Pasture Pests Hazard Identification






A report prepared by Sandy Toy for the Ministry for Primary Industries and pastoral sector partners Beef + Lamb New Zealand, DairyNZ, Deer Industry New Zealand and Dairy Companies Association of New Zealand

December 2013

Contributors to this Hazard Identification
The primary author, Sandy Toy, completed all sections and subsections of this report **except** for the subsection entitled *"Possible methods of post-border management and surveillance"* within each pest hazard assessment. Sandy Toy completed the work in October 2012, under contract to MPI. The subsection entitled *"Possible methods of post-border management and surveillance"* was completed by secondary authors, Sarah Clark and Kim Crook of MPI.

Primary Author's Acknowledgements
This report has benefited from advice, information and feedback from Sarah Clark, Ministry for Primary Industries and representatives of Beef + Lamb New Zealand, DairyNZ, Deer Industry New Zealand and Dairy Companies Association of New Zealand.

Primary Author's Disclaimer
The information in this report and any accompanying documentation is accurate to the best of knowledge and belief of Sandy Toy. While she has exercised reasonable skill and care in the preparation of this report, Sandy Toy does not accept any responsibility or liability for error of fact, omission, interpretation or opinion that may be present nor any loss, damage, injury or expense, whether direct, indirect or consequential, arising out of the provision of information in this report.

Additional Disclaimer
This report is a technical report and does not represent the position of The Ministry for Primary Industries, Beef + Lamb New Zealand, DairyNZ, Dairy Companies Association of New Zealand or Deer Industry New Zealand. Every reasonable effort has been made to ensure the information in this report is accurate. The Ministry for Primary Industries, Beef + Lamb New Zealand, DairyNZ, Dairy Companies Association of NZ and Deer Industry New Zealand, and their personnel, do not accept any responsibility or liability for any damages caused to third parties by error of fact, omission, interpretation or opinion that may be present in the report, however the error may have occurred.

Publisher's information
This report is published by the Ministry for Primary Industries, Beef + Lamb New Zealand, Dairy NZ, Dairy Companies Association of New Zealand and Deer Industry New Zealand.

Ministry for Primary Industries PO Box 2526 Wellington 6140 New Zealand	Beef + Lamb New Zealand Ltd PO Box 121 Wellington 6140 New Zealand	DairyNZ Corner Ruakura & Morrinsville Roads Private Bag 3221 Hamilton 3240 New Zealand	Dairy Companies Association of New Zealand PO Box 10002 Wellington 6143 New Zealand	Deer Industry New Zealand PO Box 10702 Wellington 6011 New Zealand
Tel: 0800 00 83 33 info @mpi.govt.nz	enquiries@beeflambnz.com	Tel: +64 7 858 3750 info@dairynz.co.nz	Tel: 04 471 6901 info@dcanz.com	Tel: 04 473 4500 info@deernz.org

Approved by MPI for general release in September 2013

Christine Reed, Manager
Biosecurity Risk Analysis Group
Ministry for Primary Industries

Dr Christopher Houston
Senior Advisor – Technical Policy
Beef + Lamb New Zealand

Elizabeth Kamber
Policy Manager
Dairy NZ

Catharine Sayer
Science and Policy Manager
Deer Industry New Zealand

Lindsay Burton
Technical Advisor
Dairy Companies Association of New Zealand

ISBN: 978-0-478-42306-8 (online)
December 2013

Table of Contents

1 Executive Summary

Purpose and Context: The purpose of this report is to present the findings of a biosecurity hazard identification process undertaken for MPI and the New Zealand pastoral sector, one of New Zealand's largest export earners.

There is currently a lack of understanding of which exotic pests are a threat to New Zealand pasture species, what the likely impact of their establishment in New Zealand would be, and what the potential pathways of introduction are. An understanding of these matters is required to provide MPI and industry organisations with information about the biosecurity risks to the pastoral sector in New Zealand. As a starting point in addressing this knowledge gap, some of the biosecurity hazards for priority pasture species and their potential pathways of entry into New Zealand have been identified and presented in this report.

Methods and Results: A list of 151 pests (excluding plant weed species) associated with priority pasture species, but not thought to be present in New Zealand, was identified from major databases. This list is not complete, but contains the most significant pests for which information is readily available. The budget allowed for sixty four of these species to be assessed in more detail. The assessments determined whether the pests are a biosecurity hazard for the New Zealand pastoral sector according to their:

- Potential to establish in New Zealand
- Nature and severity of potential impacts in New Zealand
- Potential pathways of entry into New Zealand

Of these, eleven species were determined **not** to be hazards after all. The remaining fifty three species were grouped into high and low hazard groups. Twenty four species were allocated to the high hazard group. **Table 1** summarises the hazard assessments for these species. Most of the identified hazards are insect pests of clovers and lucerne. The prevalence of these host species may reflect their greater global economic significance in comparison with pasture species such as ribwort plantain and consequently a higher level of research and published literature on their pest associations.

Conclusions: This assessment is a starting point to understanding the biosecurity risk facing the New Zealand pastoral sector. A number of pests of the pasture species that underpin New Zealands' pastoral sector have been identified which are not yet present in New Zealand, but have the potential to establish here and cause harm to the sector. Most of these hazards are invertebrates. They have potential to enter New Zealand on several pathways, but until a risk analysis has been completed it is not possible to determine the relative significance of each pathway. The report is a starting point to help inform decisions about managing the biosecurity risks to the pastoral sector.

Limitations and how this information can be used: This hazard assessment does not constitute a risk assessment. Hazards and risks are distinctly different concepts – the terms are not interchangeable, and the information from a hazard and risk assessment can not be used in the same way.

- A hazard is strictly the **potential** to cause harm, but it does not consider the likelihood of that harm occurring.
- A risk, on the otherhand, does take account of the likelihood of the harm occurring: it is the product of the **likelihood** of harm, and the **severity** of the harm.

To put this into some context, the risk status of the hazard pests identified in this report can only be determined if an assessment is done of the likelihood of the pests entering New Zealand, and the mechanisms by which the pests could be exposed to a suitable host plant in New Zealand (amongst other factors). The species identified in Table 1 may in fact be low risk, for instance, due to a low likelihood of entry (perhaps they do not not occur in the

countries that we import goods from), or due to a lack of mechanisms of exposure to vulnerable hosts in New Zealand.

The hazards identified in this report cannot be considered to represent the full range of hazards to the priority pasture species. As the identification of hazards is incomplete, the hazards identified may not pose the highest biosecurity risk to the sector. In particular, emerging pests that are not currently well known are unlikely to have been identified. Nonetheless, the hazards that have been identified provide an indication of the type of pests that are of concern and their potential pathways for entry. The assessments were based on readily available information in major databases. In many cases original sources were not accessed and consequently the assessments may be based on inaccurate or incomplete information.

Table 1: Summary hazard assessment for high hazard pests of New Zealand priority pasture species

Hazard	Type	Priority pasture plants affected	Potential entry pathways	Establishment potential	Impact potential
Agriotes sputator (Common click beetle) Page 31	Beetle	Timothy (*Phleum pratense*) Ribwort plantain (*Plantago lanceolata*) Ryegrass (*Lolium perenne*) Red clover (*Trifolium pratense*)	Fresh produce Used agricultural machinery	High	High
Gonioctena fornicata (Lucerne beetle) Page 33	Beetle	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) Red clover (*Trifolium pratense*)	Hitchhiker: inanimate objects Passengers	Moderate	Moderate
Hypera postica (Lucerne weevil) Page 39	Beetle	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) Red clover (*Trifolium pratense*) Ribwort plantain (*Plantago lanceolata*)	Hitchhiker: timber Fresh produce Passengers	High	High
Hypera zoilus (Clover leaf weevil) Page 42	Beetle	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) Red clover (*Trifolium pratense*) Timothy (*Phleum pratense*)	Used agricultural machinery Passengers	High	Moderate
Limonius californicus (Sugarbeet wireworm) Page 44	Beetle	Lucerne (*Medicago sativa*) Red clover (*Trifolium pratense*)	Fresh produce Used agricultural machinery	Moderate	Moderate
Oulema melanopus (Oat leaf beetle) Page 48	Beetle	Tall fescue (*Festuca arundinacea*) Timothy (*Phleum pratense*)	Hitchhiker: timber Seed for sowing Passengers	High	Moderate
Sitona cylindricollis (Sweetclover weevil) Page 51	Beetle	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*)	Used agricultural machinery Passengers	High	Moderate
Sitona hispidulus (Clover weevil) Page 53	Beetle	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) Red clover (*Trifolium pratense*)	Hitchhiker: used agricultural machinery Passengers	High	High

Hazard	**Type**	**Priority pasture plants affected**	**Potential entry pathways**	**Establishment potential**	**Impact potential**
Sphenophorus venatus confluens (Billbug) Page 55	Beetle	Cocksfoot (*Dactylis glomerata*)	Hitchhiker: used agricultural machinery Passengers	High	Moderate
Oscinella frit (Frit fly) Page 73	Fly	Rye grass (*Lolium multiflorum*) Timothy (*Phleum pratense*) Cocksfoot (*Dactylis glomerata*) Bent grasses *(Agrostis spp.)*	Seed for sowing Grain Passengers	High	Moderate
Tipula paludosa (European Cranefly) Page 76	Fly	Lucerne (*Medicago sativa*) Ryegrass *(Lolium perenne*) White clover (*Trifolium repens*)	Used agricultural machinery	High	High
Dichroplus elongatus Page 78	Grasshopper	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.*) *Grass species* Ribwort plantain (*Plantago lanceolata*)	Used agricultural machinery Hitchhiker	High	Moderate
Melanoplus bivittatus (Two striped grasshopper) Page 80	Grasshopper	Lucerne (*Medicago sativa*) Red clover (*Trifolium pratense*) Chicory (*Cichorium intybus*)	Used agricultural machinery Hitchhiker pathways including passengers	High	High
Agrotis segetum (Turnip moth) Page 83	Moth	Lucerne *(Medicago sativa),* Clovers (*Trifolium* spp.)	Fresh produce Used agricultural machinery Passengers Cut flowers Nursery stock	High	Moderate
Autographa gamma (Silver Y moth) Page 86	Moth	Lucerne (*Medicago sativa*) Red clover (*Trifolium pratense*) Chicory (*Cichorium intybus*)	Fresh produce Cut flowers Passengers	Moderate	High

