection than other smaller species and is unlikely to escape detection at the vehicle compliance checking centres. *Bradybaena similaris* is also relatively large with a shell diameter of 11 to 15 mm (Lee, 1973).

In conclusion, visual inspection coupled with bringing the LTNZ compliance checking centres into the formal biosecurity management system (Chapter 4) would be more likely to meet the risk management objective than the current regime.

27.7.2 Vacuuming

This is not an effective measure given that snails are external contaminants of vehicles.

27.7.3 Pressure wash

There is limited information on the efficacy of pressure washing in removing snails from cargo. The United States Armed Forces Pest Management Board (1990) advises that it is effective if infestation is obvious and snails are superficially attached to military equipment. It would be unlikely to remove snails hidden in the structure of the vehicle.

27.7.4 Heat treatment

There is relatively little information on the thermo-tolerance of land snails. Kempster and Charwat (2003) looked at the tolerance in a laboratory incubator of three species of Mediterranean snails. All three species died after six hours at 60°C, but *Cernuella virgata* and *C. acuta* required 12 hours at 55 °C to achieve 100 percent mortality, whilst *Theba pisana* did not survive 3 hours at 55 °C. No difference was found between the tolerances of spring and summer (aestivating) collected snails, suggesting that aestivating snails of these species are not more tolerant of high temperatures. Preliminary work by the USDA suggests that steam heat may be more effective than dry heat at least for *Cernuella cisalpina*. Treatment with steam from a portable generator resulted in 100 percent control when the temperature of treated locations reached 54°C for 20 minutes (Dowdy, 2002). Heat treatment is not yet an accepted quarantine treatment for *A. fulica* in the USA (United States Department of Agriculture). Tolerance of temperature extremes is related to the range of temperatures normally experienced. *T. pisana* is a Mediterranean species and its thermal tolerance is reported as 50 percent mortality at 49°C for 20 minutes. This is intermediate between the tolerance of desert species such as *Sphincterochila biossieri* and more moisture loving species such as *Helix aspera* (McQuaid et al. 1979). Snails use behavioural measures as do other

more active hazard groups such as ants to avoid very high surface temperatures which may exceed thermal tolerances. There may be small seasonal differences in thermal tolerances of some snails (Al-Habbib and Grainger, 1977).

In conclusion, there is uncertainty over the effectiveness of heat treatment for snails and there are differences in tolerance between species. This suggests a conservative approach should be taken to the use of heat treatment with a treatment regime of 60°C for six hours. It is assumed that this is not a practical treatment option.

27.7.5 Fumigation

Methyl bromide is generally considered an effective treatment for snails (Bond, 1984). However, snails in a condition of aestivation are very difficult to kill. Aestivating *Colichella barbara* snails reportedly require 128g/ m³ for 72 hours at 12.8°C (concentration time product of 9216 g.h/m³) although resistance varies from year to year, and a concentration time product of 960 g.h/m³ is adequate for aestivating *Theba pisana* (Richardson and Roth, 1965). Treatment at 128g/m³ at 12.5+°C for 72 hours for *Cochlicella* spp., *Helicella* spp. and *Monacha* spp. but only 24 hours (concentration time product of 3072 g.h/m³) for *Achatina fulica* is specified by Karpati et al. (1983) and Bond (1984). Other genera require treatment at lower concentrations. Fumigation at 96 g/m³ for 16 hours (concentration time product of 1536 g.h/m³) at 4.5 to 26°C has been recommended for *Bradybaena* spp. (Armed Forces Pest Management Board, 1990). The current New Zealand treatment for vehicles, tyres, machinery and containers contaminated with snails is 128 g/m³ at 12.5°C for 24 hours (concentration time product of 3072 g.h/m³) (Biosecurity New Zealand, 2006).

In conclusion, there is evidence that aestivating snails are resistant to methyl bromide fumigation. No experimental evidence has been found for the regimes recommended for *Achatina fulica*, but there is broad agreement on the regime between a number of regulatory authorities. *Colichella barbara* appears to be a worst case example. However it has not been intercepted from the vehicle pathway, and since the levels required for this species are much higher than for other snails, the use of such rates cannot be justified.

27.7.6 Offshore versus onshore risk management

There is little information on which to base an assessment of the relative merits of the application of risk management measures off-shore as opposed to on-shore. The risk assessment provides no clear benefit of one over the other. Re-contamination of offshore managed vehicles could be prevented through the use of vegetation management and/or snail pellets. Roads and walls are reportedly barriers to dispersal of *Bradybaena similaris* (Komai and Emura, 1955).

27.8 RECOMMENDED MEASURES

- 1) For **used** vehicles and machinery, the current regime of visual inspection followed by fumigation at 128 g/m³ at 12.5°C for 24 hours when snails are found **and** bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4) is likely to give an adequate level of protection; **and**
- 2) A systems approach to the management of imported **new** vehicles incorporating surveillance and appropriate storage yard maintenance measures should be investigated

In addition it is recommended that provision of biosecurity information in all imported cars with information on snails, in addition to other hazards be considered. The effectiveness of this management measure is unknown.

An alternative package of measures involving pressure wash of all used vehicles and machinery coupled with audits using a videoscope would reduce the risk associated with snails, but is unlikely to meet the risk management objective because of uncertainties over the efficacy of pressure wash for this hazard group.

27.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- The frequency of entry of exotic snails via the vehicle pathway is unknown –the data for this group of hazards are limited.
- It is not known what proportion of snails contaminating vehicles are fertilised.
- The frequency of contamination of new vehicles is unknown. It is the conditions in which the vehicles are stored rather than their age which is likely to determine whether or not they are contaminated.
- There is limited information on the efficacy of some risk management measures, particularly pressure wash against snails.

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28 Spiders, Araneae

28.1 HAZARD IDENTIFICATION

28.1.1 Identity

Taxonomic Group: Class: Arachnida Order: Araneae

Common name(s): Spiders

28.1.2 Introduction

Spiders are ubiquitous invertebrate predators that play important roles in terrestrial ecosystems worldwide (Wise, 1995). There are over 39,000 described species and over 3,600 genera of spiders in the world (Platnick, 2006). Many species of spiders are adapted to living in human-modified environments, including homes and other buildings. As generalist predators, spiders do not have association with particular 'hosts'. They arrive as hitchhiking organisms whose association with a particular pathway occurs by chance, for instance while searching for the best habitat to lay eggs sacs.

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates. Nonetheless there have been at least 45 different spider taxa recorded in association with the vehicles/machinery pathway, and of these at least 22 are not present in New Zealand (Table 1). The majority of these records were of live adults, mainly females, but numerous interceptions of egg masses have also been recorded (Table 1). Some records involved numerous specimens in a single vehicle.

Table 1. Interception records of spiders in association with imported vehicles/machinery, between 1994 and 2006. Unless otherwise stated all specimens are of adults.

Family	Species	Status in NZ*	Country of Origin	viability & life-stage (n)
Agelenidae	<i>Agelena opulenta</i>	not present	Japan	live female (1)
	<i>Tegenaria</i> sp.	1 sp. present	UK	live juvenile female (1)
	<i>Poecilopachys australasiae</i>	present	Japan	live female (1)
	Unidentified sp.	-	Japan	male (1)
	-	-	unknown	live juvenile female (1)
Araneidae	<i>Araneus</i> sp.	not present	Japan	live female (3)
	-	not present	Japan	juvenile (1)
	-	not present	Japan	adult (1)
	<i>Cryptaranea</i> sp.	7 spp. present	Australia	live female (1)
	-	7 spp. present	Spain	live juvenile male (1)
	<i>Eriophora heroine</i>	present	Japan	live female (1)
	<i>Eriophora pustulosa</i>	present	Japan	live male (1)
	<i>Eriophora</i> sp.	3 spp. present	Australia	live female (1)
	-	3 spp. present	Japan	unrecorded (1)
	<i>Eriophora transmarina</i>	not present	Australia	live adult (2)
	Unidentified sp.	-	Australia	juvenile (1)
	-	-	Japan	eggs & >100 dead juveniles (1)
	-	-	Japan	egg masses (3)
	-	-	Japan	live juvenile (4)
	-	-	Japan	juvenile male (1)
-	-	Japan	many live juveniles (1)	
-	-	Japan	adult (7)	

Family	Species	Status in NZ*	Country of Origin	viability & life-stage (n)
		-	Japan	live adult (1)
		-	Singapore	live juvenile (1)
Clubionidae	Unidentified sp. [but not NZ sp.]	not present	Japan	juvenile (1)
	Unidentified sp.	-	Australia	adult (1)
Ctenidae				
	Unidentified sp.	-	Japan	live juvenile (1)
Desidae	<i>Badumna insignis</i>	present	Australia	live female (2)
		present	Japan	live male (1)
		present	unknown	live male (1)
	<i>Badumna longinqua</i>	present	Australia	live adult (1)
		present	Japan	live female (2)
		present	Japan	live male (2)
		present	East Timor	live female (1)
	<i>Badumna</i> sp.	2 spp. present	Japan	egg mass (1)
		2 spp. present	Australia	juvenile (2)
		2 spp. present	Australia	live female (1)
		2 spp. present	Germany	adult (1)
		2 spp. present	unknown	live juvenile female (1)
		2 spp. present	unknown	dead adult (1)
		2 spp. present	Japan	? (1)
		2 spp. present	USA	adult & juvenile (1)
	Unidentified sp.	-	Japan	? (1)
Dysderidae	<i>Dysdera crocata</i>	present	Australia	live adult (1)
		present	Japan	live female (2)
Hexathelidae	<i>Hexathele</i> sp.	20 spp. present	Australia	live female (1)
Linyphiidae	? <i>Lepthyphantes</i> sp.	not present	Solomon Islands	adult (1)
	Unidentified sp.	-	Japan	live female (2)
Lycosidae	Unidentified sp.	-	unknown	2 dead adults (1)
		-	Japan	juvenile (1)
Miturgidae	Unidentified sp.	-	Japan	? (1)
Oxyopidae	<i>Oxyopes</i> sp.	1 sp. present	Japan	live female (1)
Pholcidae	<i>Crossopriza lyoni</i>	not present	USA	live female (1)
	<i>Pholcus phalangioides</i>	present	Australia	? (1)
		present	Japan	live female (2)
	<i>Pholcus</i> sp.	1 sp. present	Australia	male (1)
		1 sp. present	Australia	female (1)
	<i>Physocylus</i> sp.	not present	Japan	adult (1)
Salticidae	<i>Phidippus</i> sp.	not present	USA	live juvenile male (1)
	<i>Phidippus audax</i>	not present	USA	live male & female (1)
	<i>Phintella</i> sp.	not present	Japan	? (1)
	<i>Plexippus</i> sp.	1 sp. present	Japan	live female (1)
	Unidentified sp.	-	Japan	adult (2)
		-	Japan	live female (4)
Sparassidae	<i>Heteropoda jugulans</i>	not present	Australia	live male (1)
	<i>Heteropoda venatoria</i>	not present	UK	live female (1)
		not present	Japan	live juvenile (1)
	<i>Holconia immanis</i>	not present	Australia	live adult (1)
		not present	Australia	live male (1)
	<i>Isopedella pessleri</i>	not present	Australia	live female (1)
	<i>Olios</i> sp.	not present	unknown	? (1)
	<i>Pediana</i> sp.	not present	Australia	adult (1)
	Unidentified sp.	Unknown (1 Australian species occurs in NZ)	Australia	adult (1)
		not present	Japan	juvenile (1)
		not present	Japan	dead adult (1)

Family	Species	Status in NZ*	Country of Origin	viability & life-stage (n)
		not present	Korea	female (1)
		not present	South Africa	adult (1)
Stiphidiidae	Unidentified sp.	-	Australia	adult (1)
		-	unknown	live female (1)
		-	UK	adult (1)
		-	USA	juvenile (1)
Theridiidae	<i>Achaearanea</i> sp.	3 spp. present	Australia	live juvenile female (1)
		3 spp. present	France	live juvenile female (1)
		3 spp. present	Japan	adult (2)
		3 spp. present	Japan	live female (3)
		3 spp. present	Japan	live male (1)
		3 spp. present	Japan	live female + >20 live juveniles (1)
		3 spp. present	USA	live female (1)
		3 spp. present	USA	adult (1)
	<i>Achaearanea tepidariorum</i>	present	Japan	live female (1)
		present	Japan	juvenile male (1)
		present	South Africa	adult (1)
		present	USA	? (1)
	<i>Achaearanea veruculata</i>	present	Japan	live female (1)
		present	Japan	juvenile (1)
	<i>Latrodectus geometricus</i> (Brown widow)	not present	unknown	live female (1)
		not present	Singapore	live female (2)
		not present	Singapore	live adults (2)
		not present	USA	adult (1)
	<i>Latrodectus hasselti</i> ** (redback spider)	confined distribution	Australia	live female (10)
		confined distribution	Australia	2 live females (1)
		confined distribution	Australia	several live adult females (1) [new car]
		confined distribution	Australia	juvenile (1)
		confined distribution	Australia	live adults (4)
		confined distribution	Australia	live females & ca.20 eggs (1)
		confined distribution	Australia	live male (1)
		confined distribution	Japan	adult (1)
	<i>Latrodectus hesperus</i> (Western black widow)	not present	USA	live female (5)
		not present	unknown	live female (1)
	<i>Latrodectus mactans</i> ** (black widow)	not present	USA	live juvenile (2)
		not present	USA	live female (3)
		not present	USA	adult (9)
	<i>Latrodectus</i> sp. (widow spiders)	not present (?)	Japan	live female (2)
		not present (?)	Japan	live juvenile (1)
		not present (?)	Japan	adult (1)
		not present	USA	adult (1)
	<i>Steatoda capensis</i>	present	unknown	adult (1)
	<i>Steatoda grossa</i>	present	Japan	live female (1)
		present	USA	? (1)
		present	unknown	adult (1)
	<i>Steatoda</i> sp.	4 spp. present	Australia	live male & female (1)
		4 spp. present	Japan	live female (1)
	<i>Theridion</i> sp.	14 spp. present	USA	2 live juveniles (1)
		14 spp. present	USA	? (8)
		14 spp. present	Australia	live female (1)
	Unidentified sp.	-	Australia	live juvenile (3)
		-	Australia	egg (1)
		-	Australia	? (1)
		-	Fiji	adult (1)
		-	Japan	adult (4)
		-	Japan	egg mass (2)

Family	Species	Status in NZ*	Country of Origin	viability & life-stage (n)
		-	Japan	eggs, juveniles (4)
		-	Japan	juvenile (1)
		-	Japan	10 dead juveniles (1)
		-	Japan	many juveniles (1)
		-	Japan	? (3)
		-	Japan	live female (1)
		-	USA	non-viable egg sac (1)
Thomisidae	<i>Diaea</i> sp.	3 spp. present	USA	adult? (1)
Thomisidae	<i>Xysticus</i> sp.	not present	Japan	live female (1)
	Unidentified sp.	-	Japan	live female (1)
Uloboridae	? <i>Uloborus</i> sp.	1 sp. present	unknown	live male (1)
Zoridae	<i>Harioctenoides</i> sp.	1 sp. present	Japan	live female (1)
Unidentified	Unidentified sp.	-	Australia	egg sac (1)
		-	Australia	live adult (1)
		-	Japan	adult (1)
		-	Japan	egg masses (10)
		-	Japan	non-viable egg mass (6)
		-	Japan	juvenile (2)
		-	Japan	dead adult (4)
		-	USA	egg masses (4)
		-	USA	3 dead adults (1)
		-	Singapore	live juvenile (1)
		-	Singapore	egg sac? (1)
		-	South Africa	eggs (1)
		-	Taiwan	dead adult (1)
		-	unknown	non-viable egg mass (1)

* Based on Sirvid et al, in press

* *recorded from new vehicle

Brief summaries of distribution, taxonomy and biology of each family intercepted on the pathway are set out below.

Agelenidae: there are 39 genera and 503 species described in this family (Platnick, 2006). The Agelenidae has a worldwide distribution, including the Australian biogeographic realms (Bennett, 2005). In New Zealand the family is found in a wide variety of native ecosystems (Forster and Forster, 1999), but in Europe a number of species such as *Tegenaria* spp. are cosmopolitan synanthropes (Bennett, 2005) being commonly found trapped in bathrooms (Foelix, 1996). Agelenids usually build non-sticky funnel webs, and are agile and can move quickly (Bennett, 2005). No spiders in this family seem to be of medical significance (Bennett, 2005). There are 97 described species in New Zealand, only one of which is exotic (Sirvid et al. in press).

Araneidae: This is one of the largest spider families (Levi, 2005) with 166 genera and 2840 described species worldwide (Platnick, 2006). Described as the orb-web spiders they are responsible for impressive web designs (Foelix, 1996). There are 32 known species in New Zealand, including a single known exotic species (Sirvid et al. in press). There seems to be no evidence of any species being of medical significance (Phil Sirvid, pers. comm. 2006).

Clubionidae: There are 15 genera and 538 described clubionid species (Platnick, 2006). Clubionids are wandering hunters, have sac-like webs for retreats rather than prey capture, and occur in foliage, under rocks or loose bark and in leaf litter (Richman et al. 2005). Clubionids are restricted to open areas on low vegetation, e.g. shrubs, tussock, foliage and under rocks, with a few species restricted to forest sites (Forster and Forster, 1999). There are

16 endemic and one exotic species in New Zealand. There seems to be no clubionids of major medical significance, but various species of *Cheiracanthium* (one species in NZ) have been reported as causing painful bites with minor medical consequences (Phil Sirvid, pers. comm. 2006).

Ctenidae: Primarily a tropical family with a few nearctic species (Ubick and Dávilla, 2005). There are 39 genera and 458 described species worldwide (Platnick, 2006). Ctenids are large nocturnal wandering hunters that can be found under rocks and logs, although some tropical species are arboreal (Ubick and Dávilla, 2005). There are no species in New Zealand (Sirvid et al. in press). This family includes the *Phoneutria* spiders which have a potent venom and are highly aggressive (Foelix, 1996).

Desidae: There are 38 genera and 182 described desid species worldwide (Platnick, 2006). The family appears to be relatively over-represented in New Zealand where 94 endemic and 2 exotic species have been described (Sirvid et al. in press). Both exotic species present in New Zealand (*Badumna longinqua* and *B. robusta*) have been intercepted on the vehicle pathway. These species are widespread in Australia, and are synanthropic, being commonly found in human inhabitations (Forster and Forster, 1999). There seems to be no evidence that any desid spiders are of medical significance (Phil Sirvid, pers. comm. 2006).

Dictynidae: There are 48 genera and 562 described species worldwide in the Dictynidae (Platnick, 2006), with 10 endemic species known in New Zealand (Sirvid et al. in press). The Dictynidae has a worldwide distribution with most species described from the northern hemisphere (Bennett, 2005) where they are abundant (Forster and Forster, 1999). Most dictynids are arboreal and forest dwellers, but many species live deep in the litter (Bennett, 2005). There seems to be no evidence of any dictynid species being of medical significance (Phil Sirvid, pers. comm. 2006).

Dysderidae: There are 24 genera and 492 described dysderid species (Platnick, 2006), with no native species known to exist in New Zealand (Sirvid et al. in press). The Dysderidae is a northern hemisphere group, particularly Mediterranean (Forster and Forster, 1999) and the only species present in New Zealand is the exotic *Dysdera crocata* (Sirvid et al. in press), which has also been the only dysderid intercepted in association with the pathway. *Dysdera crocata* is a synanthropic species that occurs primarily in urban areas and disturbed habitats (Ubick, 2005). There seem to be no dysderid spiders of proven medical significance (Phil Sirvid, pers. comm. 2006)

Hexathelidae: There are 11 genera and 86 species described from this family (Platnick, 2006), with 25 endemic species known for New Zealand (Sirvid et al. in press). Hexathelids are the biggest spiders in New Zealand by weight and frequently wander into households, where they may cause consternation (Forster and Forster, 1999). The New Zealand species may bite, but this seems to cause little more than local soreness and inflammation (Forster and Forster, 1999). However, this family includes the highly venomous Australian *Atrax*, the Sydney funnelweb spider.

Linyphiidae: This worldwide family has the largest number of genera (569) described for any spider family, with 4320 known species. In New Zealand there are 104 described species, 95 of which are endemic (Sirvid et al. in press). Most species live on leaf litter or on ground surface, but linyphiids are present in almost all habitats (Draney and Buckle, 2005). Apart

from one Hawaiian genus, all species in the Linyphiidae tend to be very small, and there is no evidence of any species being of medical significance (Phil Sirvid, pers. comm. 2006).

Lycosidae: This family includes 104 genera and 2304 described species worldwide (Platnick, 2006). In New Zealand there are 27 species, 25 of which are endemic and two exotic (Vink, 2002). Lycosids are known as wolf spiders, which are fast-moving spiders that are free-living hunters (Forster and Forster, 1999). A characteristic of lycosids is that females carry the egg sac on spinnerets, and eventually carry the spiderlings on their backs (Forster and Forster, 1999; Vink, 2002). Lycosids do bite people, but the health effects appear to be usually minor, being characterized mainly by localized pain (Isbister and Gray, 2002). There are however, reports of necrotic arachnidism associated with lycosid bites (Sheals, 1973).

Miturgidae: There are 26 genera and 351 species described from this family (Platnick, 2006), with only 2 endemic species known in New Zealand (Phil Sirvid, pers. comm. 2006). Miturgids are wandering hunters, most of which are ground dwellers found under rocks or plant detritus (Richman et al. 2005). No Miturgidae species seem to be of medical significance (Phil Sirvid, pers. comm. 2006).

Oxyopidae: There are 9 genera and 419 species described from this family (Platnick, 2006), with only one species (native) present in New Zealand (Vink and Sirvid. 1998). Oxyopids are known as lynx spiders and are free-living daylight hunters that are usually associated with warmer climates, and New Zealand provides marginal conditions for the group (Forster and Forster, 1999). There seem to be no known species of medical significance (Phil Sirvid, pers. comm. 2006).

Pholcidae: There are 80 genera and 959 species described in this family (Platnick, 2006), with possibly three exotic species present in New Zealand (Forster and Forster, 1999), although the presence of only one of these has been verified (Phil Sirvid, pers. comm. 2006). These are known as the daddy-long-leg spiders. One, *Pholcus phalangioides* has become widespread worldwide, including New Zealand (Forster and Forster. 1999). Despite the myth that *P. phalangioides* has a deadly venom but is incapable of biting humans, there is no evidence of this species or any other pholcid being of medical significance (Phil Sirvid, pers. comm. 2006).

Salticidae: This is the largest Araneae family with 5025 species described from 553 genera worldwide (Platnick, 2006). In New Zealand there are approximately 210 species, most of which are yet to be described (Sirvid et al. in press). Salticids are known as jumping spiders and are found in every continent but Antarctica, occurring in a broad range of microhabitats (Richman et al. 2005), including urban areas and households (Phil Sirvid, pers. comm. 2006). No salticids seem to be of medical significance (Phil Sirvid, pers. comm. 2006).

Sparassidae: This family (previously known as Heteropodidae) includes 82 genera and 1009 described species worldwide (Platnick, 2006). Sparassids are large spiders and ‘crablike’, hence these are commonly known as ‘giant crab spiders’ (Forster and Forster, 1999) or ‘huntsman spiders’. The only species present in New Zealand is the introduced Australian *Delena cancerides*, Avondale spider. Although they are unlikely to be dangerous to humans, sparassids are said to attack if provoked and the bite will be painful and cause minor swelling. As with any arthropod bite, infection may occur. The establishment of such large and fast moving synanthropic spiders could cause social impacts in New Zealand.

Stiphidiidae: There are 13 genera and 94 species described from in this family (Platnick, 2006), with 33 endemic and two exotic species present in New Zealand (Sirvid et al. in press). Some species in this genus in New Zealand are very widespread and commonly found in association with humans in and around houses (Forster and Forster, 1999). No stiphidiid species seem to have been described as being of medical significance (Phil Sirvid, pers. comm. 2006).

Theridiidae: This is a large family that is distributed worldwide with 87 genera and 2248 species described (Platnick, 2006), with an estimated 200 species in New Zealand including 5 exotics (Phil Sirvid, pers. comm. 2006). This family includes numerous species that are synanthropic (Forster and Forster, 1999) with many species being associated with modified habitats (Phil Sirvid, pers. comm. 2006). This family is of medical significance as it includes the cosmopolitan venomous *Latrodectus* genus, which includes brown and black widow and redback spiders.

Thomisidae: There are 170 genera and 2026 species described (Platnick, 2006), with at least 10 endemic and one exotic species present in New Zealand (Phil Sirvid, pers. comm. 2006). These are known as ‘crab spiders’ and have a near worldwide distribution (Dundale, 2005). Most species appear to be found in association with vegetation, although some are arboreal and some are ground dwelling (Dundale, 2005; Forster and Forster, 1999). There seem to be no thomisid species of medical significance (Sirvid, pers. comm. 2006)

Uloboridae: The Uloboridae has 18 genera and 262 species described (Platnick, 2006), with only one endemic species known in New Zealand (Forster and Forster, 1999). Members of this family have no venom glands (Phil Sirvid, pers. comm. 2006).

Conclusion

Approximately 20 spider taxa recorded in association with the pathway are not present in New Zealand, and are considered to be potential hazards. This risk analysis focuses on the venomous *Latrodectus* species as an example of this group of potential hazards. *Latrodectus* species belong to the family Theridiidae, and is the most frequently recorded spider genus associated with the vehicle/machinery pathway (Table 1). They are spiders of human health significance. Risk management measures proposed for *Latrodectus* spp. would be expected to cover all other exotic spider groups identified as potential hazards in association with the pathway since:

- the distribution of the intercepted *Latrodectus* species and the countries of origin of the reported interceptions cover 99.5 percent of the imported used vehicle/machinery pathway; and
- *Latrodectus* are among the species identified in the videoscope survey (Table 4) as able to slip through the current risk management regime.

28.2 ENTRY ASSESSMENT

28.2.1 Current Distribution

The *Latrodectus* genus is cosmopolitan throughout the world in temperate and tropical zones (Rauber, 1984), and has 31 recognized species (Platnick, 2006). There are two recognized indigenous *Latrodectus* spp. in New Zealand: *L. katipo* and *L. atritus*. The Australian redback spider (*L. hasselti*) has been recorded numerous times in New Zealand, with an established population known to exist in central Otago.

There have been four *Latrodectus* species intercepted on the pathway: *L. mactans*, *L. geometricus*, *L. hasselti* and *L. hesperus*, the majority of which were live adult females (Table 2). There have also been interceptions of unidentified *Latrodectus* sp. from Japan. *Latrodectus* species have been recorded from vehicles/machinery originating from Australia, Japan, Singapore and USA. These four countries export approximately 99.5 percent of all imported used vehicles/machinery entering New Zealand.

Table 2. List of *Latrodectus* spp. intercepted in association with imported vehicles and machinery.

Species	Common Name	Status in NZ	Worldwide Distribution ¹	Country of origin
<i>Latrodectus geometricus</i>	brown widow spider	not present	Cosmopolitan Relevant: Australia, Japan ² , Singapore and USA	Singapore USA
<i>Latrodectus hasselti</i>	redback spider	localized distribution	Southeast Asia to Australia, New Zealand Relevant: Australia, Japan	Australia Japan
<i>Latrodectus hesperus</i>	western black widow spider	not present	North America, Israel Relevant: USA	USA
<i>Latrodectus mactans</i>	black widow spider	not present	Americas ³ Relevant: USA	USA
<i>Latrodectus</i> sp.	widow spiders	-	?	Japan

1 Based mostly on Platnick (2006).

2 See Ono (1995) and Raven (2003).

3 Although Platnick (2006) states that the distribution of *L. mactans* is “probably North America only”, the published literature describes the species (or associated subspecies) from South America (e.g. Souza et al. 1998).

Three of the four intercepted *Latrodectus* species, *L. mactans*, *L. geometricus* and *L. hesperus*, have never been recorded in New Zealand, except when directly associated with a recently imported commodity. *Latrodectus hasselti* is the only species established in New Zealand (e.g. Garb et al. 2004) but its distribution is unknown. Forster and Forster, (1999) state that: “it [*L. hasselti*] has probably become established in a few places in this country” (p.244), stressing the point that the species’ status in New Zealand is uncertain. The published data provide reliable evidence for established populations of *L. hasselti* in the Southland-Central Otago area in the early 1980s. These were extensively discussed by Forster (1982; 1984a; 1984b; 1985), with records for *L. hasselti* given for at least four localities. Currently, reliable evidence is only available for an established population in the Alexandra area (Trudy Murdoch, Department of Conservation, pers. comm. 2006), whose specimens have been recently checked by Phil Sirvid (Te Papa, pers. comm. 2006). The status of *L. hasselti* in the rest of the country is unknown. Occasional anecdotal evidence emerges for other possible populations of redback spiders, such as one in Te Rapa (Hamilton) in the late 1980s (Peter de Lange, pers. comm. 2005), and New Plymouth (McCutcheon, 1992). However, in most cases there are no specimens to back up such claims. It is not known whether these records mean “a long term establishment, a series of one-off incidents, or several invasions, each followed by a die-off of the spiders” (Phil Sirvid pers. comm. 2005). The same opinion is shared by Grace Hall (Landcare Research) and Cor Vink (AgResearch pers.comm.2006).

Most records of *L. hasselti* in New Zealand not linked to any recent imported commodities are of single female specimens, as one-off records from individual locations. Redbacks in Australia are usually found in relatively dense groupings (R.Raven, pers. comm. 2006). This suggests that the records are of post border interceptions of recently arriving spiders, rather than specimens from established populations. This is especially likely, since site searches invariably fail to yield another spider. If these were specimens from established populations other redback spiders would be likely to be found in the immediate surroundings.

In conclusion, whilst *L. hasselti* is known to be established in the Central Otago area, its status in other regions of New Zealand is uncertain. However, on the basis of the available data and the opinion of experts, it is considered unlikely to be established anywhere else in New Zealand.

28.2.2 Likelihood of association with the pathway

All the intercepted *Latrodectus* species are common in urban areas (Guarisco, 1999; Nishida and Tenorio, 1993; Robinson, 2005), although their level of synanthropism varies according to species. In Kansas (USA), Guarisco, (1999) concluded that *L. hesperus* and *L. mactans* are occasionally found in houses, where they do not appear to establish breeding populations but where they are nonetheless seasonally abundant. In Hawaii, *L. mactans* is described as being usually found in garages, basements, sheds and wood piles (Nishida and Tenorio, 1993). Robinson (2005) reports *L. hesperus* building webs indoors (e.g. corners of rooms) and outdoors (e.g. sheds and barns), but that although *L. mactans* is common in peridomestic habitats such as firewood piles, discarded household materials, vents and water-meter boxes, they are rarely found indoors. In contrast, *L. geometricus* is widespread in peridomestic and domestic habitats, being very common for example around buildings in Brazil and South Africa (Robinson, 2005; Zerbini and Motta, 2004). *L. hasselti* is frequently found in discarded household materials, machinery, benches and bins (Forster, 1996; Raven, 2003).

Vehicles appear to be one of the most suitable *Latrodectus* habitats provided by humans (Raven, 2003). *Latrodectus hasselti*, in particular, has an association with vehicles, which appears to aid its dispersal into new habitats (Raven, 2003). In Japan *L. hasselti* was originally found “in very high densities around wharves where ships carrying oil from Australia are normally docked” (Raven, 2003), indicating the most likely pathway of introduction of the species into that country.