Hazard	Type	Priority pasture plants affected	Potential entry pathways	Establishment potential	Impact potential
Chrysoteuchia culmella (Garden grass-veneer) Page 88	Moth	Cocksfoot (*Dactylis glomerata)* Timothy (*Phleum pratense*) Fescues (*Festuca spp.)*	Used agricultural machinery Passengers	High	Moderate
Chrysoteuchia topiaria (Cranberry Girdler) Page 90	Moth	Fescues (*Festuca spp.*) Bent grasses *(Agrostis spp.)*	Used agricultural machinery Passengers Fresh produce	High	Moderate
Helicoverpa punctigera (Native budworm) Page 95	Moth	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) *Red clover* (*Trifolium pratense*) Subterranean clover (*Trifolium subterraneum*)	Cut flowers Nursery stock Fresh produce Passengers Hitchhiker pathways	High	Moderate
Papaipema nebris (Common stalk borer) Page 100	Moth	Cocksfoot (*Dactylis glomerata)* Tall fescue (*Festuca arundinaceae*) Lucerne (*Medicago sativa*)	Cut flowers Nursery stock Fresh produce Passengers Used agricultural machinery	High	Moderate
Adelphocoris lineolatus (Lucerne bug) Page 107	Plant bug	Lucerne (*Medicago sativa*) White clover (*Trifolium repens*) Red clover (*Trifolium pratense*)	Fresh produce nursery stock seed for sowing Passengers	High	High
Empoasca fabae (Potato leaf hopper) Page 110	Plant bug	Lucerne (*Medicago sativa*) Clover *(Trifolium spp.)*	Fresh produce Passengers	Moderate	High
Lygus lineolaris (Tarnished plant bug) Page 113	Plant bug	Lucerne (*Medicago sativa*)	Fresh produce Cut flowers Passengers	High	Moderate

Hazard	Type	Priority pasture plants affected	Potential entry pathways	Establishment potential	Impact potential
Drechslera catenaria (Leaf spot of grasses) Page 129	Fungus	Common bent (*Agrostis tenuis*) Cocksfoot (*Dactylis glomerata*) Timothy (*Phleum pratense*) Fescues (*Festuca spp.*) Ryegrasses (*Lolium spp.*)	Seed for sowing Grain Passengers	High	Moderate
Meloidogyne chitwoodi (Colombian root-knot nematode) Page 147	Nematode	Lucerne (*Medicago sativa*) Grasses	Fresh produce Used agricultural machinery Passengers	High	Moderate

2 Introduction

2.1 Background and context

The Ministry for Primary Industries (MPI) and three representative organisations of the pastoral sector (Beef + Lamb New Zealand, DairyNZ, and Deer Industry New Zealand) have agreed to work in partnership to identify potential pests of New Zealand pasture species.

The pastoral sector is one of New Zealand's largest export earners. In the year ended June 2011 the total value of pastoral sector exports was $m FOB[1] 19, 346, comprising 47.3% of total New Zealand merchandising exports (Beef & Lamb NZ 2012). None of the species used for sown pastures in New Zealand are native to the country. Most were indigenous to Eurasia and North Africa and were common in the European countries from where the early settlers migrated to New Zealand (Corkill et al. 1981). Many pests and diseases entered with these pasture species and have become established in New Zealand. However, these introduced pasture species underpin the pastoral sector and new pests or diseases could have serious consequences for the sector and the wider economy.

There is currently a lack of understanding of which exotic pests are a threat to New Zealand pasture species, what the likely impact of their establishment in New Zealand would be, and what the potential pathways of introduction are. An understanding of these matters is required to provide MPI and industry organisations with information about the biosecurity risks to the pastoral sector in New Zealand.

As a starting point in addressing this gap in knowledge and understanding, MPI and the pastoral sector agreed that a list of some of the biosecurity hazards for priority pasture species and their potential pathways of entry into New Zealand should be identified. The findings can be used to inform further discussions between MPI and industry on managing risks across the biosecurity system (including pre-border, border and post border activities).

The primary objective of this report is to undertake a high-level[2] hazard identification of some of the potential pests of New Zealand pasture species that may require additional management across the biosecurity system, either pre-border, border or post border.
Specific goals are to:

- Identify some of the obvious pests of the priority pasture species, and determine whether they are a hazard to New Zealand;
- Identify the potential pathways of entry for obvious pests;
- From the partial list of species identified as hazards, if possible, identify the groups of pests which represent the greatest hazard[3] and of which MPI and/or pastoral sector stakeholders could consider undertaking a detailed risk analysis.

2.2 Scope

This document comprises a high-level[2] biosecurity hazard identification process for the New Zealand pastoral sector. It does not provide a complete list of hazards, nor is it a detailed

[1] FOB = Free on Board

[2] "High-level" in this context refers to the reliance on summarised/collated data in major databases, i.e. secondary sources of data, as compared to primary sources of the data. It reflects the fact that a detailed analysis of the evidence in primary data sources was not undertaken.

biosecurity risk analysis. The budget and timeframe do not allow for an exhaustive identification and analysis of all potential pest organisms of New Zealand pasture species.

The scope of the assessment is limited to identification of some obvious hazards associated with the priority pasture species identified by the pastoral sector.

Weeds have the potential for significant adverse impacts on the New Zealand pastoral sector. However, information on the biology and distribution of weeds would need to be sourced separately from other pests of pasture species. The identification of weed hazards is complicated by the fact that there are hundreds of invasive or potentially invasive plants already in New Zealand but currently limited in their distribution. Weeds are therefore excluded from this assessment. Nonetheless, weeds have the potential to adversely impact the sector and some possible pathways of entry and further assessment warranted in this regard are noted in section 4.

The potential pathway(s) of entry is identified for each pest assessed and the main pathways are summarised in section 4.

This hazard identification for pasture pests also identifies for each assessed hazard, possible methods of post-border management and surveillance which are reported to have been used with some success in other countries. This may assist the Environmental Protection Authority (EPA) review of the availability of carbamate and organophosphate insecticides in New Zealand. Note these sections of the report were completed by MPI.

2.3 Methodology Overview

The identification of hazards is based on MAF's Biosecurity Risk Analysis Procedures (MAFBNZ, 2006). However, it differs from the standard process in being significantly less exhaustive. The full hazard identification process attempts to identify every organism with a reported association with a specified commodity or host and then apply a series of screening criteria. Such a process would take months or years to complete for the thirteen pasture species considered by representatives of the pastoral sector in New Zealand pasture species to be of greatest importance (Appendix 1). Resources were not available for a complete hazard identification and consequently the aim of this report is to identify some of the obvious biosecurity hazards for priority pasture species. However, the assessment of the potential of pests to establish and cause impacts in New Zealand undertaken in this report is slightly more detailed than is required for the standard hazard identification process. Potential entry pathways and potential post-border management options, which would not usually be included in a hazard identification process are included in this report.

The hazard identification was undertaken according to the following process:

Step 1 Creation of a long list of potential hazards (151 pests)
Output: list of 'obvious' pests associated with the 13 priority pasture species (potential hazards listed in Appendix 2).
Process: Search of key sources filtered against the following criteria:

1. Not present in New Zealand[4] and
2. Described as 'major' 'serious' or 'significant' in the databases and/or
3. Have one or more of the priority pasture species as a 'main' host.

Sources:

[4] In the context of this report, "Not present in New Zealand" means that the organism was not reported as present in the sources that were checked. The main sources that were checked were PPIN (for invertebrates), and NZFungi (for fungi and bacteria).

- Crop Protection Compendium
- Plant Quarantine data Retrieval system of the European Plant Protection Organisation (EPPO, 2012)
- Commonwealth Agricultural Bureau abstracts
- Draft import risk analyses for Festuca and Lolium seed for sowing

Step 2 Creation of a short-list for assessment (64 pests)
Output: Short list of potential hazards for further assessment
Process: Potential hazard species were prioritised for assessment taking account of the following factors:

- Type of pest. Examples of the invertebrates, fungi, bacteria and viruses were selected;
- Plant associations. Pests of each of the priority pasture species were selected;
- Probable impact. Pests reported to have high impact in countries with similar climates to New Zealand were selected.

In practice, all the potential hazards that met all of these criteria were assessed in Step 3, as well as a number that had doubtful associations with priority pasture species or little indication of high impacts.

The other 87 pests from the long list (Step 1) were excluded from the short-list in Step 2 because there was little evidence for association with the priority pasture species or little indication that they would cause adverse impacts to the New Zealand pastoral sector. Further assessment may have identified relevant information but there were insufficient resources to assess all species on the long list.

Step 3 Hazard identification assessment (53 hazard pests; 11 non-hazard pests)
Output: List of hazards which have the potential to establish in New Zealand and cause adverse impacts to the New Zealand pastoral sector.
Process: A high level[5] assessment was undertaken for each shortlisted potential hazard, of its potential to establish and spread in New Zealand and of the nature and severity of the potential impact it would have on the New Zealand pastoral sector. This process is described in section 2.4.

Step 4 Identification of Potential entry pathways
Output: a list of potential entry pathways for each identified hazard species.
Process: A high level[3] assessment was undertaken for each shortlisted potential hazard taking account of its biology. This process is described in section 2.5.

Step 5 Hazard rating (24 pests)
Output: a list of 'high' hazard species
Process: Pests were rated as high or low hazard, taking account of:

- potential to establish and spread in New Zealand,
- severity of impact in New Zealand, and
- the nature and number of potential pathways of entry.