MAF Quarantine inspectors report that *Latrodectus* spp. are frequently intercepted in older imported cars from the United States (Smith and Toy, 2006), but the vehicle data recording system does not allow this to be quantified. MAF Quarantine Service process procedures identify that vintage vehicles that have been in long-term storage are high risk for venomous spiders and snakes and recommend door inspection of containerised vehicles of this type prior to de-vanning to look for signs of spider threads in recognition of the heightened likelihood of spider contamination (MAF Quarantine Service, 2006). It is thought that ‘vintage’ cars are likely to have been stored in a garage or in a backyard for a considerable period of time. These conditions are conducive to infestation by *Latrodectus* spp. Although the sample size was very small the Biosecurity Monitoring Group videoscope survey found much higher incidences of contamination in vehicles imported from USA or Canada compared to those from other countries. 90 percent of 10 vehicles surveyed from USA or Canada had biosecurity risk contamination compared with 58 percent of 300 vehicles surveyed in total. 50 percent of the vehicles from USA or Canada had cobwebs compared with 24 percent of total vehicles surveyed, although the relationship between the presence of cobwebs and the presence of viable spiders is not known (Biosecurity Monitoring Group, 2006).

There have been eight records of *Latrodectus* intercepted from imported new vehicles.

An indication of the frequency of infestation of imported used vehicles with spiders can be obtained from the following sources:

- 1) **fumigation records.** Over a 20-month period in 2004-2005, 68 600 vehicles were imported via Auckland, of which at least 162 (0.2 percent) were treated due to the

presence of spiders. This figure is derived from the inspectors recorded comments. These do not follow a prescribed format and the required treatment, but not necessarily the contaminant is recorded by MAF quarantine inspectors for each imported vehicle.

- 2) **during the period 12-20 March 2006, MAF quarantine officers recorded the contaminants found on inspected vehicles by hazard group** (Maf unpublished data). The results for spiders, egg sacs and spiders' webs are summarised in Table 3. As discussed above the relationship between the presence of spiders' webs and the presence of live spiders is not known, but given the mobile nature of most spiders, webs are more likely to be detected than spiders.

Table 3. Spider-related contamination recorded on imported used vehicles 12-20 March 2006

Place of inspection	Japan	New Zealand
Number of vehicles inspected internally and externally	1509	1469
Number of vehicles inspected only partially	628 internal only 998 external only	0
percentage of vehicles pre-cleaned	95%	0
Number & percentage of vehicles cleared through assisted cleaning	624 (20%)	13 (1%)
Number & percentage of all inspected vehicles with spiders/eggs sacs &/or webs	166 (7.8%)	158 (11%)
Number and percentage of all inspected vehicles with live spiders &/ or eggs sacs	48 (1%)	27 (2%)

Many vehicles imported from Japan are subject to vacuuming and pressure wash immediately prior to MAF inspection. This is called pre-cleaning. In some instances where an inspector finds a very small quantity of contamination it is removed from the vehicle either by the inspector or by a non- MAF assistant, enabling clearance of the vehicle without further treatment and inspection. This is called assisted cleaning.

Note the percentage contamination figures in Table 3 are based on all vehicles inspected, not just those inspected both internally and externally. The proportion of internal contaminants will therefore be under-recorded. Also, this survey was a brief snapshot and there may be differences in levels of contamination during different seasons, which are not reflected in these figures. Records from all the Terminal Receiving Facilities in Japan have been amalgamated, as have the records from all ports of entry into New Zealand. It is assumed that there are no significant differences in contamination rates or detection rates between facilities and ports. Only four items of machinery were inspected during this period. The results are therefore not representative of this sub pathway.

Whilst there are limitations to the use of these data, they indicate that evidence of contamination by spiders such as webs, is removed by pre-cleaning. The relationship between the presence of spider webs on a vehicle and the presence of viable spiders or egg masses is not known. Given the mobility of spiders and the evidence from the videoscope survey (see below), that spiders are not readily detected by visual inspection, it is likely that webs will indicate the presence of some viable spiders and that the contamination rates recorded from New Zealand inspections which are not affected by pre-cleaning, are therefore more representative of contamination by spiders.

- 3) **The Biosecurity Monitoring Group videoscope survey** of 300 vehicles which had received biosecurity clearance found eight instances of contamination with a live spider and 1 of a dead spider. Most could not be identified, but there was one identification of a brown widow spider with an egg sac. The videoscope was able to examine parts of the vehicle that are not generally accessible for visual inspection (Biosecurity Monitoring Group, 2006). Whilst based on a small sample, these results indicate that the likelihood of entry of spiders on the vehicle pathway may be much higher than previously thought on the basis of routine visual inspection, see section 28.7.1. Furthermore it is thought that the videoscope may not have detected all spiders, due to their fast moving and secretive nature and the limited field of view of the videoscope (Biosecurity Monitoring Group, 2006).

28.2.3 Likelihood of surviving shipment to New Zealand

The regular interception of live adult specimens, in particular females of the *Latrodectus* species (Table 1), shows that these spiders survive long journeys in used vehicles. More specific information on their ability to survive such journeys is available at least for the redback spider. Food deprivation studies on *L. hasselti* showed that it could survive long periods of starvation incarcerated in cargo, with some adults surviving for more than 300 days (Forster and Kavale, 1989) which is well in excess of the journey time to New Zealand from any vehicle exporting country. Adult black widow spiders have been reported to survive on average 100 days without food; the first to die living only 36 days but some surviving seven months (Kaston, 1970).

Longevity of egg masses is likely to vary with species, but from the time the eggs are laid until they hatch it can take anything from a few weeks to a couple months depending on environmental conditions (Phil Sirvid, pers. comm. 2006). Cooler temperatures, for example, may delay the process or reduce egg mass viability (Phil Sirvid, pers. comm. 2006). Spiderlings usually disperse on the wind via silken threads, but if conditions are poor and food is scarce they remain and become cannibals (Raven and Gallon, 1987) and thus may be able to survive even if they hatch during shipment.

28.2.4 Conclusion on entry assessment

Given that:

- the association of at least four *Latrodectus* spp. with the new and used vehicle/machinery pathways is clear (Table 1). Numerous interceptions of live life stages have occurred both at the border and also post-border;
- *Latrodectus* spp. occur in urban environments in the countries from which the majority of used cars are imported;
- live spiders and viable egg sacs have been recorded on imported vehicles;
- these spiders are able to survive long journeys on imported vehicles and machinery.

It is concluded that the likelihood of entry of exotic spiders and of *Latrodectus* spp. in particular in association with the **used** vehicle and machinery pathway is **non negligible**.

Given the records for spiders intercepted on imported **new** vehicles the likelihood of contamination of new vehicles is considered to be **non negligible**. The location and conditions in which the vehicle is stored prior to shipping is more likely to determine whether it is contaminated than its age.

28.3 ESTABLISHMENT ASSESSMENT

28.3.1 Environmental suitability of New Zealand

Latrodectus spiders appear to prefer drier habitats (Raven, 1995), which could be a limiting factor for their establishment in many places in New Zealand. However, their close association with urban habitats means that certain limiting temperature and humidity requirements could be potentially overcome. In addition, some of the intercepted *Latrodectus* species appear to have relatively wide climatic tolerances.

Latrodectus hesperus appears to be able to occur over a wide temperature range (R. Vetter, pers. comm to (Reed and Newland, 2002)). It is found in Western Canada (Robinson, 2005), so New Zealand's temperate climate is likely to be suitable for this species. *L. mactans* also appears to have a relatively wide climatic tolerance based on its described distribution in the United States (Levi and Levi, 1968; Robinson, 2005). *Latrodectus geometricus* is a very widespread species, cosmopolitan in particular throughout the tropical regions of the globe (Garb et al. 2004). Its presence in nations with similar climatic range to New Zealand such as Japan, suggests that this country also offers potentially suitable conditions for its establishment.

Considerably more information is available on *L. hasselti* from Lyn Forster's work with populations in the Central Otago/Southland area. It is clear that *L. hasselti* can withstand sub-zero temperatures (Forster, 1982, 1984a), and low winter temperatures do not seem to be a limiting factor for its establishment in New Zealand, but whether the summer is warm enough for them to breed successfully is less clear (Forster, 1982). However, Japanese redbacks are successfully breeding through winter in Japan, often with sustained daily maxima of 2°C (Raven, 2003). Raven (pers. comm. 2006) points out that Japanese redbacks seem to have become highly cold adapted, which suggests that the Japanese strain could establish over a much greater climatic range in New Zealand or Australia, provided the humidity in a particular habitat is not too high. Redbacks from Japan consequently pose a higher biosecurity risk than specimens coming from Australia.

28.3.2 Biological characteristics

Female *Latrodectus* can produce a large number of eggs at a given time, as long as the environmental conditions are suitable. In theory, a single mated or gravid *Latrodectus* female would be capable of founding a new population following its arrival into an area of suitable habitat and climate. Mated females of *L. hasseltii* are capable of storing sperm and using it over a period of a couple of years to lay several batches of eggs (Raven and Gallon, 1987), which means that eggs could be potentially produced after arrival in New Zealand.

Latrodectus hesperus females can produce up to ten egg sacs with a mean of 196 eggs in each, although some egg sacs have been recorded to contain nearly 600 eggs (Kaston, 1970). For *L. mactans*, egg sacs contain 255 eggs on average, with the largest number of eggs recorded being 919 (Levi and Levi, 1968 cited in Reed and Newland, 2002). *L. geometricus* females may produce up to ten sacs, each containing 80 to 100 eggs (Smithers, 1944 cited in Reed and Newland, 2002).

In the laboratory, female *L. hasselti* can produce 10 egg sacs in 16 weeks, with up to 2500 spiderlings. An egg sac collected with a redback female in the wild from India was taken to a

laboratory and kept at room temperature, and after 16 days more than 250 spiderlings emerged (Manju and Kumar, 2001). Sibling males and females of *L. hasselti* are able to interbreed and achieve a high degree of fecundity (Forster, 1984b). It is unclear whether sibling compatibility also occurs in other *Latrodectus* species.

It should be noted that a significant uncertainty in predicting the likelihood of establishment of a new species is the impact of predation, parasitism and competition in a new environment.

28.3.3 Likelihood of transfer to suitable environment

Lack of suitable habitat is not the main deterrent to establishment of exotic *Latrodectus* in New Zealand. Since *Latrodectus* species have an affiliation with human-modified environments (Garb et al, 2004), with urban areas providing many suitable habitats for most spiders of this genus (Raven, 1995), lack of suitable micro-climate is also unlikely to be a major constraint.

Given the mobility of spiders the likelihood of them transferring from an imported vehicle to a suitable habitat in New Zealand is high.

The rate at which exotic spiders would spread in New Zealand is uncertain, as there is little information on even the most well-known pest species outside their native range. However the human assisted means by which the species arrive in New Zealand are also pathways for domestic spread. None of the domestic pathways have any biosecurity measures or restrictions on them.

28.3.4 Conclusion on establishment assessment

Given that:

- most *Latrodectus* spp. would find suitable habitat in urban areas, close to the ports of entry;
- a single egg sac or a single gravid *Latrodectus* could result in a viable population.

It is concluded that the likelihood of establishment of a new species of *Latrodectus* in association with imported vehicles or machinery is **non negligible**.

28.4 EXPOSURE AND CONSEQUENCE ASSESSMENT

28.4.1 Human Health Effects

Although venom potency may vary considerably between species e.g. (Muller, 1993), all *Latrodectus* are venomous to humans. Generally only the adult females *Latrodectus* are of concern, since the sexes are strongly dimorphic and the males are much smaller with chelicerae incapable of biting through human skin (Kavale, 1986; Sutherland and Trinca, 1978; Sutherland, 1983; Sutherland, 1983). These spiders are not particularly aggressive, and usually bite only when brought abruptly into contact with the human skin, for instance, whilst being trapped in clothing (Kavale, 1986; Sutherland and Trinca; 1978, Sutherland, 1983; Sutherland, 1983). Nonetheless, in Australia for example, *L. hasselti* bites are the most common cause of potentially serious envenomation (Mead and Jelinek, 1993; Sutherland, 1983), with at least 13 recorded deaths in the country prior to the development of an antivenom in 1956 (O'Donnell, 1983; Sutherland, 1983). Each year hundreds of people are bitten by redback spiders in Australia (Sutherland, 1983), with an estimate of nearly 10 000 bites annually (Raven, 2003).

The *Latrodectus* venom contains a vertebrate-specific neurotoxin (alphalatrotoxin) that affects the nervous system (Bonnet, 2004), “acting on the cerebrospinal and autonomic systems provoking a number of neurological signs and symptoms” (Maretic, 1983, p.462). The main symptom is pain, which comes in spasms and is acute (Bonnet, 2004; Isbister and Gray, 2002; Maretic, 1983; Sutherland and Trinca, 1978). According to (Sutherland and Trinca, 1978) “the patient is sometimes distraught and even hysterical because of its [the pain] intensity” (p.622). Other common symptoms of *Latrodectus* bites are erythema, oedema, elevated temperature, swelling of lymph nodes, hypertension, nausea, vomiting, tachycardia, and diaphoresis (Maretic, 1982; Maretic, 1983; Sutherland and Trinca, 1978).

Envenomation by *Latrodectus* is particularly traumatic for young children (Byrne and Pemberton, 1983; Sutherland and Trinca, 1978). *L. hasselti* seems to be a relatively common cause of envenomation in children, with possible redback spider bites averaging 27 every year in the 1980s in Perth alone (Mead and Jelinek, 1993).

The two recognized indigenous *Latrodectus* species (*L. atritus* and *L. katipo*) pose some risk to human health, and occasional bites by katipo occur in New Zealand e.g. (McCutcheon, 1992; O'Donnell, 1983). However, the exotic *Latrodectus* pose a considerably greater risk, as a result of their different habitat requirements and their greater size, which means they are capable of delivering a greater quantity of venom. While the katipo is confined to coastal areas and is somewhat retiring, the intercepted exotic *Latrodectus* are mostly domestic and/or peridomestic species (Forster, 1985; Kavale, 1986). There are no records of katipo inside human inhabitations (Kavale, 1986).

A report prepared for Japan's National Institute of Health (Raven, 2003) illustrates the danger to human health posed by the introduced *L. hasselti* in Osaka, where these spiders are now commonly found in high densities in urban environments despite being first observed there as late as 1995. Considerable control measures have been suggested as an attempt to halt its spread (Raven, 2003) and the potential human health impacts.

Social and cultural impacts could result from the establishment of exotic *Latrodectus* in New Zealand, particularly in urban areas, as New Zealand is relatively free of venomous organisms. Arachnophobia (fear of spiders) is one of the most widespread forms of specific phobia (Paquette et al. 2003). Sufferers experience intense fear when faced with spiders, and develop avoidance behaviour to all situations relating to these creatures (Paquette et al. 2003). Therefore, the consequent burden of anxiety that could occur in New Zealand could be significant, especially since campaigns would be necessary to educate the naïve population of New Zealand on minimizing the chances of being bitten. Note that, as a result of their venomous status, there are potential impacts for instance from bites to people handling recently imported vehicles associated with the entry of *Latrodectus* species into New Zealand, even without establishment.

28.4.2 Environmental Effects

The taxonomy of the *Latrodectus* genus is controversial, given the close proximity of many species (Garb et al, 2004). *Latrodectus hasselti* and the New Zealand *L. katipo* for example are closely related (Garb et al, 2004), and there is potential for inter-breeding (Forster, 1996). Kavale (1986) performed laboratory experiments and successfully crossed redback males with katipo females, and the resulting hybrids were fertile and capable of interbreeding. He concluded that “interspecific crossing of *L. katipo* and *L. hasselti* and the consequent

perpetuation of a population of hybrid animals is a feasible scenario in a field situation where the two species' ranges come into contact" (p.110). In fact, there is some genetic evidence that the redback and katipo have actually interbred in the wild in New Zealand (Vink and Sirvid, unpublished data).

Latrodectus katipo is an iconic invertebrate in New Zealand, and its conservation status has been recently evaluated by Patrick (2002). Its distribution has been dramatically reduced nationwide, as it was absent from 72 percent of the sites sampled within its previously recorded distribution (Patrick, 2002). Both endemic *Latrodectus* species are now listed as chronically threatened species under serious decline due to human activities (Molloy et al. 2002), and the potential hybridization with *L. hasselti* would be an additional concern (Garb et al, 2004).

The impact of other *Latrodectus* species on the katipo is difficult to predict, particularly given that their habitat preferences would likely differ. However, a number of *Latrodectus* species are closely related, and the possibility that that other *Latrodectus* species may hybridize with the katipo cannot be discarded. Furthermore, New Zealand's indigenous *Latrodectus* species would be at risk from the introduction of *Eurytoma latrodicti* (Hymenoptera: Eurytomidae), a parasitoid wasp whose larval stage parasitizes *Latrodectus* egg sacs (Cor Vink, pers. comm. 2006) should it be introduced together with exotic *Latrodectus*. *Eurytoma latrodicti* is established in Australia (Boucek, 1988) and USA (Brambila and Evans, 2001).

Latrodectus species could deleteriously affect the native fauna in a variety of ways, such as direct competition for food and/or habitat, and predation of native invertebrates. It is also possible that their establishment may impact native vertebrates, although such an impact would be difficult to predict as a result of the enormously variable susceptibility of vertebrates to *Latrodectus* venom (Maroli et al, 1973; Sutherland, 1983). In Australia at least, *L. hasselti* is known to feed on skinks (Raven, 1990). Exotic *Latrodectus* could therefore be a threat to some of New Zealand's threatened reptiles and amphibians in case their distributional range happens to overlap. However, an impact on native invertebrates and vertebrates would be less likely to occur if the establishment of exotic *Latrodectus* is restricted to urban areas.

28.4.3 Conclusion of consequence assessment

Given that:

- *Latrodectus* spp. are spiders of significance to human health;
- the establishment of any *Latrodectus* species in New Zealand could cause considerable human health, social impacts;
- Exotic *Latrodectus* could impact the native indigenous fauna, in particular the native katipo, which is one of New Zealand's iconic invertebrates if there is overlap in distribution.

The consequences of the entry and establishment of exotic *Latrodectus* species are considered to be **non negligible**. Whilst there is limited information, they are considered to be high consequence hazards.

28.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of *Latrodectus* spp. in association with imported vehicle/machinery is non negligible; and

- the human health and environmental consequences of their establishment would be non negligible.

The risk is considered to be non negligible and risk management measures are justified.

Furthermore, spiders in at least 20 additional taxa (not *Latrodectus* species) which are not present in New Zealand have been recorded from the vehicle pathway. Whilst they have not been subject to risk analysis, it cannot be assumed that the risk associated with them is negligible.

28.6 RISK MANAGEMENT

The risk management objective is to reduce the likelihood of entry and establishment of exotic spiders via the vehicle and equipment pathway to a negligible level.

The relationship between the presence of spider webs on a vehicle and the presence of viable spiders or egg masses is not known. Given the mobility of spiders and the evidence from the videoscope survey (see below) that spiders are not readily detected by visual inspection, it is assumed that webs will indicate the presence of some viable spiders. Fresh webs should therefore be treated as a biosecurity contaminant and this decision should be reviewed if evidence to the contrary is found. On the other hand, it should be noted that many spiders (e.g. Salticidae and Lycosidae) do not build webs and therefore the absence of webs does not indicate the absence of spiders.

The effectiveness of the main risk management measures identified in chapter 4 are summarised below.

28.7 OPTION EVALUATION

28.7.1 Visual Inspection

Between 2003 and 2005 there were at least 50 recorded post-border interceptions of spiders on used vehicles/machinery (MAF unpublished data). Of these, 12 were of *Latrodectus* spp., including *L. hasselti*, *L. hesperus* and *L. mactans*. These indicate that some spiders are escaping detection at the border, although, since the general public provided most of these reports, the actual rate of slippage is likely to be much higher.

The Biosecurity Monitoring group surveys demonstrate the limitations of visible inspection in detecting spiders. The vehicle slippage survey of 541 vehicles found eight vehicles with spiders not detected by visual inspection. Six were alive. Most specimens either could not be collected or were not possible to identify, however three were in the Theriidae family and one in the Sparassidae. One specimen was identified as *Phalangium opilio* an introduced species established in New Zealand (Wedde et al.2006). The videoscope survey of 300 vehicles after biosecurity clearance had been issued, also demonstrates that live adult spiders and eggs sacs go undetected under the current risk management regime (Table 4). The videoscope showed that *Latrodectus* and other spiders tend to occur in inaccessible areas of the car, areas that often cannot be visually inspected (Biosecurity Monitoring Group, 2006), although even the videoscope may not detect all spiders due to their fast-moving and secretive nature.

Table 4. Laboratory identifications of spiders (Araneae) on imported used vehicles intercepted during the 2005 videoscope survey. Note that additional spiders and egg sacs detected by the videoscope were not able to be collected and are not included in this table.

Family	Species	Status in NZ	Association with Pathway
Theridiidae	<i>Latrodectus geometricus</i>	not present	1 record (live adult)
	Unidentified sp.	spider	1 record
Desidae	<i>Badumna</i> sp.	2 spp. present	3 records (live adults)
Araneidae	<i>Araneae</i> sp.	unknown	1 record (live adult)
Unidentified	Unidentified sp.	unknown	2 records egg sacs (viability unknown) 1 record egg sac and spider remains (viability unknown)

Table 5 summarises the estimated number of vehicles with different types of contaminant that are visible during standard visual inspection, non visible during standard inspection and located in air filters, entering New Zealand during November 2005. Differences in slippage rates between ports of entry and vehicle group (breakbulk and containerised) mean that the overall results can not be pooled and applied to the entire pathway. The numbers in Table 5 are therefore derived by calculating the estimated numbers by port and vehicle group and weighting them by the proportion of vehicles in that part of the pathway. Note that the detection of low frequency contaminants in a survey of this sort is restricted by sample size. Based on the sample of 541 vehicles there is a 95 percent chance of detecting visible contamination affecting 1 in 182 imported used vehicles (Wedde et al. 2006).

Table 5. Estimated number of vehicles with slippage of visible contaminants, non visible contaminants and contaminants in air filters during November 2005, by contaminant type. Source: Wedde et al. (2006).

Contaminant type	Visible contaminants		In air filters		Non-visible contaminants**	
	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval	Estimated number and % of vehicles	95% confidence interval
Plant material	2 181 (14%)	1 977-2 840	1 862 (12%)	1 601-2 511	6 081 (40%)	5 384-6 802
Seeds	873 (6%)	205-1471	5 053 (33%)	4 521-5 765	839 (5%)	601-1273
Soil	480 (3%)	494-1 049	33 (0.2%)	125-457	1 562 (10%)	1 211-2 093
Live animals*	591 (4%)	579-1 166	380 (2.5%)	372-900	945 (6%)	692-1387
Animal material	181 (1%)	251-734	294 (2%)	298-811	230 (1.5%)	141-534

* Live animals include insects, spiders, and reptiles and comprise all viable life stages including egg masses.

**excluding machinery

Note: Since some vehicles may have more than one contaminant type or the same contaminant in multiple locations, the numbers in individual columns and rows should not be added.

Bringing LTNZ compliance checking centres into the formal biosecurity regime (see chapter 4) is likely to increase the efficacy of visual inspection, but given the mobility of spiders, some are likely to remain undetected.

Conclusion: visual inspection is not able to mitigate the likelihood of entry of *Latrodectus* spiders to a negligible level.

28.7.2 Vacuuming

The videoscope survey (see above), showed that spiders of all life stages (adults, juveniles and eggs) are found in areas that are beyond the reach of visual inspection or vacuuming.

Additionally, vacuuming prior to inspection may remove evidence of spider contamination, such as webs, see section 28.2.2.

Conclusion: vacuuming is not able to mitigate the likelihood of entry of *Latrodectus* spiders to a negligible level.

28.7.3 Pressure Wash

Given the results of the videoscope survey, this treatment is assumed to be ineffective in eliminating spiders behind secure panels, which are not removed during pressure wash.

Conclusion: pressure wash is not able to mitigate the likelihood of entry of *Latrodectus* spiders to a negligible level.

28.7.4 Fumigation with Methyl Bromide

Newland and Reed, (2002) cite experimental work done by Shorey and Wood, (1991) on black widow spiders (*L. hesperus*). No spiders were killed by the 'T-101' fumigation schedule, of 64 g/m³ for 2 hours at 7.2°C (concentration time product of 128 g*h/m³). 100 percent mortality was obtained with treatment at 16 g/m³ for 24 hours at 7.2°C (concentration time product of 384 g*h/m³).

The current MeBr fumigation standard for used vehicles prescribes treatment at 48 g/m³ for 24 hours at ≥ 21°C (concentration time product of 1152 g*h/m³). As a result, assuming that the results of the above study are applicable to vehicles, the current MeBr fumigation rate for used vehicles would be an effective mitigating measure against this species. It is assumed that it will also be effective against all other *Latrodectus* species.

Under the current risk management regime, vehicles are generally only fumigated if live spiders are detected on inspection (Smith and Toy, 2006). The efficacy might increase if the presence of webs is assumed to indicate the presence of viable spiders. However hunting, non-snare using spiders (eg Salticidae) will not be revealed by this method, nor will a web building spider securely placed behind a panel or in another difficult to view. Conversely, it is often difficult to determine whether a web is fresh and webs may be retained on a vehicle in the absence of live spiders.

Conclusion: Fumigation with methyl bromide at a rate of 48 g/m³ for 24 hours at ≥ 21°C is likely to reduce the likelihood of entry of *Latrodectus* spiders to a negligible level.

28.7.5 Insecticide application

The videoscope survey has shown that spiders occur in parts of the vehicle not accessible to visual inspection. Such locations will also be difficult to treat with insecticide. This treatment is therefore unlikely to meet the risk management objective.

28.7.6 Heat Treatment

Heat treatment has the advantage of treating organisms that are internal and external contaminants, and those which are not visible in standard inspection procedures. It is

important to ensure all parts of the vehicle reach the treatment temperature, since spiders tend to hide in well-sheltered places as demonstrated by the videoscope survey. However, the most difficult parts of a vehicle to heat are the well insulated crevices under mats, but spiders are unlikely to shelter in such places.

No published information appears to be available on the heat tolerance of *Latrodectus* species, or the efficacy of heat treatment against these spiders. Of the four intercepted species in the genus, *L. hasselti* is likely to be the most heat tolerant. For example, this species is native to areas such as Marble Bar in Australia, that country's hottest place where temperatures reach 50°C in the shade (Robert Raven, pers. comm. 2005). As a result, an effective heat treatment against this species is likely to be effective against all other species in the genus.

The presence of *L. hasselti* in habitats such as Marble Bar means that heat treatment at 54°C is unlikely to reach this species critical thermal maximum (CTM), although the behavioural characteristics of the species may enable them to tolerate extreme environmental temperatures, much higher than their critical thermal maximum for brief periods. The CTM value for the spider *Argiope trifasciata*, a diurnal temperate-zone species (Schmalhofer, 1999), was found to be as high as 58.6°C (Pulz, 1987). Although no CTM data are available for redbacks, based on the habitats occupied by the redbacks, the species' CTM may be around the 60°C mark, but it would be necessary to perform laboratory experiments to determine the actual value.

In the absence of any data on the CTM for *Latrodectus* species, it would be therefore advisable to provide a safety margin and prescribe heat treatment at 60°C for 10 minutes as a likely effective measure to mitigate the risk. This could be an interim regime until adequate efficacy data are available.

Conclusion: Heat treatment at a core temperature of 60°C for 10 minutes is likely to mitigate the likelihood of entry of *Latrodectus* spiders to a negligible level, as long as all parts of the vehicle/machinery reach the prescribed temperature for that time period.

28.7.7 Targeted Surveillance and Information

The likelihood of certain *Latrodectus* species entering New Zealand in association with this pathway is higher for certain countries of origin, such as *L. mactans* from USA and *L. hasselti* from Australia. However, *Latrodectus* species are cosmopolitan and could arrive in used vehicles/machinery from any country. Most importantly, the four *Latrodectus* associated with the pathway originated from Australia, Japan, USA and Singapore, which together make up approximately 99.5 percent of all imported used vehicles.

Conclusion: targeted surveillance and information is not an effective measure to mitigate the likelihood of introduction of *Latrodectus* spiders to a negligible level.

28.7.8 Onshore versus offshore treatment.

There is little information on which to base an assessment of the relative merits of the application of risk management measures offshore as opposed to on-shore. Four of the eight instances of adult spiders found during the Biosecurity Monitoring Group's slippage survey were found vehicles that had been pre-cleared overseas (Wedde et al. 2006). Since *Latrodectus* spiders are mobile they may escape from an imported vehicle prior to treatment onshore. Off-shore treatment may therefore be more effective in reducing the likelihood of establishment than on-shore treatment.

28.8 RECOMMENDED MEASURES

- 1) Heat treatment of imported **used** vehicles and used machinery at a core temperature of at least 60°C for 10 minutes. The efficacy of this regime against *Latrodectus* spiders is uncertain and should be validated **or** fumigation with methyl bromide at <48 g/m³ for 24 hours at ≥ 21°C **and** recontamination prevention measures for offshore managed vehicles **and**
- 2) A systems approach to the management of imported **new** vehicles incorporating surveillance and appropriate storage yard maintenance measures should be investigated.

An alternative package of measures comprising:

- visual inspection and fumigation/heat treatment of all vehicles found contaminated with cobwebs or live spiders; **and**
- additional measures to prevent re-contamination of offshore inspected vehicles including surveillance, buffer zones, and/or physical protection measures; **and**
- mandatory heat treatment or fumigation of all containerised vehicles imported from USA or Canada; **and**
- bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 4);

would reduce the risk to a lower level than that associated with the current risk management regime but would not meet the risk management objective.

28.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above have been based on informed assumptions, after consideration of these uncertainties. Should additional information from research, interception records or pathway monitoring invalidate any of these assumptions, then the risk estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- The frequency of entry of exotic spiders via the vehicle pathway is uncertain but available evidence indicates that it is higher than some other hazard groups. The Biosecurity Monitoring Group slippage surveys found more spiders than other invertebrate types.
- The frequency of contamination of new vehicles is unknown. It is the conditions in which the vehicles are stored rather than their age which is likely to determine whether or not they are contaminated.
- The status of *Latrodectus hasselti* in New Zealand is uncertain, but given its restricted distribution and the evidence of cold adapted strains in Japan it is considered to be a hazard on the vehicle pathway.

- The relationship between the presence of spider webs on a vehicle and the presence of viable spiders or egg masses is not known. It is assumed that webs will indicate the presence of some viable spiders or egg masses.
- The efficacy data for some treatment options, particularly heat treatment and methyl bromide fumigation against *Latrodectus* spiders is limited.

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29 Springtails (Collembola)

29.1 HAZARD IDENTIFICATION

29.1.1 Identity

Category: Collembola

Taxonomic Group: Class: Collembola; Order: Collembola

Name: Springtails

29.1.2 Association with pathway

Interceptions of springtails recorded during the period 1994-2006 are summarised in Table 1.

Table 1 Interception records for Collembola in association with imported vehicles and machinery. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status (Scott and Emberson, 1999)	Country of origin and pathway	Lifestage (number of records) & viability
<i>Entomobrya</i> sp.	Entomobryidae	unknown	Japan used vehicle	live adults (2)
<i>Sinella</i> sp.	Entomobryidae	genus not present in NZ	Japan used vehicle	live adults (1)
unidentified	Entomobryidae	unknown	Japan used vehicle	live adults (1)

There are 11 families of Collembola and some 6000 species. They are small wingless insects, 1-5mm in length, generally found in soil or leaf litter, but sometimes in association with the nests of ants or termites, on the surface of ponds, in the marine environment or in domestic premises. They feed on fungi, pollen grains and dead or living plant material. They can occur in very high densities but are susceptible to desiccation. They have a worldwide distribution but are most abundant in temperate soils. Some species are regarded as pests due to the root and seedling damage they cause (Hill, 1994). They are of environmental importance, because of their role as detritivores in maintaining soil structure and fertility.