If either the potential to establish or the severity of impact were assessed as low the pest was rated a low hazard (Appendix 3). All others were rated as high hazard.

2.4 Methodology of Hazard identification assessment (step3)

A pest can be considered a hazard to the New Zealand pastoral sector if it has a non-negligible potential to establish and spread in New Zealand and cause adverse impacts on the

---

[5] "High-level" in this context refers to the reliance on summarised/collated data in major databases, i.e. secondary sources of data, as compared to primary sources of the data. It reflects the fact that a detailed analysis of the evidence in primary data sources was not undertaken.

priority pasture species grown in New Zealand. A hazard assessment was undertaken for each potential hazard prioritised for assessement in step 2. Assessments are based on information collated from a few key databases. In most cases time constraints limited data collection to secondary sources, mainly large international databases. Only readily available information was used – there was insufficient capacity to identify or source more obscure data. For species known to be already present in New Zealand, no investigation was undertaken of sub-species or variants even though some may be absent from New Zealand and may be considered a hazard. Species with little readily available information were not selected for assessment and it is assumed that if the organism were a major pest, more information would be available. No consideration was given to the impact of climate change on the future potential for establishment of pests in New Zealand.

The assessments are presented in section 6 and summarised in Appendix 3.

2.4.1 Potential to establish and spread in New Zealand.

The basis for this assessment is:

- the alignment of the preferred eco-climatic requirements of the pest with the New Zealand ecology and climate (at least at regional level); and
- the life history traits of the pest.

A pest may be able to establish at a suitable location in New Zealand, but its potential distribution may be limited. Each pest was assigned to one of the following categories of potential[6] to establish and subsequently spread in New Zealand. It is assumed that the pest will eventually spread to all climatically suitable areas with appropriate host plants. The assessments were informed by information on the climate of New Zealand (Appendix 4).

The following criteria were used to assign ratings for potential to establish and spread in New Zealand:

Negligible: There is clear evidence, and sufficient data, to confidently say that the pest could not establish in New Zealand's climate e.g. the organism has had opportunities to develop in climates similar to New Zealand but hasn't or the organism has a clear need for hot/arid conditions.

Low: In its current distribution the pest is known to occur only in climates that exist in New Zealand in restricted locations[7]; the biology and life-history[8] suggest that even if the pest had the opportunity to enter New Zealand, the climate in New Zealand is probably not suitable even at a regional scale[9]; the occurrence of hosts in suitable regions for the pests is limited. Particular biological factors are required for spread such as a specific vector, or assisting virus, and their occurrence in New Zealand is rare.

Moderate: Current distribution and the biology and life-history of the pest suggest that the climate in New Zealand might be suitable on a regional scale; and host availability, in the

[6]"Potential to establish and spread" is not to be confused with "likelihood of establishment and spread". They are distinctly different concepts in biosecurity risk analysis methodology. Hazard Identification is the first stage of a Risk Analysis, and it considers "potential to establish and spread". Subsequent stages of a Risk Analysis deals with "likelihood of establishment and spread"

[7] Restricted locations: e.g. microclimates in few locations, rather than regional climates.

[8] Biology and life-history: e.g. includes temperature requirements, minimum temperature thresholds for completion of lifecycle, and how long it takes to complete a life cycle.

[9] The information available about the pests suggests that there are no regions in New Zealand that appear to have a climate suitable for the pest. However, there is still a low potential for establishment in New Zealand because pest behaviour and ability to adapt can be unpredictable.

region(s) where the climate is suitable, is not limited. There may be limitations to self-dispersal or vectoring.

> e.g. the pest comes from a temperate climate but not similar to New Zealand's temperate climate; (could be from a place with dry winter, rainy summer; could be from a temperate climate with more extremes of hot and cold);
> e.g. comes from a tropical climate, but where altitude lowers the temperature;
> e.g. may be known from climates that exist in New Zealand only as micro-climates; but there might be good data on biology and life history of the pest that suggests that the current limited range of the pest is possibly more to do with a limited opportunity to enter into different countries/climates, rather than the range being limited by climatic factors.

High: In its current distribution the pest is known from climates (e.g. south-eastern Australia, parts of Europe and South America) that also exist in New Zealand at a regional level, and host availability is not limited in the New Zealand region(s) where the climate is suitable. The organism is capable of self-dispersal; or there are one or more vectors that are very efficient at spreading the pest.

Note: Where there is clear uncertainty it is mentioned in the hazard assessments, but the uncertainty does not influence the rating.

2.4.2 The nature and severity of potential impact to the pastoral sector in New Zealand.

The potential economic impact of each pest was assessed in relation to the pastoral sector. Any obvious environmental, socio-cultural, and health impacts are noted, but there is no in-depth assessment of these impacts.

The severity of impact is closely linked to the potential for a pest to become widespread in New Zealand. The assessment is based on impacts of the pest on the whole pastoral sector rather than on the impacts for individual farmers. The nature and severity of the damage caused by the pest in climates similar to New Zealand is described but the costs of such damage are not quantified. The assessment excludes consideration of response tools available.

Each pest was assigned to one of the following categories of impact:

Low: one or more priority pasture species likely to be affected, but pest is unlikely to cause noticeable lost productivity; and/or limited to one region.[10]

Moderate: several priority pasture species likely to be affected, but the productivity loss from those crops is unlikely to be significant or significant productivity losses are likely to be limited to only one or two regions.

High: The productivity of multiple priority pasture species is likely to be significantly reduced in multiple regions; or just one species is affected throughout New Zealand, or the impact on a single species is severe (e.g. it is common for plants to die).

The assessment was informed by the information compiled about the pastoral sector (Appendix 1).

[10] "Region" is a generic term used to refer to the areas encompassed by for example Regional Councils. e.g. Northland, Auckland, Waikato, Otago, Southland etc.

2.5 Potential pathways of entry into New Zealand (commodity association step 4)

The potential pathways for entry into New Zealand were assessed for each pest[11]. Possible pathways include:

- commodities comprising host plants such as imported nursery stock (including seeds, whole plants, cuttings), other imported plant products not intended for human consumption (e.g. animal feed),
- commodities with potential to be contaminated with host plant material such as imported animals and animal products, and imported fresh produce (fruit and vegetables),
- inanimate pathways that may contain hitchhiking pests or be contaminated with host plant material (e.g. shipping- and air-containers, farm machinery, imported vehicles, fertiliser, packaging, building materials, manufactured goods, etc),
- passengers and personal effects that may contain hitchhiking pests or host plant material.

Factors considered in assessing potential pathways of entry include the biology of each pest as well as the scale of relevant pathways.

Organisms intercepted on imported commodities during routine entry inspection or targeted surveys (collectively called 'interception records') are recorded in MPI's interceptions database. These records provide direct evidence for an association between an organism and the pathway. Interception records were obtained for the genera of species assessed. It is important to note that while interception records provide valuable information about potential pathways they can not be used quantitatively to provide an indication of the frequency with which pathways are contaminated with particular organisms. This is because:

- The levels of quarantine inspection, identification and recording are not constant over time and between pathways;
- interceptions recorded during surveys or over a short period of time reflect only that season or set of import conditions;
- many interceptions are not identified taxonomically by species;
- there may be biases in the collection of data according to national priorities (Toy & Newfield 2010).

The interception records date back many years and the nature of the import pathways and the conditions required for import may have changed. The records therefore do not provide information about the likelihood of entry on a pathway.

2.6 Summary hazard rating (step 5)

All assessed pests were grouped to determine which pests represent the greatest hazard[12] to the New Zealand pastoral sector. The MPI and/or pastoral sector stakeholders may consider undertaking a full, detailed, risk analysis for these pests. Pests were rated as high or low hazard taking account of:

a) potential to establish and spread in New Zealand,

b) severity of impact in New Zealand, and

[11] This assessment focussed on types of goods/commodities that could have pests associated with them, rather than which part of the world those goods/commodities might come from. Consideration of whether New Zealand imports those goods/commodities from countries where the pasture pests are present is outside the scope of this hazard assessment, but would be considered in a Risk Analysis (future work).

[12] "greatest hazard" pests are those pests that have the highest potential to establish and spread in New Zealand AND have the highest potential to cause a negative impact in New Zealand.

c) the nature and number of potential pathways of entry.
If either the potential to establish or the severity of impact were assessed as low the pest was rated a low hazard (Appendix 2). All others were rated as high hazard.
Note that some pests rated as high hazard may nevertheless be low risk to the pastoral sector if the likelihood of entry is low. Assessment of the likelihood of entry is outside the scope of this report.

A meaningful ranking of each individual pest from highest ranked to lowest ranked hazard is not considered feasible in this project.

A small number of the 64 pests assessed (11) were not considered to be hazards after the assessment, and are identified as such in the assessments in Section 6 and in the summary in Appendix 3. No further assessment was made for these pests.

2.7 Methodology for reviewing "Possible methods of post-border management and surveillance"

Possible methods of post-border management and surveillance were researched and documented for a pest if the hazard assessment concluded that the pest was a hazard. No consideration was given to post-border management and surveillance for the pests that were concluded to be 'not hazards'.

The scope for this section of the pest hazard assessments was to identify post-border management (including chemical treatments) and surveillance methods which were reported to have been used with some success in other countries to manage and detect the pest. No analysis of efficacy of the reported methods was required. As such, both MPI and the pastoral sector stakeholders acknowledge that there are significant limitations with regard to how this information can be used.

With regard to the interest in chemical treatments for controlling insect pests, the primary objective was to gain knowledge of which chemicals other countries have used to control the pest, and whether the chemical is a carbamate or organophosphate insecticide.

Given the scope of the hazard identification, secondary sources of information were considered adequate (primarily the Crop Protection Compendium; Pherobase was also searched). If no suitable secondary sources of information were available, searches of CAB abstracts '1910 to 2012 week 37 or 38' were undertaken to identify primary sources of information. In most cases only abstracts of articles were viewed, but in some instances the full articles were retrieved and viewed.