Given their small size and association with soil and plant debris which is not routinely inspected for individual contaminant species, it is likely that Collembola are significantly under-recorded on the vehicle and equipment pathway.

29.1.3 Conclusion

Given that Collembola:

- are very small and are almost certainly an under-recorded contaminant on the used vehicle and equipment pathway;
- are difficult to identify, and consequently it is not possible to determine whether any individual collembolan associated with vehicular contamination is already present in New Zealand;
- are associated with soil contamination;
- can in some cases cause adverse effects on host plants;

they are considered a potential hazard on the **used** vehicle and machinery pathway.

Given the lack of species level identification, it is not possible to generalise about the likelihood of entry, establishment and potential consequences of establishment and spread and no further analysis is undertaken. It is assumed that the risk management measures recommended for the hazard group, soil, plant and animal debris, will effectively mitigate any risks associated with Collembola on the used vehicle and machinery pathway.

Given the association of Collembola with soil contamination, they are not considered potential hazards on the **new** vehicle and machinery pathway.

29.2 REFERENCES

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30 Stick insects (Phasmatodea)

30.1 HAZARD IDENTIFICATION

30.1.1 Identity

Category:

Taxonomic Group: Class: Insecta; Order: Phasmatodea

Name: Stick and leaf insects

30.1.2 Association with pathway

Interceptions of stick insects recorded during the period 1994-2006 are summarised in Table 1.

Table 1. Interception records of stick insects in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Status	Association with pathway
unidentified	Phasmatidae	unknown- this family is native to NZ (but not endemic)	1 record of live juvenile on used vehicle from Japan

There are six families of stick and leaf insects and some 2500 to 3000 species. They are a group of largely tropical, nocturnal, phytophagous insects, remarkable for their cryptic resemblance to leaves or twigs (Hill, 1994).

30.1.3 Conclusion

Given that insufficient information is available to determine whether stick insects that are not present in New Zealand are associated with **used** vehicles and machinery and their phytophagous feeding habits, a precautionary approach is taken and they are assumed to be a potential hazard.

Given the lack of species level identification, it is not possible to generalise about the likelihood of entry, establishment and potential consequences of establishment and spread. Since they are most likely to enter in association with plant debris contamination it is assumed that the risk management measures recommended for plant debris will manage any risk associated with stick insects and no further analysis is undertaken for stick insects as a potential hazard group on the vehicle pathway.

Given the association of phasmatids with plant contamination, it is assumed that they are not a potential hazard on **new** vehicles and machinery.

30.2 REFERENCES

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31 Stoneflies (Plecoptera)

31.1 HAZARD IDENTIFICATION

31.1.1 Identity

Category: Insects

Taxonomic Group: Class: Insecta; Order: Plecoptera

Name: Stoneflies

31.1.2 Association with pathway

Table 1. Interception records for Plecoptera in association with the vehicle and machinery pathway. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Association with pathway
unidentified	unidentified	2 records of dead adults in vehicles from Japan

There are some 14 families of stoneflies worldwide with about 1700 species. They have aquatic larvae that live largely in unpolluted flowing waters. The nymphs are largely carnivorous (Hill, 1994). Adults can live long enough to survive shipment to New Zealand e.g. (Nebeker, 1971), but are only likely to be trapped in a vehicle by chance and are unlikely to occur in sufficient numbers to establish.

31.1.3 Conclusion

Given the association of the order with flowing water, it is not considered to be a potential hazard on the **new or used** vehicle or machinery pathway.

31.2 REFERENCES

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32 Termites (Isoptera)

32.1 HAZARD IDENTIFICATION

32.1.1 Identity

Category: Insects

Taxonomic Group: Order: Isoptera

Name: termites

There are 7 families comprising some 1900 species in this largely tropical order of insects (Hill, 1994).

32.1.2 Association with pathway

Interceptions of termites recorded during the period 1994-2006 are summarised in Table 1.

Table 1. Interception records of termites in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Country of origin and pathway	Lifestage (number of records) & viability
unidentified	unidentified	Japan used vehicle	1 record of many live Isoptera
unidentified	unidentified	Japan used vehicle	dead adult (1)

The limitations associated with interception records (see section 2.3.1) mean that they can only be used to demonstrate association with the pathway. They do not provide contamination rates.

There are three indigenous species of termites in New Zealand *Kalotermes browni*, *Stolotermes ruficeps* and *S. inopinus* (Ross, 2005). These are similar in appearance to subterranean termites but are generally non-invasive and are found in rotting timber, tree stumps and firewood.

An incursion of *Coptotermes acinaciformis*, Australian subterranean termite into New Zealand, was declared officially eradicated in 2005, but another incursion in the South Island has been reported in 2006. All incursions have been associated with poles or sleepers imported from Australia. There have also been interceptions on yachts and a fishing vessel. AQIS fumigate yachts being imported due to the risk from Formosan termites.

32.1.3 Conclusion

Termites are a potential hazard on the used vehicle and equipment pathway. The risk assessment is based on the *Coptotermes* genus since it is most likely to be associated with the pathway.

32.2 ENTRY ASSESSMENT

32.2.1 Current Distribution

Coptotermes is a tropical genus of some 35 species, best represented in south-east Asia and Australasia. *Coptotermes acinaciformis* originates in Australia. *Coptotermes formosanus* is thought to have originated in China has been introduced to and is now established in Japan, South Africa, Sri Lanka and the southern United States, with reports from Pakistan and Brazil (Su and Tamashiro, 1986).

32.2.2 Likelihood of association with the pathway

Coptotermes are primarily forest species that live in moist stumps of dead trees, but have adapted to both urban and agricultural conditions. In Japan *C. formosanus* is largely restricted to the southern coastal belt, particularly around sea ports (Mori, 1986). *C. formosanus* is thought to have been spread through shipping containers and associated wooden pallets and crates as well as infested boats (Su and Tamashiro, 1986). Nests of *Coptotermes* spp. are generally subterranean, but aerial colonies of *C. formosanus* can occur in buildings (Su and Tamashiro, 1986). Only young adults are winged and the wings have fracture lines at the bases so that after a brief mating flight the wings are shed prior to the adults starting their subterranean life. Their flight is weak and most mating flights are held on moist still evenings and last an hour or less. Paired mated adults find a suitable location, dig a tunnel and start a new colony. It is assumed that adults are unlikely to become trapped within vehicles during the short mating flight, and even if they did would not be able to create a nest. Sterile, wingless workers gathering food or soldiers might occur in association with plant material contamination of vehicles, but they would be unable to establish a viable population. A nest would only likely to be associated with a significant quantity of soil contamination, which is most likely to occur on used agricultural or forestry equipment or perhaps in wooden decking.

32.2.3 Likelihood of surviving shipment to New Zealand

A relatively high level of humidity is needed to sustain a termite nest. It is unlikely this could be sustained during shipment from Japan or the USA but there is a much greater likelihood of surviving the short voyage from Australia. The workers are able to break down cellulose. Plant material would be necessary in a vehicle as a food source if they are to survive shipment.

32.2.4 Conclusion on entry assessment

Given that:

- *Coptotermes* spp. are found in the main vehicle exporting countries, but not in New Zealand;
- the likelihood of termites contaminating vehicles is negligible except for vehicles contaminated with significant quantities of soil or boats or trucks with significant volumes of wood;
- the likelihood of termites surviving the journey to New Zealand is very low except from Australia.

It is concluded that the likelihood of termites entering New Zealand on the **used** vehicle and equipment pathway is relatively low but **non negligible**.

The likelihood of such contamination of **new** vehicles is considered to be **negligible**.

32.3 ESTABLISHMENT AND EXPOSURE ASSESSMENT

32.3.1 Environmental suitability of New Zealand

Termites are principally tropical and sub-tropical species. However since several species are able to survive in an urban environment and heating of buildings enable *C. Formosanus* to survive winter conditions in Japan (Mori, 1986). Given that there have been incursions of *C. acinaciformis* in New Zealand it is assumed that conditions are suitable for establishment in at least some areas.

32.3.2 Biological characteristics

Termites have a complex social structure. The founding pair becomes the queen and king. The queen is the sole egg-layer, can live for many years and can lay thousands of eggs a day. The ability of workers to digest cellulose means that a very wide range of plants and indeed timber in buildings can be used as a food source. These characteristics enable them to establish relatively easily in a new area.

32.3.3 Likelihood of transfer to suitable environment

For a colony of termites to become established from a nest entering New Zealand in an imported vehicle it would be necessary for the nest to remain active long enough to produce a winged generation of sexual adults and for the vehicle to be located in the northern part of New Zealand where conditions are most likely to be suitable for establishment. Colony development in *C. formosanus* is slow and it takes at least 5 years before a newly established pair of alates can produce a colony large enough to produce a new generation of alates (Tamashiro et al. 1986). Suitable habitats for establishment occur in the vicinity of the port of Auckland. It would therefore be possible for termites to become established either prior to, or after dispersal of the imported vehicle to its final destination.

Coptotermes formosanus is a poor flier and un-assisted spread is very slow (Tamashiro et al. 1986).

32.3.4 Conclusion on establishment assessment

Given that:

- the northern part of New Zealand is likely to be climatically suitable for termite species adapted to urban environments;
- termites are polyphagous and have an extremely broad dietary capacity; and
- it would be possible for a termite nest to remain concealed in the decking of a boat or under the wooden bed of a truck.

It is concluded that the likelihood of establishment in northern New Zealand via the used equipment pathway is relatively low but **non negligible**.

32.4 CONSEQUENCE ASSESSMENT

32.4.1 Direct effects

The ability of termites to break down cellulose into food sugars, enabling them to destroy wooden structures and trees, means that they could have a significant economic impact, especially given the abundance of wooden buildings in New Zealand. *Coptotermes formosanus* is considered an extremely destructive structural pest, because it can penetrate noncellulose materials such as cracks in concrete and metal in search of food. The estimated annual cost of control of this termite in Japan in 1985 was US \$400 million (Su and Tamashiro, 1986). In addition to structural lumber, *C. formosanus* also attacks many living plants, including urban fruit and shade trees and crop plants such as macadamia nuts (Tamashiro et al. 1986). Such activity is also likely to impact on native ecosystems. Termites are therefore considered high consequence pests, even if the extent of impacts will be limited by climatic suitability in New Zealand.

32.4.2 Indirect effects

There are likely to be significant social consequences from the establishment of termites due to their ability to feed on timber and consequently affect domestic dwellings.

32.4.3 Conclusion of consequence assessment

The economic, social and environmental consequences of the entry and establishment of new species of termite are **non negligible**.

Termites are considered high consequence hazards.

32.5 RISK ESTIMATION

Given that:

- the likelihood of entry and establishment of *Coptotermes* termites associated with the used equipment pathways is low but non negligible; and
- the economic and social consequences of establishment of would be non negligible.

The risk is considered to be **non negligible** for used trucks, boats forestry and agricultural machinery and risk management measures are justified. The risk associated with other types of vehicle is considered to be negligible.

32.6 RISK MANAGEMENT

The objective is to reduce to a negligible level the likelihood of exotic termites entering via imported vehicles and equipment and establishing in New Zealand.

32.7 OPTION EVALUATION

The effectiveness of the main risk management measures identified in Chapter 4 are summarised below.

32.7.1 Visual inspection:

Since the risk of entry is associated with a nest which is likely to be located either within significant soil contamination or within a significant quantity of wood such as a timber deck, detection should be possible through inspection for these contaminants/features.

32.7.2 Pressure wash

Pressure washing is unlikely to remove termite nests in inaccessible parts of a vehicle. The post-border interceptions of ants after a vehicle had been steam cleaned support this supposition.

32.7.3 Heat treatment:

Heat has long been used to control termites and has been reviewed by Woodrow and Grace (1998). *Coptotermes formosanus* workers and soldiers have a critical thermal maximum of 46.3 °C and the critical thermal maxima of workers and soldiers of *Reticulitermes flavipes*, the eastern subterranean termite, are 45.4 and 45.2°C respectively (Sponsler and Appel, 1991). These figures accord with the range of thermal tolerances for most insects (Sherwood, 1996). Thermal maxima for queens and eggs are not known. It is assumed that whilst the nest will have an insulating effect and indeed is often designed specifically to facilitate thermoregulation in natural conditions, in the more exposed conditions of a nest within a vehicle the insulation factor would be insufficient to protect it from the lethal effects of high temperatures. Treatment of a house at 48.9°C for 30 minutes resulted in 100 percent mortality of drywood termites, *Incisitermes minor* in the USA, except where the wooden boards adjoined a concrete heat sink (Lewis and Haverty, 1996). Laboratory studies of the efficacy of heat to control the drywood termite (*Cryptotermes brevis*), which is well known for its desiccation tolerance found that 46°C and 49°C core temperatures were 100 percent lethal in wooden blocks 13.5cm by 13.5 cm at both 30 and 60 minute exposures (Woodrow and Grace, 1998). This study found that slower rates of temperature increase reduced thermal tolerance and may enable lower treatment temperatures without reducing efficacy. These studies are not directly applicable to the vehicle situation, but there is sufficient information to support the assumption that a vehicle treatment regime of a core temperature of 54°C for ten minutes, would adequately control termite contaminants.

32.7.4 Fumigation

There is little information available on the efficacy of fumigants against termites. The effectiveness of the current border vehicle fumigation regime (48 g/m² for a period of 24 hours) against termites is not known but is assumed to be effective against all life stages. This rate is used by Australia for fumigation against termites.

32.8 RECOMMENDED MEASURES

- 1) Visual inspection of imported used machinery, trucks and boats and fumigation/heat treatment where necessary, coupled with bringing LTNZ compliance checking centres into the formal biosecurity regime (see Chapter 3) **or**
- 2) Mandatory heat treatment of imported used machinery, trucks and boats at a core temperature of at least 54°C for 10 minutes or fumigation.

32.9 UNCERTAINTY/ASSUMPTIONS SUMMARY

As discussed in Chapter 2 there is a considerable amount of uncertainty associated with this pathway. Since it is not possible to reduce this uncertainty in the near future, a number of assumptions have been made in the analysis of this hazard group which are summarised below. The risk management recommendations above are made on the basis of these uncertainties and assumptions. Should additional information from research, interception recording or pathway monitoring invalidate any of these assumptions, then the risk

estimation, the risk management objective and the recommendations for this hazard group will need to be reviewed. Critical uncertainties and assumptions are prioritised for further work in Chapter 35 which also includes recommendations for monitoring and review of the pathway.

- It is assumed that termites are unlikely to survive the journey to New Zealand from vehicle exporting countries except Australia.
- It is assumed that for termites to enter New Zealand and become established, contamination of an imported vehicle with a nest would be required. It is assumed this is only likely to be associated with a significant quantity of soil contamination or rotten wooden decking.
- It is assumed that environmental suitability in New Zealand is sufficient to enable termites to establish over sufficiently large areas to have significant consequences.

32.10 REFERENCES

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33 Thrips (Thysanoptera)

33.1 HAZARD IDENTIFICATION

33.1.1 Identity

Taxonomic Group: Class: Insecta; Order: Thysanoptera;

Name: Thrips

33.1.2 Association with pathway

Interception records for thrips recorded during the period 1994-2006 are summarised in Table 1.

Table 1. Interception records of thrips in association with imported vehicles and machinery 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Country of origin	Pathway	Interceptions (number of records)
unidentified	Thripidae	UK	used vehicle	frass and exuviae (1) 2 dead adults on plant material (1)
		USA	new machinery	adult on plant material viability not recorded (1)

There are 6 families of Thysanoptera and some 5 000 species. They are small insects, 1-8 mm in length. All species of Thripidae feed on plants by piercing the surface tissues with their mouthparts and sucking up the exuding sap and can act as vectors of viral and fungal diseases. Some are plant pollinators. Reproduction may be parthenogenetic and in some species males are rare. Eggs are laid on foliage or leaf litter. The nymphs feed continuously and pupate in the soil. Field identification of adults is difficult (Hill, 1994).

Given their small size and association with plant material and soil which is not routinely inspected for individual contaminant species, it is likely that thrips are under-recorded on the vehicle and equipment pathway.