The search terms used for searching CAB abstracts included: [surveillance OR monitor*], and sometimes [OR survey] if the search needed to be broadened; and [control OR manage*]. If little or no information was available on CAB abstracts using the species name as a search term, the search was broadened by using the genus name. Google and Google Scholar searches were generally not used to search for management and surveillance information.

2.8 Limitations of the assessment of biosecurity hazards

The primary objective of this project is to undertake a high-level hazard identification of the potential pests of New Zealand pasture species that may require additional management across the biosecurity system. It is a starting point in understanding the biosecurity risk and it is important that the limitations of the assessment are understood.

2.8.1 Data about absence from New Zealand

One of the first steps in creating the list of pasture pest hazards was to determine absence from New Zealand for each hazard. In the context of this report, "not present in New Zealand" means that the organism was not reported as present in New Zealand in the sources that were checked. The main sources of information that were used to determine absence from New Zealand were PPIN[13] (for invertebrates), NZFungi[14] (for fungi and bacteria) and Commonwealth Agricultural Bureau abstracts for some organisms. The limitations of this methodology are a) this is not a comprehensive search for information and b) the limitations of those databases influence the accuracy of the information in this report. Consequently, there may be some organisms in the hazard list that are in fact in New Zealand already. For instance, *Erysiphe pisi* var. *pisi* has not been recorded from New Zealand, but the parent species *Erysiphe pisi* is present in New Zealand. It is not clear which variety(ies) of *Erysiphe pisi* occur in New Zealand, but it may be that *Erysiphe pisi* var. *pisi* is here even though it has not been recorded (NZFungi 2012).

2.8.2 Incomplete lists

Sections 2.3 -2.4 describe the process of identifying pests that pose a hazard to New Zealand pasture species. Hundreds of organisms are described in databases as pests of these species. It would take months merely to determine the status of all these pests. This document assesses some pests (64), from a limited number of databases, that are considered likely to be problematic should they establish in New Zealand. The hazards identified in this project cannot be considered to represent the full range of hazards to the priority pasture species. As the identification of hazards is incomplete, the hazards identified may not pose the highest biosecurity risk to the sector. In particular, emerging pests that are not currently well known are unlikely to have been identified. Nonetheless, the hazards that have been identified provide an indication of the type of pests that are of concern and their likely pathways for entry.

2.8.3 Inaccurate information

The assessments in this document are high-level, i.e. based on information that could be gathered rapidly from a few key sources. The majority of sources are secondary. There was insufficient time available to identify and obtain primary sources. Secondary sources, by their nature are less reliable than primary sources. They have not usually been subject to peer review. The reliability of information was not tested through checking multiple sources, except in a few instances. Consequently, some of the information on which the assessments are based will be incomplete and some may be incorrect.

2.8.4 Insufficient information

The hazards identified in this document were derived from a rapid assessment using secondary data. The information collated was the minimum necessary to reach a conclusion on the status of each species. More information and a greater level of analysis would be required to understand the biosecurity risk posed by each pest and to determine how best to manage that risk. For some species there is insufficient information to meaningfully distinguish between the descriptors for potential to establish and nature and severity of potential impacts. A particular area of uncertainty is the impact of hazards on priority pasture species grown in extensive pasture situations. Some of the hazards are pests of commercial

---

[13] PPIN is the Plant Pest Information Network. It is a national database for collection, management and dissemination of plant pest surveillance information. The PPIN database is maintained by MPI. http://www.biosecurity.govt.nz/pests/plants/ppin

[14] NZFungi is a webportal providing access to data content from the New Zealand Fungal and Plant Disease Collection. NZFungi and the national collection are maintained by Landcare Research. http://nzfungi2.landcareresearch.co.nz/default.aspx?NavControl=home

crops such as cereals or chicory grown as a vegetable. There is little available information on the impact of these species on host plants grown in pastures.

2.8.5 Unpredictability of pest adaptation

There is an inherent unpredictability about the ability of any given pest to adapt to a new environment; in this case the New Zealand pastoral environment. Consequently, the assessments of 'potential to establish' and 'potential impacts', which are based on information about the behaviour and adaptation of pests in other countries rather than in New Zealand, also have inherent uncertainty.

2.8.6 Lack of entry and exposure assessment

It is important to note that no assessment is made of the likelihood of entry or of exposure of assessed pests to vulnerable hosts in New Zealand. This is because these assessments are pathway specific and usually require a more detailed understanding of the pathway and the biology of the pest than was available to this project. As a consequence, some of the pests assessed as a having a high potential to establish and spread may actually have a negligible likelihood of establishment if the likelihood of entry is negligible (if for instance the pathway volume is very small) or if there is no feasible means of exposure. This would need to be determined through a more thorough risk assessment.

2.9 Expert Peer Review

This report has been peer-reviewed by experts within MPI, whose main focus was on comparision of the hazards identified in this project against some documented Australian pastoral pests. Some additional potential hazards are listed in Appendix 2.2.

This report has also been peer-reviewed by pastoral system experts, Alison Popay and Philippa Gerard of AgResearch. Additional potential hazard species identified by the peer reviewers have been listed in Appendix 2.3. Refer to Appendix 5 for the scope of external peer-review.

3 Hazard identification summary

Most pests and diseases associated with the priority pasture species are already present in New Zealand and are therefore not considered to be hazards (within the scope of this project). Note this document does not consider whether any significant changes in behaviour of pests might occur as a result of environmental changes like climate variability.

Of the 64 species assessed in Section 6, 11 species were determined not to be hazards after all and 21 species were allocated to the high hazard group. **Table 2** indicates the number of hazards identified for each of the priority pasture species and the number that were rated as 'high' hazards.

Relatively few hazards were identified for the following priority pasture species: chicory, (*Cichorium intybus),* ribwort plantain (*Plantago lanceolata),* Timothy (*Phleum pratense)* and crested dogs tail, (*Cynosurus cristatus).* This may reflect the fact that these pasture species are not major economic crops on a global scale and consequently are less well studied. No specific records for association with crested dogs tail were found. The EPPO *Cynosurus cristatus* datasheet (2012) describes pest records for this species as 'as Poaceae' presumably indicating a lack of specific host association records with this grass. Only four of these pests were described as 'major' and two of these are already present in New Zealand. The pasture form of chicory (*Cichorium intybus*) rather than the vegetable form is only important in New Zealand, Australia and parts of the USA (CPC 2012). Most of the hazards identified for chicory are pests of the vegetable form of the species (Italian chicory). There is no information about their pest status in pastoral situations, so it is assumed that they will also be pests on the pasture form, but with smaller impacts[15]. Consequently most hazards of chicory are rated as low hazards. There is similar uncertainty about the likely impact of hazards on the other pasture species that are not globally of economic importance.

Table 2 Number of hazards identified for priority New Zealand pasture species

Priority pasture species		**Number of hazards identified**	**Number of high rated hazards**
Bent grasses	*Agrostis* spp.	5	2
Crested dogs tail	*Cynosurus cristatus*	0	0
Cocksfoot	*Dactylis glomerata*	10	4
Fescue grasses	*Festuca* spp.	10	4
Ryegrass	*Lolium* spp.	9	3
Timothy	*Phleum pratense*	11	5
Chicory	*Cichorium intybus*	5	2
Lucerne	*Medicago sativa*	32	17
Ribwort plantain	*Plantago lanceolata*	3	3
Clovers	*Trifolium* spp.	25	15

[15] Impacts are likely to be smaller because the information about impacts of chicory pests on vegetables are due to damage to appearance of the vegetable, rather than on productivity. Appearance impacts are unlikely to have the same consequence in pastoral systems.

4 Main pathways

The potential pathways for entry of hazards of priority pasture species are summarised in **Table 3**. The pathways for which a pest association is more likely are distinguished from those that are less likely by taking account of the biology of each hazard and the nature of the pathway. Hazards for which no potential for pathway-association could be identified, such as *Tipula paludosa,* appear only in the right hand column (less likely). Note that the association of a pest with a particular pathway, or the likelihood of entry of that pest on a given pathway, cannot be confirmed in the absence of a more detailed entry assessment. For instance, a hazard with a limited current distribution and host range may not be able to enter on fresh produce if no host commodities are imported from countries in which the hazard is present.

Table 3 Potential entry pathways for pastoral sector biosecurity hazards

Potential entry pathway	**Hazards likely to be associated with pathway**	**Hazards less likely to be associated with pathway**
Fresh produce	*Napomyza cichorii* *Ophiomyia pinguis* *Autographa gamma* *Spodoptera littoralis* *Adelphocoris lineolatus* *Empoasca fabae* *Lygus lineolaris* *Piezodorus hybneri* *Thrips angusticeps* *Thrips flavus* *Phymatotrichopsis omnivore* *Meloidogyne arenaria* *Meloidogyne graminicola* *Meloidogyne chitwoodi* *Helicoverpa punctigera* *Spodoptera frugiperda* *Papaipema nebris* *Hydraecia micacea* *Agrotis segetum* *Limonius californicus* *Agriotes sputator* *Liriomyza sativae* *Liriomyza trifolii*	*Chrysoteuchia topiaria*
Nursery stock	*Agrotis segetum* *Spodoptera littoralis* *Spodoptera frugiperda* *Adelphocoris lineolatus* *Phymatotrichopsis omnivore* *Meloidogyne arenaria* *Hydraecia micacea* *Liriomyza sativae* *Liriomyza trifolii* Aster yellows phytoplasmas	*Helicoverpa punctigera* *Papaipema nebris*
Cut flowers/foliage	*Autographa gamma* *Agrotis segetum* *Spodoptera littoralis* *Lygus lineolaris* *Thrips flavus* *Helicoverpa punctigera* *Spodoptera frugiperda* *Papaipema nebris*	Aster yellows phytoplasmas *Thrips angusticeps*