33.1.3 Conclusion

Given that thrips:

- are small and are likely to be an under-recorded contaminant on the used vehicle and equipment pathway;
- are difficult to identify so that it is not possible to determine whether any individual species associated with vehicular contamination is already present in New Zealand;
- are associated with plant contamination;
- can in some cases cause adverse effects on host plants;

they are considered a potential hazard on the **used** vehicle and machinery pathway.

Given the lack of species level identification, it is not possible to generalise about the likelihood of entry, and establishment or of the potential consequences of establishment and spread. Since risk management measures are proposed for soil, plant and animal debris

contamination associated with the vehicle and equipment pathway, no further analysis is undertaken for thrips as a potential hazard group on the vehicle pathway.

Given the association of thrips with plant and soil contamination, they are not considered potential hazards on the **new** vehicles and machinery pathway.

33.2 REFERENCES

Hill, D S (1994) *Agricultural entomology*. Timber Press; Portland, Oregon.

34 Woodlice (Isopoda)

34.1 HAZARD IDENTIFICATION

34.1.1 Identity

Category: Taxonomic Group: Class: Malacostraca; Order: Isopoda, Suborder: Oniscidea
Name: woodlice, slaters and pillbugs

34.1.2 Association with the pathway

The world's isopod fauna exceeds 10,000 described species but the actual number is certainly several times this. There are big gaps in knowledge of the deep sea, the tropics, and some families with small individuals. The New Zealand fauna totals 379 living species (fossils are also known) in 48 families, but it appears that few shallow marine groups are well covered taxonomically. New Zealand isopods are largely endemic (Webber et al. in press).

There are 72 known species of Oniscidea in New Zealand. Most are endemic, four species are naturally occurring non-endemics and six others are introduced. Damp places, and under leaves and decaying logs, are favoured habitats as they rely for respiration on their pleopods, which are kept damp with a variety of water-conservation measures (Webber et al. in press). Most species are scavengers on dead plant litter but some can be pests in gardens. The most commonly seen species are introduced from Europe.

Interceptions of woodlice recorded during the period 1994-2006 are summarised in Table 1.

Table 1. Interception records of woodlice in association with imported vehicles and machinery during the period 1994 to 2006. Source: MAF Biosecurity Monitoring Group interceptions database

Organism	Family	Association with the pathway
<i>Porcellio sp.</i>	Porcellionidae	1 record of adult on used vehicle from Japan. Viability not recorded
<i>Armadillidium sp.</i>	Armadillidiidae	1 record of 2 dead adults on vehicle from Japan

Porcellionidae are mainly detritivores and are most likely to be found with significant quantities of plant debris in association with the vehicle pathway. Two species in this family have already been introduced to New Zealand from Europe (Webber et al. In press). At least one woodlouse, *Armadillidium sp.* has been introduced to New Zealand from Europe.

Isopods are readily visible and the paucity of interception records supports the assumption that they are unlikely to be a hazard on the pathway. Given their requirements for moisture it is unlikely that they would survive shipment to New Zealand in association with the vehicle pathway.

34.1.3 Conclusion

Given that woodlice:

- are rarely reported to have been intercepted on the vehicle pathway;
- are unlikely to survive shipment from the main vehicle exporting countries, due to moisture requirements.

They are **not considered to be a potential hazard** on the **new or used** vehicle or machinery pathway.

34.2 REFERENCES

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35 Summary of recommended risk management measures

The Biosecurity Monitoring Group surveys and this risk analysis have demonstrated that the current risk management regime does not adequately manage all the risks associated with imported vehicles and machinery. In particular visual inspection is not able to detect hidden and mobile organisms, which include a number of high consequence but low frequency hazards.

The analysis for each hazard group in the preceding chapters includes an assessment of the range of potential biosecurity risk management measures. The efficacy of these measures in reducing the risk associated with the groups of high consequence hazards to a negligible level is summarised in Table 1. The hazard groups that were analysed in detail are shown in bold. Other groups assumed to be managed by the same measures follow in brackets.

Given the wide variety of hazard groups associated with the commodity, there is no single appropriate risk management measure. A package of measures is therefore recommended. The risks associated with imported new vehicles and with used machinery are distinct from those associated with imported used vehicles. They are therefore subject to separate risk management recommendations— see sections 35.4 and 35.5.

35.1 RECOMMENDED MEASURES FOR IMPORTED USED VEHICLES (EXCLUDING MACHINERY AND VEHICLES CAPABLE OF HOLDING WATER) APPLIED ON OR OFFSHORE

1. vacuuming and pressure wash; **and**
2. heat treatment at 60°C core temperature for 10 minutes or fumigation with methyl bromide at a rate of 48g/ m³ for 24 hours at 21°C (see Table 2 for rationale for these regimes); **and**
3. improved facility specification including measures to prevent recontamination offshore or escape of hazards prior to treatment onshore (see 35.3.3); **and**
4. for crash damaged vehicles thoroughly spray all potential larval mosquito habitats offshore with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than eight weeks or thoroughly spray onshore with a synthetic pyrethroid spray; **and**

This package of measures will reduce the risk to a negligible level for the majority of high consequence hazards associated with the pathway, except for plant seeds and snails. It is anticipated that the number of incursions via the vehicle pathway would be very low under this regime.

Table 1. Evaluation of the efficacy of a range of risk management measures in reducing the risk of biosecurity hazards associated with imported used vehicles and machinery to a negligible level

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
Ants (bees & wasps)	no	yes (55°C for 30 minutes)	yes (48 g/ m ³ for 24 hours)	Partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	partial (removing food source)	no	partial (likely to kill some)	uncertain (shipboard treatment with toxic bait)
Dermestid Beetles (earwigs)	yes (if not precleaned)	yes (55°C for 15 minutes) except <i>T. granarium</i> which may require 60°C for 30 minutes	yes (< 48g/ m ³ for 24 hours)	no	no	unknown (may not remove eggs)	partial (removal of mats, seat covers & back seats)	partial (likely to kill some)	surveillance by industry for <i>T. granarium</i> around grain stores
Butterflies & moths (flies except mosquitoes)	no	yes (55°C for 5 minutes)	yes (< 48g/ m ³ for 24 hours at 21°C)	Partial (measure to prevent re-contamination prevention offshore and escape onshore & inspection ramps)	uncertain	no	no	unknown but may prevent re-contamination	no
Cockroaches (m antids, crickets, reduviid bugs)	no	yes (55°C for 10 minutes)	yes (<48g/ m ³ for 24 hours at 21°C)	no	no	partial (remove food supply)	no	partial (likely to kill some)	no
Mosquitoes	no	uncertain for vehicles containing water	yes (but adults likely to fly away before treatment)	no	no	no	no	yes (spray cavities - UV resistant formulation for	partial (treatment of pooled water &/or receptacles with 10% chlorine & 4%

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
								offshore treatment)	detergent solution for 30 minutes)
Organisms associated with soil, plant and animal debris	no	no	no	partial (LTNZ compliance centres & improved screening and chlorine treatment of waste water at onshore decontamination sites)	partial together with vacuum	partial together with pressure wash	air filters for machinery	no	partial (disinfection of machinery /trucks with faecal or other infected material & provision of targeted information)
Plant seeds	no	no	no	partial (improved screening of waste water at onshore decontamination sites)	partial together with vacuum	partial together with pressure wash	uncertain (air filters)	no	no
Reptiles (amphibians)	no	yes (50°C for 10 minutes)	yes (<48 g/m ³ for 24 hours)	partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	no	no	no	partial (visual inspection of boats arriving as cargo)
Snails	uncertain	no	yes (128 g/ m ³ at 12.5°C for 24 hours)	partial (LTNZ compliance centres)	uncertain (audit with videoscope)	no	no	no	no
Spiders	no	yes (60°C for 10 minutes)	yes (<48 g/m ³ for 24 hours)	partial (measure to prevent re-contamination prevention offshore and escape onshore)	no	no	no	unknown	no

Assessed Hazard group (other hazards)	Visual inspection (current regime)	Heat treatment	Methyl bromide fumigation	Improved facility & inspection specification	Pressure wash	Vacuum	Remove vehicle part	Synthetic pyrethroid spray	Other
Termites	yes	yes (54°C for 10 minutes)	uncertain	partial (LTNZ compliance centres)	no	no	no	unknown	no

35.2 OTHER MEASURES CONSIDERED FOR USED VEHICLES

A different package of measures which would reduce the level of risk below that provided by the current risk management regime, but not to a negligible level has also been identified. The main concern with this package is its low efficacy for mobile, low frequency, high consequence hazard groups (e.g. ants, moths, reptiles, spiders). It is expected that it would reduce the likelihood of further incursions of these organisms, but it is expected that there would be some incursions via the vehicle pathway. Where the consequences of an incursion are small and/ or eradication cheap and easy to achieve, this may be appropriate. Because of the impacts of the pests involved and the costs and consequences of even a successful eradication are high, this is not considered to be the case here and this is not the recommended risk management package. However it is likely to be more efficacious for plant seeds and snails. This alternative package comprises:

- 1) vacuuming and pressure wash of all vehicles; **and**
- 2) visual inspection of all imported vehicles by a MAF quarantine officer coupled with fumigation or heat treatment as necessary, the regime depending on the organisms identified through the inspection; **and**
- 3) improved facility and inspection specification including measures to prevent recontamination offshore or escape of hazards prior to treatment onshore; **and**
- 4) LTNZ compliance centres required to register as Transitional Facilities to provide a back up biosecurity risk management measure; **and**
- 5) mandatory spraying of all potential larval mosquito habitats in crash damaged vehicles with a residual synthetic pyrethroid. If treated offshore a formulation resistant to sunlight degradation for no less than 8 weeks must be used **or** if spraying is not practical, fumigation with methyl bromide at bromide at 48g/m³ for 24 hr. These vehicles may not be able to be properly inspected, and have a greater likelihood of retaining water and being contaminated with mosquitoes; **and**
- 6) classification of fresh spiders webs as a biosecurity contaminant as they are likely to indicate contamination with viable spiders/ egg sacs. This recommendation should be reviewed if evidence to the contrary is found **and**
- 7) mandatory heat treatment or fumigation of all containerised vehicles imported from USA or Canada.

A variation on this package including application of residual insecticide would be expected to reduce the risk still further, but insufficient information is currently available on the efficacy of this as a measure against the range of hazards associated with vehicles.

35.3 SPECIFIC ISSUES REGARDING THE RECOMMENDED MEASURES

Variations of the recommended measures are outlined below. The detailed issues relating to the practical implementation of the recommendations, such as audit regimes are beyond the scope of this risk analysis. The issues will be explored in more detail as part of the review of the import health standards.

35.3.1 Methyl bromide fumigation or heat treatment

Both fumigation with methyl bromide and heat treatment will manage the risk of vehicles contaminated with viable arthropod and vertebrate life stages. However, there are clear disadvantages associated with the use of methyl bromide (see Chapter 4) and it may not be available as a routine treatment in the longer term, where a viable alternative treatment is available. There is currently no appropriate alternative fumigant available for treatment of vehicles. However research is being undertaken and the recommendations of this risk analysis should be reviewed should an alternative become available.

The fumigation and heat regimes identified in the preceding chapters for the range of hazard groups associated with the pathway are summarised in Table 2. Whilst there is uncertainty about the heat treatment regime required to achieve 100 percent kill of all life stages of some hazards, treatment at 60 °C core temperature for 10 minutes is likely to be effective against all arthropod and vertebrate hazards, but not dormant snails or the most resistant *Trogoderma granarium* lifestages. There are also issues regarding the effect of heat treatment on the larval stages of mosquitoes in water. The recommended heat treatment measure will kill some but not all fungi, bacteria, viruses, nematodes and seeds associated with vehicles.

Table 2. Summary of heat and methyl bromide fumigation regimes required to kill the range of hazards associated with vehicles. (Data are derived from the preceding chapters)

Hazard group	Heat treatment regime (°C time)	MeBr treatment regime	MeBr Concentration: Time (g.h/ m ³)	Organism and lifestage on which recommendation is based
current standard	54 °C for 10 mins	48g/ m ³ 24hrs @ 21°C+	1152 g.h/ m ³	Arthropods
		56g/ m ³ 24hrs @ 16-20.9°C	1344 g.h/ m ³	
		64g/ m ³ 24hrs @ 11-15.9°C	1536 g.h/ m ³	
		72g/ m ³ 24hrs @ 10-10.9°C	1728 g.h/ m ³	
		128g/ m ³ 4hrs @ 12.5°C	3072 g.h/ m ³	
		72g/ m ³ 12 hrs @ 21°C.	864 g.h/ m ³	
ants	55 °C for 30 mins	32g/ m ³ 24hrs	768 g.h/ m ³	<i>Solenopsis invicta</i> workers
butterflies and moths	55 °C for 5 mins	35.5g/ m ³ 2hrs @ 21°C	71 g.h/m ³	AGM diapausing eggs (heat) Codling moth eggs on fruit (MeBr)
cockroaches	46 °C for 60 mins	29g/ m ³ 8hrs @ 21°C	160 g.h/ m ³	<i>Blattella germanica</i> , (MeBr) <i>Blattella orientalis</i> , <i>Periplaneta americana</i> tolerance of eggs not known

Hazard group	Heat treatment regime (°C time)	MeBr treatment regime	MeBr Concentration: Time (g.h/ m ³)	Organism and lifestage on which recommendation is based
dermestid beetles	60 °C for 30 mins 55 °C for 15 mins	Time & rate unknown 15°C	550 g.h/ m ³ ,	<i>Trogoderma granarium</i> , all life stages (heat) other dermestids all life stages (heat) Diapausing larvae (MeBr)
fungi	60°C for 30 mins	240gms 72hrs at 18°C	17280 g.h/ m ³	most but not all (heat) in wooden blocks (MeBr)
nematode	60 °C for 60 mins	48g/ m ³ 24hrs at 20°C	1152 g.h/ m ³	golden nematode all life stages (heat) pine wood nematode in wood (MeBr)
bacteria	>70°C	Not used		depends on the organism and the medium
viruses	>70°C	Not used		depends on the organism and the medium
mosquitoes	50 °C for 5 mins	48g/ m ³ 24hrs at 20°C	1152 g.h/ m ³	<i>Culex rotoruae</i> , <i>C. pervigilans</i> , <i>Aedes notoscriptus</i> adults and larvae (heat) <i>Aedes aegypti</i> all life stages except submerged eggs (MeBr)
seeds	120°C for 15 mins	Not effective		Weed seeds
reptiles	50°C for 10 mins	40g/ m ³ 4hrs at >16°C	160 g.h/ m ³	<i>Ctenophorus nuchalis</i> assumed based on thermal death temperature of 49.3 °C (heat) Snakes in general (Mebr)
snails	60°C for 360 mins	128g/ m ³ 72hrs at 12.8°C 128g/ m ³ 24hrs at 12.5°C	9216 g.h/ m ³ 3072 g.h/ m ³	three species Mediterranean snails (heat) <i>Cohlichella</i> spp. (MeBr) <i>Achatina fulica</i> (MeBr)
spiders	60°C for 10 mins	48g/m ³ 8hrs at 26°C	384 g.h/ m ³	assumed based on critical thermal maximum for a desert species of 58.5°C (heat) <i>Latrodectus hesperus</i> (MeBr)
termites	54°C for 10 mins	No information found		Assumed based on critical thermal maximum of <i>Coptotermes formosanus</i> (heat)

The current methyl bromide fumigation rate of 48g/ m³ for 24 hours at 21°C (1152 g.h/ m³) is more than is required to kill most arthropod and vertebrate contaminants (Table 2). However, this level builds in a safety margin to take account of the many uncertainties around fumigation. This rate is equivalent to a concentration time product of 1152 gh/m³ at 21°C. This rate could be reduced to 768 gh/m³, the level required to kill most hazard groups, provided that accurate concentration monitoring is achieved. This level is insufficient to treat fungi, nematodes, seeds and snails. It is anticipated that pressure washing prior to fumigation will remove a high proportion of these contaminants, but it is recognised that the residual likelihood of entry will be higher for these hazard groups if vehicles are treated with methyl

bromide. If the alternative package of risk management measures (section 35.2) is adopted, the fumigation rate should be appropriate to the intercepted hazard.

35.3.2 Risk management measures applied offshore versus onshore

Risk management in the exporting country meets the principle of preventing close association of hazards with potential establishment sites. As part of the review of the import health standards, MAF will be looking at the policy considerations around the offshore decontamination of imported vehicles and machinery. The risk is currently managed offshore for some 55 percent of imported used vehicles.

The Biosecurity Monitoring Group survey of used vehicles found that over all there was no significant difference in slippage rates between vehicles managed offshore and those managed onshore (Wedde et al. 2006). The relative merits of applying risk management measures onshore or offshore have been considered for each hazard group in the preceding chapters. Offshore management is preferred for the majority of hazard groups.

A requirement for effective off-shore risk management is a system for preventing re-contamination prior to shipping. This is currently managed through MAF Quarantine Service officers overseeing the conditions and processes at Terminal Receiving Stations in Japan (MAF Quarantine Service, 2006), and the initiative of individual site operators. A maximum of 10 days storage between inspection and shipping is currently permitted under the current import health standards. This is intended to limit re-contamination. There is no information on the frequency with which vehicles are recontaminated between inspection/treatment and shipping. However, the risk analysis has identified that recontamination is a particular concern for hazard groups such as Lepidoptera and ants. The actual risk period will depend on the hazard group and the time of year. For instance, for Asian gypsy moth in Japan the likelihood of recontamination will be greatest during the flight season while for plant debris it will be during the autumn. The risk analysis has not found any scientific justification for a ten day period, and **it is recommended that offshore risk management should be coupled with targeted measures to prevent re-contamination rather than an arbitrary time period.**

Such measures will vary according to the exporting country and the location and nature of the vehicle storage yard within it. Site specific regimes to prevent recontamination should therefore be determined. Off-shore surveillance for some hazards such as ants or some of the moths, can be used to identify when management to prevent recontamination is required. Other factors likely to result in a greater likelihood of recontamination, which should be considered include:

- the presence of vegetation in or near the storage facility. The exact width of a buffer zone will depend on the relevant hazard type. For instance, Asian gypsy moth females can fly a few kilometres, whereas giant African snail will only move a matter of metres a night (Raut and Barker, 2002; Tomiyama, 1992);
- the type of habitat nearby. For instance saltmarsh, paddy fields, urban parks and weedy wasteland are more likely to be a source of many hazard groups than are heavily built up urban areas. Note however that hazards such as some container breeding mosquitoes will actually prefer the latter conditions, and some can cross hostile habitat;
- the presence of depressions, debris, drains and other receptacles where water can accumulate within the storage area. Artificial containers such as silt traps, tyres and tarps are attractive to container breeding mosquitoes such as *Aedes albopictus*. The presence of these conditions could increase the likelihood of contamination by hazards such as mosquitoes;

- the presence of debris or buildings within or near the storage area which could harbour hazard groups such as reptiles and spiders.

The extent to which requirements are specified is a matter for consideration as part of the import health standard review and could include onshore checking.

The current risk management regime requires a minimum of three metres to be maintained between biosecurity inspected vehicles and surroundings containing vegetation and un-cleared vehicles. This separation between cleared and un-cleared vehicles extends to storage on the ship. This risk analysis has not found any scientific justification for the three metre rule. It will not prevent cross contamination by hazard groups such as reptiles and amphibians, by flying or wind blown contaminants and the majority of insects are capable of walking three metres. Recontamination for hazards such as ants can occur from populations on the ship itself, or in the case of mosquitoes from ports en route between the exporting country and New Zealand. Furthermore there is currently no such storage requirement for new vehicles, which are also likely to be contaminated during certain storage or shipping conditions. It is recommended that offshore risk management should be coupled with targeted measures to prevent re-contamination rather than an arbitrary separation distance. Such measures could include transport only within the closed hull of vessels, and other measures discussed above.

Re-contamination after treatment is not an issue when risk management measures occur onshore, but the converse issue of contaminants escaping prior to the application of risk management measures is important. Space for inspection and treatment at ports of entry is limited (Wards, 2006). Under the current regime, vehicles are often transported under controlled conditions to off-wharf facilities for decontamination (MAF Quarantine Service, 2006). The frequency with which contaminants escape during such transfers is not known. There is also an opportunity for escape of contaminants from Transitional Facilities, most notably through the limited screening of wash water. Offshore risk management ensures that hazardous material does not arrive in New Zealand and therefore does not need to be disposed of securely. The current import health standards require inspection and treatment for live organisms to occur within 12 hours of arrival or devanning. Whilst there is no scientific basis for this period and mobile organisms could escape within this period, it will limit the opportunities for escape and **should be retained**.

The order in which risk management measures occur will vary with the location of intervention. Offshore, vacuuming and pressure wash should precede heat treatment or fumigation, whilst onshore it will be important to undertake heat treatment or fumigation as soon as possible on arrival and prior to other interventions which may activate mobile organisms.

In-transit shipboard treatments are likely to minimise the opportunities for recontamination after treatment, as well as avoiding the logistical difficulties of treating large numbers of vehicles on arrival. Various issues would need to be investigated including legal as well as technical and safety considerations. **It is recommended that these are explored.**

35.3.3 Improved facility and inspection/treatment specifications

A number of improvements to facilities and inspection processes have been identified through discussion with stakeholders in the course of the review. Those relating to inspection would apply to an audit inspection regime of decontaminated vehicles as well as to inspection as a

primary risk management measure. These are primarily issues for the IHS and implementation phases of the review to develop. Recommendations include:

- tightening the inspection facility specifications such as availability of a ramp or pit and lighting provisions. The availability of decontamination facilities at the inspection site is important for effective management of any contamination found;
- reducing the screen size requirements of on-shore waste water outfalls at approved treatment facilities. The current 2 mm screening requirement enables small contaminants such as seeds and ants to pass through the system;
- treatment of wash water from vehicles contaminated with faecal and other infectious material with chlorine, unless disposed of to the public sewer;
- application of best practice in inspection and decontamination (such as checking behind plastic inserts in wheel arches) across all sites;
- a system which enables the location and type of contaminant to be recorded and tracked;
- measures to prevent/manage recontamination of off-shore inspected/ treated vehicles. Site specific regimes or on-shore re-inspection are options (see above);
- measures to reduce the likelihood of escape of contaminants prior to treatment on-shore including timeframes and order of intervention. The efficacy of transport regimes should be investigated;
- awareness raising of decontamination staff such that any cavities in vehicles likely to contain water are reported and treated with a synthetic pyrethroid spray; and of stevedores unloading vehicles on arrival so that any adult mosquitoes are contained and reported.

35.3.4 Definition of clean

There is currently not enough information on the species assessed in this risk analysis to suggest an acceptable threshold level of entry via this pathway below which establishment is unlikely to occur. At present it is therefore considered that in order to achieve the objective of reducing the likelihood of entry and establishment of each high consequence hazard to a negligible level, entry of low frequency, high consequence hazards such as some moth species, as well as mobile hazards that are able to hide within the structure of a vehicle such as spiders and ants must be reduced as close to zero as possible. For other hazard groups such as dermestid beetles, cockroaches, plant seeds and micro-organisms associated with soil, animal and plant debris, the risk analysis has demonstrated that the likelihood of establishment is lower. Therefore whilst it is not possible to quantify an acceptable level of slippage for organisms in these groups, a higher level of slippage in entry will be acceptable. In particular, whilst there is considerable uncertainty, the risk associated with small quantities of desiccated plant material remaining on a vehicle after decontamination appears to be lower.

The risk analysis has identified some contaminants that are not of biosecurity concern. All soil, plant and animal contamination is assumed to be a hazard, except:

- sand or other material free of plant residues or other organic materials;
- any finely textured particles of dust that may be deposited on a vehicle by air currents during shipment;
- any finely textured particles free of organic material deposited on or under a vehicle from use on hard surfaced roads – commonly known as road film;
- any material, including seeds on the radiator which operates in the region of 90-100°C, unless freshly blown in;
- any material, including seeds on the exhaust, which reaches up to 400°C;
- any material, including seeds on the wheel brakes which reach in excess of 150°C;
- non visible plant material.

35.4 RECOMMENDED MEASURES FOR IMPORTED NEW VEHICLES

A wide range of hazards have been intercepted from imported new vehicles (Table 3).

Table 3. Summary of interception records and risk estimates for organisms on imported new vehicles (see relevant chapters for detail).

Note: new vehicles are not routinely inspected, so interception records do not reflect contamination rates.

Hazard group	Species in group not present in New Zealand intercepted on new vehicles	Risk estimate for imported new vehicles
Ants	<i>Anoplolepis gracilipes</i> <i>Linepithema humile</i> <i>Tapinoma minutum</i>	non negligible
Bees/wasps	<i>Eumenes pomiformes</i> <i>Odynerus quadrifasciatus</i>	non negligible
Organisms associated with soil/plant material	<i>Ectopsocopsis cryptomeriae</i> (a booklouse)	non negligible
Butterflies & moths	<i>Catocala</i> sp. <i>Idia</i> sp.	non negligible
Mosquitoes	no interceptions	non negligible except for passenger vehicles, from risk assessment
Plant seeds	no interceptions	non negligible from risk assessment
Reptiles	<i>Hemidactylus frenatus</i> <i>Lepidodactylus lugubris</i>	non negligible
Snails	no interceptions	non negligible from risk assessment
Spiders	<i>Latrodectus haseltii</i> *	non negligible

* restricted distribution in New Zealand

Imported new vehicles are considered to be of lower risk than used vehicles, but for the hazard groups listed in Table 3 the main risk factor is the conditions in which the vehicle is stored and the length of time it is stored prior to shipment rather than the number of kilometres travelled. At present it is not known which vehicles are likely to be infested by particular hazards and which are not, but there are likely to be consistent patterns with different factories, locations and manufacturers. It is likely for instance that a vehicle that is shipped directly to New Zealand within 2 weeks of manufacture, having been stored during that time on a hard surface, away from vegetation is unlikely to have significant biosecurity contamination. However, a vehicle that is stored in a variety of conditions for extended periods of time or has been tested in open environment conditions is much more likely to be contaminated.

Given the risk estimates in Table 3 and the significant volume of new vehicles imported into New Zealand (112 000 in 2005 (New Zealand Customs, 2005)), risk management measures are recommended. Since the risk from new vehicles is considered to be lower than from used vehicles, the package of measures recommended for used vehicles is not justified for new vehicles.

An approach based around identifying which vehicles are most likely to be infested and then either decontaminating and/or treating those, or requiring system improvements that would reduce the likelihood of infestation, is a feasible way to substantially lower the risk. Such an approach would incorporate surveillance for key hazard groups, appropriate storage conditions and times, and audit. Since it is uncertain whether this approach would achieve the risk management objective, it would be necessary to review the system after a period.

Since the degree of contamination of new vehicles is not well known, it is recommended that a slippage survey is undertaken. Since most hitchhiker species occur at comparatively low frequencies, large sample sizes will be required to give meaningful results.

35.5 RECOMMENDED MEASURES FOR NEW AND USED MACHINERY, TRUCKS AND OTHER VEHICLES CAPABLE OF HOLDING WATER

The risk associated with some hazard groups, notably: micro-organisms in soil; animal and plant debris; the beetle, *Trogoderma granarium*; and mosquitoes, is higher in association with used machinery, as well as trucks, and other open backed vehicles, than in associated with passenger vehicles. Inspection and decontamination of machinery is more specialised. The package of measures recommended for used vehicles is not appropriate for machinery.

There is a paucity of information for this part of the pathway. Gaps include:

- contamination rates of **new** machinery. There are no data, but there are anecdotal reports of field-tested machinery being imported as new (Wards, 2006);
- contamination rates for different types of machinery. For instance, it might be expected that forestry log harvesting machines will be more likely to be contaminated with forest pathogens than specialised mining machinery;
- slippage rates for the current risk management regime.

A videoscope survey of used machinery planned for 2006-2007 will provide additional information. These recommendations should be reviewed once the results of the survey are available. In the meantime the following **interim** package of enhanced risk management measures is recommended:

1. Inspection by MAF Quarantine Service officers, trained in the inspection of complex machinery with follow up decontamination and/or treatment as necessary. Offshore inspection should be encouraged given the higher risk from some hazard groups. Shipboard inspections of machines that have not been inspected offshore should ensure that no grossly contaminated machinery is permitted to disembark; **and**
2. Cleaning or replacement of all used air filters; **and**
3. Removal and destruction **or** heat treatment at 121°C for 15 minutes or 70°C for four hours of wire ropes on used agricultural and forestry equipment; **and**
4. Provision of targeted information to importers of machinery. This is likely to increase the level of protection by focussing on the highest risk vehicles; **and**
5. Heat treatment at a core temperature of at least 60°C for 30 minutes or fumigation with methyl bromide at 48g/ m³ for 24 hours at 20 °C of all imported used trucks and machinery which have been used for transporting grain whether or not there is any

evidence of contamination. This is required because of the increased likelihood of infestation of these vehicles with the beetle, *Trogoderma granarium*. Note that the heat treatment regime is more stringent than for other classes of vehicle because of the greater tolerance of diapausing *T. granarium* larvae; **and**

6. Disinfection of all vehicles likely to be contaminated with faecal material including garbage lorries, sewerage trucks and vehicles used for transporting livestock, agricultural products and food stuffs. Note this requires a means of identifying these vehicles; **and**
7. Improved facility and inspection specification (see 35.2.3): **and**
8. Offshore, all water-filled cavities must be drained **and** all potential larval mosquito habitats must have the surfaces thoroughly sprayed with a synthetic pyrethroid formulation resistant to sunlight degradation for no less than 8 weeks; **or**

Onshore, visual inspection for adult mosquitoes immediately on arrival. Any found must be killed immediately with a 2 percent permethrin spray. If the specimen is found inside a vehicle, the interior of the vehicle must be treated with a 2 percent permethrin spray and sealed for an hour; **and** within 12 hours of the ship berthing in New Zealand all water-filled cavities:

- a. filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
- b. must be treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **and**
must be drained; **and**
have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

and

Within 12 hours of the ship berthing in New Zealand all cavities capable of impounding water, whether or not they contain evidence of having held water, but which are dry:

- c. must be filled to the point of overflow and treated with a 10 percent sodium hypochlorite and 4 percent detergent solution for 30 minutes; **or**
- d. have the surfaces thoroughly sprayed with a residual synthetic pyrethroid formulation.

The definition of machinery should include trucks and other similar vehicles which are more likely to be contaminated with soil, plant debris and water and are therefore more similar in risk to agricultural and forestry equipment. In the calendar year to December 2004, 7 341 used trucks and vans more than 3500 Kg and 4 620 trucks and vans less than 3500 Kg were imported (New Zealand Customs, 2004) compared to some 4 000 items of machinery (from MAF's Quancargo database).

Note that 'Potential larval mosquito habitats' are defined as any receptacles capable of harbouring water, irrespective of whether or not they are water-filled at the time of inspection. These may vary from small containers such as jars and cans, to concrete mixers and excavating buckets.

The recommendations in section 35.2 also apply to imported machinery.

In addition, it is recommended that the revised import health standard specifically covers boats, arriving as cargo on a vessel rather than under their own power, since they are not currently covered by any import health standard, but are managed in practice through the used equipment standard. This risk analysis has found that they are likely to be a significant entry pathway for exotic frogs and mosquitoes. MAF Quarantine Service Quancargo database indicates that 1 135 boats were imported during the period 01/01/2004 to 30/09/2005. This is intended as an interim measure whilst a risk analysis of hull fouling on vessels and a review of freshwater biosecurity risks are undertaken.

One of the difficulties in managing the risk associated with machinery is the very wide range of types of equipment involved. The volume imported of many types of specialised machinery is small, so it is unlikely that the videoscope survey will be able to determine whether more stringent measures are required for particular types.