Potential entry pathway	Hazards likely to be associated with pathway	Hazards less likely to be associated with pathway
	Liriomyza sativae *Liriomyza trifolii*	
Seed for sowing	*Glyphipterix simpliciella* *Alternaria cichorii* *Drechslera catenaria* *Tilletia controversa* *Didymella festucae* *Erysiphe pisi var. pisi*	*Oulema melanopus* *Napomyza cichorii* *Oscinella frit* *Adelphocoris lineolatus* *Sitobion avenae* *Ustilago lolii* *Epichloë typhina*
Grain	*Empoasca fabae* *Tilletia controversa* *Erysiphe pisi var. pisi*	*Oscinella frit* *Sitobion avenae* *Drechslera catenaria* *Epichloë typhina*
Soil/plant contamination on inanimate pathways	*Hypera zoilus* *Sitona cylindricollis* *Sitona hispidulus* *Dichroplus elongates* *Melanoplus bivittatus* *Xanthomonas axonopodis pv. alfalfae* *Phymatotrichopsis omnivore* *Meloidogyne arenaria* *Tylenchorhynchus acutus* *Tylenchorhynchus claytoni* *Agrotis segetum* *Hypera brunneipennis* *Meloidogyne graminicola* *Meloidogyne chitwoodi*	*Naupactus xanthographus* *Sphenophorus venatus confluens* *Napomyza cichorii* *Tipula paludosa* *Chrysoteuchia culmella* *Papaipema nebris* *Spodoptera littoralis* *Chrysoteuchia topiaria* *Hydraecia micacea* *Limonius californicus* *Agriotes sputator* *Agromyza frontella* *Liriomyza trifolii* *Chromatomyia fuscula* *Thrips angusticeps*
Growing media		*Naupactus xanthographus* *Phymatotrichopsis omnivore* *Meloidogyne arenaria* *Meloidogyne chitwoodi* *Meloidogyne graminicola* *Tylenchorhynchus acutus* *Tylenchorhynchus claytoni* *Limonius californicus* *Agriotes sputator*
Hitchhiker pathways	*Solenopsis geminata* *Gonioctena fornicata* *Hypera postica* *Naupactus xanthographus* *Oulema melanopus* *Helicoverpa punctigera* *Hypera brunneipennis*	*Sphenophorus venatus confluens* *Dichroplus elongatus* *Melanoplus bivittatus* *Empoasca fabae* *Chromatomyia fuscula*
Passengers and/or their personal effects		*Solenopsis geminata* *Gonioctena fornicata* *Hypera postica* *Hypera zoilus* *Oulema melanopus* *Sitona cylindricollis* *Sitona hispidulus* *Sphenophorus venatus confluens* *Napomyza cichorii* *Ophiomyia pinguis* *Oscinella frit* *Autographa gamma* *Chrysoteuchia culmella*

Potential entry pathway	Hazards likely to be associated with pathway	Hazards less likely to be associated with pathway
		Glyphipterix simpliciella *Adelphocoris lineolatus* *Empoasca fabae* *Lygus lineolaris* *Piezodorus hybneri* *Sitobion avenae* *Thrips flavus* *Alternaria cichorii* *Drechslera catenaria* *Phymatotrichopsis omnivore* *Tilletia controversa* *Ustilago lolii* *Meloidogyne arenaria* *Tylenchorhynchus acutus* *Tylenchorhynchus claytoni* *Agromyza frontella* *Chrysoteuchia topiaria* *Hypera brunneipennis* *Helicoverpa punctigera* *Hydraecia micacea* *Papaipema nebris* *Agrotis segetum* *Liriomyza sativae* *Liriomyza trifolii* *Chromatomyia fuscula* *Didymella festucae* *Erysiphe pisi var. pisi* *Epichloë typhina* *Meloidogyne chitwoodi* *Meloidogyne graminicola* *Thrips angusticeps* *Spodoptera frugiperda*

A factual description of the nature and degree of management of these entry pathways will be undertaken by the MPI as a separate exercise, but aspects relevant to the hazards identified are discussed in this section.

Fresh host material

The entry pathway with the most potential for enabling entry of most of the hazards identified would be imported host material in the form of the priority pasture species. However, since no hay, silage or nursery stock of any of the priority pasture species are imported into New Zealand (C. Black pers comm. 2012) this pathway does not exist.

Most of the hazards identified have a restricted host range. However, some hazards, particularly those of chicory, are polyphagous and are reported to have fruit and vegetables as hosts. New Zealand imports fresh vegetables and fruit, so this is a potential entry pathway for some hazards. However, the risk will depend on the volumes of host material imported from countries in which the hazard species occurs as well as the management of the import process.

Palm kernal expeller (PKE) is imported in large quantities as stock feed (C. Black pers. comm.). However, it and other stock feeds are highly processed and cannot be considered fresh host material. Furthermore, none of the hazards identified in this assessment have oil palm as a host.

Nursery stock
Nursery stock of plant species listed in the Plants Biosecurity Index may be imported in any of the following types, depending on the species:

- Cuttings (dormant and/or non-dormant)
- Whole Plants
- Dormant Bulbs and Tubers
- Tissue Culture

The conditions for import depend on the species and country of origin (MPI 2012). In general the volumes of nursery stock are much lower than those of imported fresh produce. Therefore, fresh produce is probably the pathway with the most potential of enabling entry of hazards that require fresh plant material. However, the likelihood of entry depends on the details of the pathways and it is possible that nursery stock may be important for a few species.

Cut flowers/foliage
Cut flowers and foliage may be imported subject to treatments depending on the species involved and the country of origin (MAF Biosecurity 2011). Volumes of imported cut flowers have fallen in recent years (B. McDonald pers comm. 2012). The biggest volume is of roses from India. Large numbers of cut flowers are also imported from Malaysia, Singapore, USA and Australia. Detailed pathway analysis is beyond the scope of this report, but the likelihood of entry, and therefore the risk associated with the pathways, depends in large part on the detail of the import pathway. For instance none of the hazards identified are associated with roses, the largest import line. Chrysanthemums, which are a host plant for some hazards are imported in relatively large numbers from Singapore and Malaysia. However, the relevant hazards are not present in those countries.

Seed for sowing and grain for consumption
Large volumes of seed for sowing of many of the priority pasture species are imported into New Zealand (C. Black pers comm. 2012). Grains (particularly wheat and including dry beans) are imported for human consumption and animal fodder but much of these imports are processed (S. Olsen per comm. 2012). Given the relative scale of these pathways, they have the greatest potential for enabling entry of any hazard associated with seed (such as weeds). Detailed pathway analysis is beyond the scope of this report, but the likelihood of entry, and therefore the risk associated with the pathways, depends in large part on the detail of the import pathway. For instance most grains are currently imported from Australia (S. Olsen pers. comm. 2012) but few of the hazards identified are present in Australia.

Inanimate pathways contaminated with soil and/or plant debris
Inanimate pathways, particularly imported used agricultural machinery or vehicles are identified as the pathways with the most potential for enabling the entry of hazards associated with soil or plant debris. An assessment of the likelihood of entry is beyond the scope of this project - but factors such as the biology of the organism, the amount of contamination, the delay between contamination and shipment, the location of the contamination on the vehicle and the number of contaminated items are important (MAFBNZ 2007). The amount of soil likely to be associated with footwear and likely use patterns suggest that contaminated footwear is a less important entry pathway for many of the soil related hazards.

Growing media
Many of the identified hazards have life-stages that are associated with soil. Imported soil would therefore be an important entry pathway. However, the importation of soil is prohibited except for small quantities for analysis which are usually heat treated[16]. The only other

[16] Soil and peat section of the MPI import health standard for soil, rock, gravel, sand, clay, peat and water from any country.

growing media imported are cocopeat (made from the fibres of coconut husks), peat[17], and growing media of plant origin (made by decomposition, compost or heat treatments)[18]. While contamination, particularly with weed seeds, is possible, the likelihood of these media being associated with the hazards identified in this assessment is negligible.

New Zealand imports fertiliser from many countries and in a variety of forms: manufactured and raw ingredients, bulk and bagged. Guano, phosphate rock, potash and urea are the most commonly imported fertilisers (C. Duthie, pers comm. 2012). Again, contamination, particularly with weed seeds, is possible, but the likelihood of imported fertilisers being associated with the hazards identified in this assessment is negligible.

Fertilisers and growing media of plant origin such as oil seed meals are imported in accordance with MAFBNZ (2009) and growing media such as bark, associated with the importation of nursery stock are assessed on a case by case basis. The hazards identified in this assessment are not likely to be associated with any of these materials.

Any hazards associated with soil are more likely to enter on contaminated inanimate objects such as imported used machinery than in growing media.

Hitchhiker pathways

Many of the identified hazards are have potential to enter New Zealand as hitchhikers. In this context, a hitchhiker is defined as an organism that has an opportunistic association with a commodity or item with which it has no biological host relationship (MAFBNZ 2008). Recent risk analyses for hitchhiker organisms show that there are traits that contribute to the likelihood of the species becoming associated with transport pathways and surviving to reach new locations (Toy & Newfield 2010). These traits include:

- an attraction to habitats modified by humans e.g. Attraction to lights;
- the ability to complete their entire life cycle in human environments or highly disturbed habitats e.g. many species of ants;
- a life stage that seeks sheltered areas to avoid extreme conditions e.g. many snails;
- a life stage with dormancy that enables them to survive extended periods in transit;
- an association with common contaminants of imported goods such as soil (see above).

The opportunistic nature of hitchhikers means that it can be difficult to understand their association with a pathway. Consideration of an organism’s biology in relation to the traits identified can be helpful in distinguishing between hitchhikers that have a rare or tenuous association which are unlikely to be a risk, from those with a mechanism for regular association with a commodity. Organisms that are accidentally associated with a commodity and have no predictable association with a pathway are not likely to enter New Zealand in sufficiently large numbers to be able to establish in New Zealand. It is beyond the scope of this project to analyse the association between pasture hazards and hitchhiker pathways but in many cases an understanding of the circumstances in which commodities have been stored and used prior to export is key to understanding the likelihood of entry of these types of hazards.

Passengers

The passenger pathway is a diverse one. It ranges from passengers deliberately bringing in host material such as apples or lettuce, to entry of hitchhiker organisms that happen to

[17] MPI import health standards for Coco Peat and Coir Fibre Products, and the soil and peat section within the MPI import health standard for soil, rock, gravel, sand, clay, peat and water from any country.
[18] MPI import health standard for Fertliser and Growing Media of Plant Origin.

become associated with personal effects or clothing because of the way in which they were used or stored prior to leaving the country of origin. The passenger pathway has been identified as a potential entry pathway for most hazards (table 3) because of the scale and diverse nature of the pathway. Assessing the likelihood of entry of any individual pest via this pathway would be challenging due to the number of factors involved.

A comment about potential pathways for entry of weeds

The identification of weeds that are likely to be hazards to the New Zealand pastoral sector is outside the scope of this project (section 2.2). Nonetheless, weeds have the potential to adversely impact the sector and some possible pathways of entry are considered here. The import of any new species is highly regulated in New Zealand and would require a detailed risk assessment, so entry through deliberate importation of a new species which subsequently becomes weedy is unlikely.

Weeds have most potential to enter as a contaminant, generally in the form of seeds, on imported commodities. There are many challenges to assessing the risk associated with entry of any particular plant species as a contaminant. Associations between seeds and commodities will depend on a wide range of factors such as where a commodity was grown/ stored, site-specific environmental conditions and handling or processing techniques.

Because weed seeds generally do not have consistent associations with imported commodities, analysing potential entry pathways for weeds is likely to be a more useful approach than attempting to assess the risk from individual species. An example is the approach taken in the risk analysis for imported vehicles and machinery (MAF BNZ 2007). The key question in that analysis was whether there are plant species likely to be associated with vehicles that could enter New Zealand, reach a suitable habitat, establish, spread and have significant consequences. Because it is not possible to determine exactly which species will be associated with imported vehicles at any time, the analysis identified generic measures to manage the risks from seeds on vehicles in general, rather than the risks from particular species. A similar approach could be taken to analyse other entry pathways for weeds such as animal pathways. The seed and grain import pathways require seed analysis and with risk management measures dependent on the species and quantity of contaminant in any consignment.

The identification of weed hazards is further complicated by the fact that there are hundreds of invasive or potentially invasive plants already in New Zealand but currently limited in their distribution. Managing domestic pathways for spread of weeds may be an important component in risk management for the pastoral sector.

5 References

Beef + Lamb New Zealand (2012) Compendium of New Zealand Farm Facts 36th Edition. Publication No. P12009. Available online at: http://www.beeflambnz.com/Documents/Information/Compendium%20of%20New%20Zealand%20farm%20facts.pdf

Biosecurity New Zealand (2007) Import Health Standard for soil, rock, gravel, sand, clay, peat and water from any country BMG-STD-SOWTR. Issue Date: 30 May 2007. Available online at: http://www.biosecurity.govt.nz/imports/non-organic/standards/bmg-std-sowtr.htm

CPC (2012) Cichorium intybus. Last updated 26 January 2010. Accessed 15/8/12 http://www.cabi.org/cpc/?compid=1&dsid=13409&loadmodule=datasheet&page=868&site=161

Corkill, L; Williams, WM; Lancashire JA (1981) Pasture species and cultivars for regions. Proceedings NZ Grassland Association 42: 100-102.

EPPO (2012) EPPO Global database: Cynosurus cristatus data sheet. Available online at: http://gd3.eppo.int/organism.php/CYXCR Accessed 11/9/12.

EPPO (2012) PQR – EPPO database of quarantine pests. Available online at: http://www.eppo.int

MAF Biosecurity (2011) MAF Biosecurity Authority (Plants) Standard 155.02.04 Import health standard for cut flowers and foliage. 20 December 2011. Available online at: http://www.biosecurity.govt.nz/files/ihs/155-02-04.pdf

MAF Biosecurity New Zealand (2006) Risk Analysis Procedures. Available online at: http://www.biosecurity.govt.nz/files/pests/surv-mgmt/surv/review/risk-analysis-procedures.pdf

MAF Biosecurity New Zealand (2007) Import Risk Analysis: Vehicle and Machinery.

MAF Biosecurity New Zealand (2008) Pest risk analysis for six moth species: lessons for the biosecurity system for managing hitchhiker organisms.

MAF Biosecurity New Zealand (2009) Import Health Standard BNZ-FERTGRO-IMPORT Importation of fertilisers and growing media of plant origin. Available online at: http://www.biosecurity.govt.nz/imports/plants/standards/bnz-fertgro-imprt.htm

MPI (2012) Standard 155.02.06 Importation of nursery stock. Available online at: http://www.biosecurity.govt.nz/imports/plants/standards/155-02-06.htm

Toy, SJ; Newfield, MJ (2010) The accidental introduction of invasive animals as hitchhikers through inanimate pathways: a New Zealand perspective. *OIE Scientific and Technical Review* 29(1): 123-133.

6 Hazard assessments

6.1 Ants - Formicidae

Solenopsis geminata (Tropical fire ant)

Scientific Name: *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae)
Synonyms: *Atta geminata*
Solenopsis geminata rufa Jerd.
Common Name: Tropical fire ant

Brief description:
Solenopsis geminata is an omnivorous ant which frequently eats seeds. It also damages plants, imbibes sap, and bites branches, shoots, buds, flowers and fruits. Although Tall Fescue *(Festuca arundinacea)* is described as a main host (CPC 2012), the ant does not appear to be a direct pest of pasture crops. It has spread around the world as a hitchhiker species.

Indicative host range:
S. geminata is omnivorous and so does not have an exclusive association with host plants. It is known to be more of a seed eater than other species in this genus and so might be expected to consume seed of priority pasture plants.

Priority Pasture Species: Tall Fescue *(Festuca arundinacea)* (main host)
Other plants: Tomato, strawberry, soyabean and several grass species are described as main hosts and there are association records for numerous other crops (CPC 2012).

Current geographic distribution:
This ant is native to the New World but has spread widely. It is able to survive indoors in environments where the conditions are unfavourable for it to survive outdoors such as Winnipeg, Canada.

Asia: Bangladesh, Brunei, China, Christmas Island, India, Indonesia, Japan, Malaysia, Myanmar, Pakistan, Philippines, Sri Lanka, Taiwan, United Arab Emirates, Vietnam
Africa: Gabon, Liberia, Mauritius, Reunion
Americas: Canada, USA, Mexico, Antigua, Bahamas, Barbados, Belize, British Virgin Islands, Cuba, Costa Rica, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, Saint. Kitts & Nevis, Saint Lucia, Saint Vincent, Trinidad & Tobago, Turks & Caicos Islands, US Virgin Islands, Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiana, Guyana, Peru, Venezuela.
Oceania: American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, New Caledonia, Northern Mariana Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
S. geminata is intercepted alive relatively frequently at the New Zealand border on a wide range of commodities including empty containers, personal effects, timber, fresh produce and nursery stock (MPI 2012). It appears to be entering as a hitchhiker rather than in association with particular host plants. Any commodity that is stored outside, prior to shipping, in areas where *S. geminata* is prevalent can be infested. New Zealand receives large amounts of trade from Pacific Islands where the ant is prevalent in urban as well as horticultural/ agricultural areas (Harris 2005).

Potential to establish and spread in NZ: Low
A detailed risk assessment has been undertaken for *S. geminata* which included climate modelling. It concluded that the likelihood of establishment in New Zealand is low. Suitable habitat (grassland and disturbed high light habitat) is available but the areas considered climatically suitable for invasion are very limited: possibly only the warmest microhabitats in open habitat in northern New Zealand and some locations in urban areas (Harris 2005). A single mated queen would be enough to found a population if it arrived in a fit condition, at the right time of year, and in a suitable environment (hot microclimate). However, the highest risk of a new population would be from a whole colony being transported in freight (Harris 2005). Nuptial flights of queens could result in local spread. Human mediated dispersal would be the main means of long distance spread but this would be limited by the availability of climatically suitable areas.

Potential Impact in NZ: Low for the pastoral sector
The economic impact to the pastoral sector of *S. geminata* establishing in New Zealand is likely to be very low given its anticipated restricted distribution. However, it could have severe environmental impacts if it established on off-shore islands in the north of the country. In addition, *S. geminata* possesses a painful sting and shows a preference for disturbed habitat such as urban areas. Wherever it establishes it will cause injury to humans and domestic animals when nests or workers are disturbed (Harris 2005).

Possible methods of post-border management and surveillance:
Surveillance: MPI conducts the National Invasive Ant Surveillance programme (NIAS) to detect newly established exotic ant species in New Zealand. Ports of entry and high-risk transitional facility are the sites where ants are likely to initially establish and so are surveyed on an annual basis. When new ant species are detected, the ants are usually found to be established in only a few and small nests, which are easily eradicated. On-farm surveillance can be carried out by checking for ants around food sources (Peacock, L. 2012, pers. com.).

Post-border management[19]: Plentovich *et al*. (2010) concluded that the formicide MaxforceReg. (active ingredient hydramethylnon) was used to control small infestations of *S. geminata* effectively but caution is required because of the ecological impact to non-target species. Chiu *et al*. 2005 reported that two organic phosphates [malathion (50% EC) and fenthion (50%)] and five synthetic pyrethroids had the greatest toxicity against *S. geminata*, when 14 chemicals were compared.

References:
Chiu, YC; Shyu, MY; Wang, CL (2005) Toxicity of insecticides to *Solenopsis invicta* and *S. geminata*. [Chinese] *Plant Protection Bulletin (Taipei*) 47(4): 371-378. Abstract only seen.

CPC (2012) last modified 27 June 2011, Crop Protection Compendium Report – *Solenopsis geminata*
http://www.cabi.org/cpc/?compid=1&dsid=50568&loadmodule=datasheet&page=868&site=161 , Accessed 16 August 2012.