35.6 MONITORING AND REVIEW

It will be necessary to monitor the implementation of the recommended risk management measures as applied through a revised import health standard, to ensure that they are achieving the results intended. In addition, it is recommended that the most critical uncertainties identified in the risk analysis are subject to further research.

35.6.1 Monitoring

Slippage surveys should be undertaken using a videoscope as well as visual inspection to compare the level of slippage with the current risk management regime and to ensure that the risk management objective for the key hazard groups is being met. The high consequence hazards considered in this analysis, in common with most hitchhiker species occur at comparatively low frequencies. This means that surveys for these species require large sample sizes in order to give meaningful results. Survey design and analysis needs to consider the problem of low frequency, high consequence pests on high volume pathways alongside resource constraints.

Even large scale surveys will not provide all the information necessary for robust review and continuous improvement of the risk management regime. Implementation of a more effective contaminant identification and treatment recording regime for the pathway will also be necessary. This should include frequency, location, identity and viability of contaminants and treatment details. This information will be particularly helpful in refining risk management by addressing areas of current uncertainty including:

- determining which types of vehicles and machinery are most likely to be contaminated by which types of organisms;
- determining whether there are seasonal patterns;
- determining whether there are specific supply chains more commonly associated with species of concern;
- determining whether particular risk management measures are effective against a range of organisms.

If such information were available, measures may be able to be targeted in a way that would reduce the likelihood of entry and establishment, but be less restrictive than blanket measures. The information needs to be available to those monitoring the pathway, reviewing standards, writing risk analyses, conducting surveillance and managing incursions. Live interceptions are the priority for identification, but identification of dead organisms provides valuable information on likelihood of surviving shipment and any pre-shipment treatment.

In addition routine audits will be necessary to ensure that the requirements of the standard are being met on a routine basis.

35.6.2 Uncertainties requiring research or investigation

The risk analysis has identified numerous uncertainties. The highest priorities for research are summarised here:

- 1) Survey of new vehicles to validate some of the assumptions in this risk analysis (see 35.3).
- 2) Trials using live arthropods in the range of hazard groups to determine whether the proposed heat treatment regime can be further refined;
- 3) Further research on the efficacy of alternative treatments and particularly fumigation regimes to expand the range of options for managing this pathway. The efficacy of existing methyl bromide fumigation regimes should also be investigated to determine whether it can be further refined;
- 4) Investigation of the efficacy of transportation between port of entry and treatment facility in New Zealand in preventing escape of contaminants and of measures at the treatment facilities themselves in preventing escape of contamination prior to treatment;
- 5) Trials of the use of detector dogs on the wharf, to determine whether they could be used to inspect vehicles for Asian gypsy moths on vehicles exported from high-risk countries during the flight season;
- 6) Trials on the efficacy of the use of residual insecticides in preventing recontamination;
- 7) Research to better understand the likelihood of establishment of micro-organisms associated with soil and particularly dry plant material in order to better define the acceptable tolerance for these contaminants;
- 8) A study on the identity and viability of seeds in different locations within imported vehicles and machinery, particularly air filters and air conditioning filters;
- 9) Research to address the major uncertainties regarding high risk moths including:
 - average and maximum distances that larvae of painted apple moth and fall webworm crawl seeking pupation sites (also expected to be useful information for a number of other Lepidoptera species);
 - factors that influence pupation site selection for Lepidoptera and for painted apple moth and fall webworm in particular;
 - effect of unusual temperature regimes on Asian gypsy moth hatching (also for other diapausing species, but particularly important for univoltine species).

35.7 OTHER RECOMMENDATIONS

- 1) The exemption of vehicles imported as personal effects from the requirement for risk management measures to be undertaken at the port of entry or transitional facilities should be reviewed. There is no evidence that the risk associated with such vehicles is any less than that associated with any other imported vehicle;
- 2) The import health standard for vehicle parts should be reviewed to provide a consistent approach to the management of potential mosquito larval habitats;
- 3) Continued targeted surveillance for high consequence species, particularly moths, ants and mosquitoes at high-risk sites within New Zealand, as a back-up measure in recognition that zero risk is not achievable;
- 4) Provision of biosecurity awareness information in appropriate languages to offshore exporters, shipping companies, port companies and importers to explain New Zealand's biosecurity requirements for vehicles and machinery. This awareness information would need to focus on the benefits of complying with the requirements as well as the costs of non-compliance. The cost of preparing the material could be reduced if it is targeted at the countries with the highest volume of exports i.e. Japan, Singapore, USA, Australia and the UK. The highest priority is to target the used machinery industry;
- 5) Provision of biosecurity awareness information for the purchasers of imported vehicles, both new and used. This could draw attention to the most serious hazards and provide information on what to do if they're discovered;
- 6) Encourage industry surveillance for the beetle, *Trogoderma granarium* around high-risk areas on-shore such as grain stores;

35.8 MAJOR ASSUMPTIONS AND UNCERTAINTIES

This risk analysis is based on currently available information. The uncertainties and consequent assumptions have been identified throughout the risk analysis. The major uncertainties and assumptions are summarised here.

1. The risk analysis is based on the number of vehicles imported during 2005. The numbers of imported vehicles have declined over recent months, although it remains a high volume pathway with 114,000 vehicles (new and old) imported in the six months to June 2006 (New Zealand Customs Service, 2006). The decline is not likely to result in a sufficiently large reduction in the biosecurity risk associated with the pathway to warrant a change in recommendations, but this conclusion may need to be revisited if the volume of imports declines significantly;
2. These recommendations are based on detailed risk assessment using example species of hazard groups that occur in the current main vehicle exporting countries and particularly Japan, Australia and the USA. They may need to be re-examined should the main exporting countries change;

3. The estimates of risk are based on the assumption that no risk management measures are in place;
4. There are significant limitations in the interception data available. In particular, the available interception data cannot be taken to indicate contamination rates. The clearest illustration of this are provided by fall webworm and painted apple moth. Based on post-border records, it is possible to determine that fall webworm has entered New Zealand (i.e. crossed the border without being detected by any biosecurity measures) on a minimum of five or six separate occasions, but has only once been detected at the border, and this was not known at the time. Painted apple moth has entered New Zealand a minimum of eight times and has been detected, identified and recorded at the border once. In the absence of detailed information the number of exported vehicles from a country is assumed to be one of the major factors in determining likelihood of entry;
5. There is limited species-level information available, particularly for some hazard groups such as micro-organisms. Risk management measures are based on example species and it is assumed that the biosecurity risks posed by all other organisms in the same group of potential hazards and other similar groups, can be managed by the measures recommended for the example species/genera. It reduces the scope of the analysis to a more manageable level as well as enabling the risks posed by unknown potential hazards to be accommodated;
6. Little is known about many hitchhiker organisms (e.g. white-spotted tussock moth which was not known as a pest from any other country prior to its incursion in New Zealand) and it is not always possible to predict which species will be considered a problem should they become established and which will be innocuous. The approach of using example species many of which are known to be of high consequence to assess the risk of hazard groups should mean that the analysis is robust should additional contaminants be found to be of high consequence;
7. Limited data are available on the levels and types of contamination of new vehicles. Since storage conditions are an important risk factor for many hazard groups, it is concluded that a systems approach to managing the supply chain will enable the biosecurity risk associated with imported new vehicles to be managed;
8. There is no information on the frequency of re-contamination of vehicles inspected/treated offshore, nor of the frequency with which contaminants escape between arrival in New Zealand and inspection/treatment onshore. It is assumed that offshore recontamination can be managed through a package of site specific measures and it is assumed given the range of mobile hazards on the pathway and the fact that it is not logistically possible to decontaminate all imported vehicles on the wharf on arrival. Offshore risk management is therefore preferable to onshore management;
9. The efficacy of different risk management regimes for the full range of hazards and life stages is not known. Whilst priorities for research are identified above, it will never be possible to obtain adequate data for all hazards. Recommendations on risk management measures are based on the assumption that a regime that is likely to be effective against the more tolerant organisms in a hazard group will also be effective against all other hazards of a similar type. In the absence of evidence that this is

flawed, it is considered reasonable to gather further efficacy data as part of operations, rather than delay implementation until efficacy had been proven;

10. Heat treatment as a risk management measure for vehicles has not been used extensively at an operational scale. These recommendations are based on the assumption that it is safe and practical.

At least nine of the hazard groups assessed in this risk analysis contain high consequence pests. Table 4 summarises some of the estimated costs associated with the establishment of a few of these species. Whilst it is not possible to determine with certainty which pathways were the cause of these particular incursions, the draft moth pest risk analysis (Biosecurity New Zealand, 2007) and the release assessment for red imported fire ant (MAF Biosecurity Authority, 2002) have identified imported vehicles and machinery as significant pathways for these species.

Table 4. Summary of estimated costs of incursions of some exotic organisms into New Zealand.

Organism	Main suspected pathways	Response cost to date (excluding staff time)	Estimated costs of establishment *
Fall Webworm	containers; vehicles	5.0 million	present value costs (2003) ranging from \$29 million to \$127 million,
Asian gypsy moth	used vehicles; sea containers	6.8 million	present value costs (2003) ranging from \$62 million to \$ 393 million
Painted apple moth	containers, container packaging; container contents	60 million	present value costs (2001/02) ranging from \$58 million to \$356 million over a 20 year period .
Red imported fire ant	containers; vehicles/equipment commodities stored on the ground	1.1 million (excluding current incursion)	full annual costs of living with the red imported fire ant would be at least NZ \$318 million. The present value of the total impacts over a 23-year period of range expansion and consolidation from initial establishment is indicated to be at least \$665 million.

* costs exclude health, environment, social amenity values.

35.9 REFERENCES

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36 Glossary

Biosecurity: The exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health (Biosecurity Strategy 2003)

Biosecurity clearance: A clearance under section 26 of the Biosecurity Act 1993.

Break-bulk: Imported in bulk within a specialised roll-on, roll-off vehicle carrier vessel (carship).

CarShips: MAF Quarantine Service software application that records and reports quarantine inspection and clearance information relating to vehicles shipped as break-bulk cargo.

Commodity: A good being moved for trade or other purposes. Packaging, containers, and craft used to facilitate transport of commodities are excluded unless they are the intended good.

Compliance checking centre: Facilities where vehicles are checked to make sure that they comply with New Zealand vehicle construction and equipment regulations.

Consequences: The adverse effects or harm as a result of entry and establishment of a hazard, which cause the quality of human health or the environment to be impaired in the short or longer term.

Contamination: Animals, invertebrates or other organisms (alive or dead, in any life cycle stage, including egg casings or rafts), or any organic material of animal origin (including blood, bones, hair, flesh, secretions, excretions); viable or inviable plants or plant products (including fruit, seeds, leaves, twigs, roots, bark); or other organic material, including fungi, food products and soil;

Entry: Movement of an organism or disease into a risk analysis area.

Environment: (Biosecurity Act 1993): Includes ecosystems and their constituent parts, including:

- people and their communities; and
- all natural and physical resources; and
- amenity values; and
- the aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to this definition.

Establishment: Perpetuation, for the foreseeable future, of a pest within an area after entry.

Exotic: Not native to a particular country, ecosystem or ecoarea.

Exposure: The condition of being vulnerable to adverse effects.

Gross contamination: Where the degree of contamination is to the extent that it poses (in the mind of the inspector) an unacceptable biosecurity risk if brought ashore in New Zealand.

Hazard: Any disease or organism that has the potential to produce adverse consequences.

High consequence hazard is considered likely to cause an unwanted impact to people, the New Zealand environment or the New Zealand economy of sufficient magnitude that should it become established in New Zealand either eradication would be attempted or other active response options would be implemented.

Hitchhiker pest: an organism that is carried by or with a commodity which is not a pest of that commodity and is not dependent on it for survival.

Import health standard: A document issued under section 22 of the Biosecurity Act 1993 by the Director General of MAF, specifying the requirements to be met for the effective management of risks associated with the importation of risk goods before those goods may be imported, moved from a biosecurity control area or a transitional facility, or given a biosecurity clearance.

Incursion: an exotic organism found beyond the New Zealand border that has not previously been reported present in New Zealand.

Inspector: A person who is appointed as an inspector under section 103 of the Biosecurity Act 1993.

LTNZ: Land Transport New Zealand, the crown entity with responsibility for land transport funding and promoting land transport safety and sustainability.

MAF: New Zealand Ministry of Agriculture and Forestry.

Measure: A measure may include all relevant laws, decrees, regulations, requirements and procedures including, inter alia, end product criteria; processes and production methods; testing, inspection, certification and approval procedures; quarantine treatments including relevant requirements associated with the transport of risk goods, or with the materials necessary for their survival during transport; provisions on relevant statistical methods, sampling procedures and methods of risk assessment; and packaging and labelling requirements directly related to biosecurity.

National Plant Protection Organisation: Official service established by a government to discharge functions specified by the IPPC.

Naturalised: Established in New Zealand but originally coming from another country.

Negligible: So small or insignificant as not to be worth considering.

Organism: (Biosecurity Act 1993)

- (a) Does not include a human being or a genetic structure derived from a human being;
- (b) Includes a micro-organism;
- (c) Subject to paragraph (a) of this definition, includes a genetic structure that is capable of replicating itself (whether that structure comprises all or only part of an entity, and whether it comprises all or only part of the total genetic structure of an entity);
- (d) Includes an entity (other than a human being) declared by the Governor-General by Order in Council to be an organism for the purposes of this Act:

- (e) Includes a reproductive cell or developmental stage of an organism:
- (f) Includes any particle that is a prion.

Pathway: Any means that allows the entry or spread of a potential hazard.

Pest: Any species, strain or biotype of plant, animal or pathogenic agent, injurious to plants or animals (or their products), human health or the environment.

Note: the definition given for “pest” here is different from that used in the Biosecurity Act 1993 “an organism specified as a pest in a pest management strategy”. The Biosecurity Act 1993 deals more with “risks” than “risk goods”.

Post-border interception: An organism found in association with recently imported items or goods after they have been given biosecurity clearance at the border.

Pre-shipment inspected: Passed an offshore MAFQS sampling, inspection and decision making process equivalent to that undertaken in New Zealand.

Quancargo: Cargo module of a MAF national database of imported risk goods, their documentation and status and any inspection information.

Quarantine Pest: A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.

Regulated Pest: A quarantine pest or a regulated non-quarantine pest (ISPM No5). Organisms for which phytosanitary actions would be undertaken if they were intercepted/detected.

Risk: The likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.

Risk analysis: The process composed of hazard identification, risk assessment, risk management and risk communication.

Risk Analysis Area: The area in relation to which a risk analysis is conducted

Risk assessment: The evaluation of the likelihood and the biological and economic consequences of entry, establishment, or spread of an organism or disease.

Risk Good: (Biosecurity Act 1993) Any organism, organic material, or other thing, or substance, that (by reason of its nature, origin, or other relevant factors) it is reasonable to suspect constitutes, harbours, or contains an organism that may:

- (a) Cause unwanted harm to natural and physical resources or human health in New Zealand; or
- (b) Interfere with the diagnosis, management, or treatment, in New Zealand, of pests or unwanted organisms.

Risk Management: The process of identifying, selecting and implementing measures that can be applied to reduce the level of risk.

Slippage: Entry of risk goods into New Zealand without biosecurity clearance, or entry of goods with biosecurity contamination into New Zealand after biosecurity clearance has been given.

Spread: Expansion of the geographic distribution of a pest within an area.

Terminal Receiving Station: A specified area for holding vehicles for inspection in Japan prior to loading onto a vessel for shipment to New Zealand, covered by MAF Quarantine Service surveillance.

Transitional Facility: Any place approved as a transitional facility in accordance with section 39 of the Biosecurity Act 1993, for the purpose of inspection, storage, treatment, quarantine, holding or destruction of specified types of un-cleared goods; or part of a port declared to be a transitional facility in accordance with section 39.

Unwanted organism: Any organism that a chief technical officer believes is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health (Section 2(1) of the Biosecurity Act, 1993).

Videoscope: A micro-camera at the tip of a flexible shaft that is used for the detailed examination of semi-enclosed areas.