Harris, RJ (2005) Ant pest risk assessment - *Solenopsis geminata*. Unpublished Landcare Research report to Ministry of Agriculture and Forestry.

MPI (2012) Interceptions database. Unpublished data. Accessed August 2012

Peacock, L. (2012), MPI Senior Adviser, personal communication to Sarah Clark (MPI) about the Ant Surveillance programme.

[19] Relevance to the EPA Review: malathion is an organophosphate under review

Plentovich, S; Swenson, C; Reimer, N; Richardson, M; Garon, N (2010) The effects of hydramethylnon on the tropical fire ant, *Solenopsis geminata* (Hymenoptera: Formicidae), and non-target arthropods on Spit Island, Midway Atoll, Hawaii. *Journal of Insect Conservation* 14 (5): 459-465. Abstract only seen.

6.2 Beetles - Coleoptera

Agriotes obscurus (Dusky wireworm)

Scientific Name: *Agriotes obscurus* (Linnaeus 1758) (Coleoptera: Elateridae)
Synonyms: *Agriotes cinnanomeus, Elater hirtellus*
Common Name: Dusky wireworm

Brief description: *Agriotes obscurus* is a polyphagous soil-inhabiting click beetle. A search of CAB abstracts indicates that it is primarily a pest of arable crops including maize, wheat, barley and potatoes. CPC (2012) describes grasses as its main host and EPPO (2012) list it as a major pest of Poaceae. However, no reports of adverse impacts on any pasture species were found. Miles (1942) indicate that it is a pest of arable crops on former grassland, suggesting that it does occur in grassland. In the absence of evidence of adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Grasses (main hosts) (CPC 2012) but see above.

Current geographic distribution:
Europe: Austria, Belgium, former Czechoslovakia, Denmark, Estonia, Finland, France, former USSR, Germany, Hungary, Italy, Latvia, Luxembourg, Netherlands, Polant, Portugal, Romania, Spain, Sweden, Switzerland, Ukraine, UK

Americas: Canada (CPC 2012).

References:
CPC (2012) last modified 27 February 2012, Crop Protection Compendium Report - *Agriotes obscurus*
http://www.cabi.org/cpc/?compid=1&dsid=3753&loadmodule=datasheet&page=868&site=161 Accessed 11/9/12.

EPPO (2012) EPPO Global database: *Cynosurus cristatus* data sheet. Available online at: http://gd3.eppo.int/organism.php/CYXCR Accessed 11/9/12.

Miles, HW (1939) Wireworms and the Breaking up of Grass Land. Agriculture 46: 5, 480-488. Abstract only accessed.

Agriotes sputator (Common click beetle)

Scientific Name: *Agriotes sputator* (Linnaeus) (Coleoptera: Elateridae)
Synonyms:
Common Name: Common click beetle

Brief description: *Agriotes sputator* is a polyphagous soil inhabiting click beetle. Larvae eat seeds, shoots and roots (Frolov 2008). It is a pest of grassland in Nova Scotia (Fox 1973).

Indicative host range:
A. sputator is a pest of grain cereals, maize, sunflower, peanut, beet, potato, and others including tree saplings. To a lesser degree it damages legumes, buckwheat, flax and mustard (Frolov 2008).
Priority Pasture Species: Rye grass*(Lolium perenne),* Timothy *(Phleum pratense),* Ribwort plantain *(Plantago lanceolata), Trifolium pratense* (Fox, 1973).

Current geographic distribution:
The geographic range covers the European part of the former USSR south of St. Petersburg. It is recorded from the Far East (Shkotov district and south Sakhalin). It occurs all across Europe (except for the Far North), North Africa, Asia Minor, Mongolia. It was introduced into North America (Frolov 2009).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid in soil in small groups at a depth of 2-5 cm, less often on the soil surface near host plants. When moisture is lacking, the eggs fail to develop and die. Larvae eat seeds, shoots and roots (Frolov 2008). The transport of contaminated soil containing eggs and/or larvae or pupae on imported used machinery is a possible entry pathway. However, although larvae are capable of surviving without nutrition for a long time, they quickly die without water (Frolov 2008) so they may be unlikely to survive transfer to New Zealand. Fresh produce containing larvae is a potential entry pathway.

Although the larvae can feed and burrow into seed, no reports of them occurring above ground were found. Thus seed for sowing and imported grains are not likely to be pathways for entry into New Zealand.

Potential to establish and spread in NZ: High
A. sputator occurs across of much of Europe including areas which have a similar climate to New Zealand. It has a wide host range including pasture plants as well as crops which occur throughout New Zealand. The species can tolerate a range of conditions. Larval feeding begins at temperatures of 12°C. Freezing to -1.5°C causes cold catalepsy, at -4-6°C the larvae die within several hours. Larvae rise to the warm upper layer of soil in early spring, descending to 1 m deep from the freezing upper layer during late autumn. In the north of its range it inhabits open dry ecosystems, whereas in the south it develops under forest canopy and on irrigated land (Frolov 2008). Given these biological features is is highly likely to be able to establish in New Zealand. Adults do not fly, but spread via infested soil or plant material is likely.

Potential Impact in NZ: High
Little information was found on the scale of impacts on pasture species. However, Fox (1977) reports that *A. sputator* is a pest of grassland in Nova Scotia and in experimental tests it fed preferentially on Ribwort plantain (*Plantago lanceolata*) followed by Timothy (*Phleum pratense*), Kentucky blue grass (*Poa pratensis*), red fescue (*Festuca rubra*) and perennial rye grass (*Lolium perenne*). Red clover (*Trifolium pratense*) was also eaten but less than the grasses. Since many of these species are important pasture species in New Zealand it is

assumed that the potential impact should this click beetle establish in New Zealand would be high.

Possible methods of post-border management and surveillance:
Surveillance: Pheromone traps have been used to monitor click beetles (Villeneuve & Latour 2011).

Post-border management: Previously the larvae of *Agriotes* spp. have been controlled with organochlorine and organophosphate insecticides. In Canada, newer chemistries have had to be developed and they are not as effective at reducing populations. Neonicotinoid (including thiamethoxam, clothianidin, acetamiprid, and imidacloprid), pyrethroid (e.g. tefluthrin) and spinosyn (i.e. spinosad) insecticides[20] can cause long-term morbidity from which the larvae can eventually make a full recovery (Herk et al 2007). However, the use of the insecticides can improve crop yield (Herk *et al*. 2007). Pheromone lures in control strategies were disappointing for the mass trapping, attrack and kill techniques tested (Villeneuve & Latour 2011). Biocontrol using the entomopathogenic fungus *Metarhizium anisopliae* has some potential (Koliker *et al*. 2011).

References:
CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Agriotes sputator*
http://www.cabi.org/cpc/?compid=1&dsid=3757&loadmodule=datasheet&page=868&site=161 , Accessed 4/9/12.

EPPO (2012) EPPO Global database: *Cynosurus cristatus* data sheet. Available online at: http://gd3.eppo.int/organism.php/CYXCR Accessed 11/9/12.

Fox, CJS (1973) Some feeding responses of a wireworm, *Agriotes sputator* (L.), (Coleoptera: Elateridae). *Phytoprotection* 54: 43-45. Abstract only accessed.

Frolov, AN (2008) *Agriotes sputator* L. in Afonin, AN; Greene, SL; Dzyubenko, NI; Frolov AN (eds.) Interactive Agricultural Ecological Atlas of Russia and neighbouring countries. Economic plants and their diseases, pests and weeds. Available online at: http://www.agroatlas.ru/en/content/pests/Agriotes_sputator/ accessed 4/9/12.

Herk, W G v; Vernon, R S; Clodius, M; Harding, C; Tolman, J H (2007) Mortality of five wireworm species (Coleoptera: Elateridae), following topical application of clothianidin and chlorpyrifos. *Journal of the Entomological Society of British Columbia; 2007.104: 55-63*

Kolliker, U; Biasio, L; Jossi, W (2011) Potential control of Swiss wireworms with entomopathogenic fungi. *IOBC/WPRS Bulletin* 66: 517-520. Abstract only seen.

Villeneuve, F; Latour, F (2011) Trapping of adult click beetles (Coleoptera: Elateridae) in vegetable crops: interests and limitations. [French] 4eme Conference Internationale sur les Methodes Alternatives en Protection des Cultures. Evolution des cadres reglementaires europeen et francais. Nouveaux moyens et strategies Innovantes, Nouveau Siecle, Lille, France, 8-10 mars 2011; 2011. 285-294. Abstract only seen.

[20] Relevance to the EPA Review: None

Gonioctena fornicata (Lucerne beetle)

Scientific Name:	*Gonioctena fornicata* Brüggemann, 1873 (Coleoptera: Chrysomelidae)
Synonyms:	*Phytodecta fornicata* (Brüggemann)
Common Name:	Lucerne beetle

Brief description: All life-stages of the beetle *Gonioctena fornicata* are closely associated with lucerne. The adults and larvae feed on the leaves causing defoliation. It is one of the most important insect pests of lucerne in central and south-eastern Europe (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*; White clover (*Trifolium repens)* and Red clover (*Trifolium pratense)* are sometimes used but are not main hosts (CPC 2012).
Other plants: *Medicago falcata; Medicago lupulina*

Current geographic distribution:

Asia: Syria, Iraq (Pest Alert 2011), Turkey (CPC 2012)

Europe: Bulgaria, Croatia, Hungary, Italy, Moldova, Romania, Russia, Serbia, Ukraine, Yugoslavia (former) (CPC 2012). It has also been reported from Germany, Poland, Czech Republic, Austria, Greece, and Great Britain (Pest Alert 2001).

Potential pathways of entry into New Zealand (Commodity Association):
Since host plant material is not imported into New Zealand (C. Black pers comm. 2012) *G. fornicata* is most likely to enter New Zealand as a hitchhiker on inanimate pathways. The beetle has been consistently detected on ceramic and quarry tiles entering the USA from Italy particularly during the month of May (Pest Alert 2001). Adult beetles can walk and fly (CPC 2012). It is not known whether they are attracted to lights. Commodities or shipping containers stored in proximity to growing hosts may become infested with *G. fornicata.* Passengers (plant material in luggage) are a possible pathway.

G. fornicata pupates in the soil below lucerne plants and most adults remain in the soil overwinter. They emerge in spring to feed and lay eggs on the growing plants (CPC 2012). Pupae or overwintering adults could be transported in soil from beneath host plants. However, they usually occur at a depth of greater than 3 cm and require warm, moist conditions to survive (CPC 2012). It is therefore unlikely that soil on imported machinery or footwear would be an entry pathway.

Potential to establish and spread in NZ: Moderate
G. fornicata inhabits restricted areas of the southern and central part of the temperate zone. The highest population density is reached when the winter is moderate and the spring is warm with normal humidity (CPC 2012). There are indications that it may be spreading to cooler areas. For instance, it was recorded in Germany for the first time in 2003 and is thought to have been introduced to the Upper Rhine valley with ship transports on the river Rhine and its tributaries (Reißmann et al. 2012). It has also been recorded in the UK and Poland (Pest Alert 2001) but it is not known whether these records relate to established populations or isolated occurrences. The beetle can penetrate greater depths in sandy soil and these conditions may enable it to tolerate colder winter conditions. Parts of the North Island of New Zealand and the top of the South Island are likely to provide suitable climatic conditions. Lucerne is commonly grown in dryland pasture systems in New Zealand (Charlton & Stewart 1999). The beetle can spread locally by flying or walking and could be spread over larger distances on plant material, soil or machinery.

Potential Impact in NZ: Moderate
G. fornicata is one of the most important insect pests on lucerne (*Medicago sativa*) in central and south-eastern Europe. Both the larvae and adults damage lucerne, eating the leaves, buds, leaf buds, young shoots and tips of stems. In May, losses can exceed 60% of green mass and reach 100% of seeds (CPC 2012). White clover (*Trifolium repens)* and Red clover (*Trifolium pratense)* may also be impacted. The limited likely range of the beetle in New Zealand would limit its impacts.

Possible methods of post-border management and surveillance:
Surveillance: Visual inspection of plants can detect the presence of *G. fornicata*; observations for the appearance of overwintered adults start in the spring, when the temperature of the soil at 10 cm depth reaches 10 to 12°C. Sweep net sampling is used to monitor *G. fornicata* populations (CPC 2012).

Post-border management: Cultural Control and Sanitary Methods: Sweeping with entomological nets and hand-collections of the larvae and adults on small plots is possible. Premature and frequent cutting or flood of the crops may cause death of the eggs, larvae and pupae.

Biological Control: The biological insecticide Novodor FC, which is a *Bacillus thuringiensis* subsp. *tenebrionis*-based formulation, shows some efficacy against young (first- to third-instar) larvae and adults of *G. fornicata*. A fungal bio-pesticide, based on *Beauveria bassiana* also shows promising efficacy results (CPC 2012).

Chemical Control: In the spring, chemical control of the adults has to prevent egg-laying. After hatching, the larvae and subsequent increase in population density have to be controlled to prevent economic losses. Contact-action insecticides are mostly used. If the plant stems are longer than 25 to 30 cm, an earlier cut is recommended and pesticide treatment is conducted after gathering the hay.

The recommended contact insecticides differ throughout the year[21]: past suggestions have included gamma BHC (benzene hexachloride); trichlorphon, malathion, dioxacarb and pirimiphos-methyl; phosalone, fenitrothion and different formulations of trichlorphon. The list also contains pyrethroids.

Recently registered pesticides in Bulgaria for *G. fornicata* are: esfenvalerate, bensultap, bifenthrin, lambda-cyhalothrin, tau-fluvalinate, fenitrothion + esfenvalerate, fenitrothion, pirimiphos-methyl, and deltamethrin.

In laboratory tests, the insect growth regulators Cascade (5% flufenoxuron) and Nomolt (15% teflubenzuron) are effective against *G. fornicata* larvae, but do not cause serious disruption in *Coccinella septempunctata* development, one of the main regulators of aphids on lucerne.

References:
Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 23 March 2012, Crop Protection Compendium Report - *Gonioctena fornicata*

[21] Relevance to the EPA Review: malathion, fenitrothion, pirimiphos-methyl are organophosphates under review.

http://www.cabi.org/cpc/?compid=1&dsid=50227&loadmodule=datasheet&page=868&site=161, Accessed 1 August 2012.

Pest Alert (2001) North American Plant Protection Associations phytosanitary alert system *Gonioctena fornicata* Brüggemann. http://www.pestalert.org/Detail.CFM?recordID=58

Reißmann, K; Hörren, T; Benisch, C (2012) The beetle fauna of Germany 2007-2012. Available online at: http://www.kerbtier.de/cgi-bin/enFeature.cgi Accessed 2/8/12.

Hypera brunneipennis (Egyptian alfalfa weevil)

Scientific Name: *Hypera brunneipennis* Boh. (Coleoptera: Curculionidae)
Synonyms:
Common Name: Egyptian alfalfa weevil

Brief description:
The Egyptian alfalfa weevil, *Hypera brunneipennis* together with *H. postica*, is the most damaging arthropod complex for lucerne in California. Feeding by weevil larvae as well as adults can cause severe defoliation, significantly reducing yields (Cothran & Summers 1971).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*
Other plants: *Trifolium alexandrinum*, broad bean, chick pea, fenugreek (Ali, 1983)

Current geographic distribution:
Native to the Middle East, *H. bruneipennis* was first detected in the USA in the early twentieth century and has since spread to California (Cothran & Summers 1971).

Potential pathways of entry into New Zealand (Commodity Association):
Adults leave the fields in summer, congregate and remain dormant for extended periods under the bark of trees or other sheltered places such as buildings or fence posts. They can become a nuisance in houses when they enter in large numbers. In the autumn, the adults become active again and return to the fields to feed and oviposit. Eggs are laid in stems that are still standing or in the litter on the ground. Upon hatching the larvae crawl up a host plant and burrow into the terminal bud (Cothran & Summers 1971).

Since lucerne plant material is not imported into New Zealand (C. Black pers comm 2012) *H. brunneipennis* is most likely to enter New Zealand as a hitchhiker on inanimate pathways. Inanimate objects or timber stored in the vicinity of host plants may become infested with aestivating *H. brunneipennis*. It is thought that the weevil may have entered the USA as aestivating adults under the bark of imported date palm nursery stock (Cothran & Summers 1971). Live adults of unidentified *Hypera* sp. have been intercepted as hitchhikers on an imported used vehicle and a shipping container at the New Zealand border (MPI 2012). Used agricultural machinery contaminated with infested host plant material could transport the weevil. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: Moderate
H. brunneipennis occurs in countries with a Mediterranean climate which is similar to some places in New Zealand, although the summers are probably less warm and dry in New Zealand. Lucerne is commonly grown in dryland pasture systems in New Zealand (Charlton & Stewart 1999). The beetle can spread locally by flying and could be spread over larger distances on plant material or machinery.

Potential Impact in NZ: Low
H. bruneipennis has caused losses of up to 25% of the Californian alfalfa (lucerne) hay crop. However, the circumstances under which large losses occur are complicated. They appear to occur when alfalfa is grown commercially for hay in the same location over several seasons. Serious damage usually only occurs in stands more than two years old. Alfalfa hay was an important economic commodity in California in the 1970s (Cothran & Summers 1971). It is uncertain but unlikely that *H. bruneipennis* would reach high population levels in less intensive production systems in New Zealand and its potentially restricted distribution could limit its potential impact.

Possible methods of post-border management and surveillance:
Surveillance: The use of screen traps to monitor *H. brunneipennis* during migration is reported (Christensen et al 1974).

Post-border management:
Oversowing various species of legumes and grasses into established lucerne is a possible method to mitigate weevil damage without insecticides (Putnam *et al.* 2001). Some lines of lucerne are more resistant to *H. brunneipennis* attack (Dreyer *et al*. 1987). *H. brunneipennis* larvae and adults were found to be at least moderately susceptible to *Bacillus thuringiensis* in the laboratory (Hall & Dunn 1958).

H. brunneipennis is susceptible to insecticides[22] (Summers 1975). Benomyl increased the forage yield of alfalfa by 11% by reducing the number of *H. brunneipennis* (Summers & McLellan 1975). Carbofuran at 1lb toxicant/acre gave effective control of larvae of *H. brunneipennis* (Summers & Cothran 1972). The pyrethroid insecticide XRD-522 (tralomethrin) performed well in field trials in Michigan against *H. brunneipennis* (Larson 1989).

References:
Ali, MA (1983) Studies on food consumption, host selection and oviposition preference of the Egyptian alfalfa weevil, Hypera brunneipennis Boh. (Col., Curculionidae). *Zeitschrift fur Angewandte Entomologie* 95: 175-180. Abstract only viewed.

Black, C (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of lucerne plant material.

Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

Christensen, J B; Cothran, W R; Franti, C E; Summers, C G (1974) Physical factors affecting the fall migration of the Egyptian alfalfa weevil, Hypera brunneipennis (Coleoptera: Curculionidae): a regression analysis. *Environmental Entomology; 1974.3: 3, 373-376*

Cothran, WR; Summers, CG (1971). Biology and control of the Egyptian alfalfa weevil, *Hypera brunneipennis (*Boh.) in California. *Proc. Alfalfa Prod. Symp, Fresno, CA., Dec 7-8,* 1971. p. 59-62.

Dreyer, D L; Jones, K C; Jurd, L (1987) Lack of chemical factors in host-plant resistance of alfalfa towards alfalfa weevil: ovicidal activity of some coumarin derivatives. *Journal of Chemical Ecology,* 13(4): 917-924 Abstract only viewed.

Hall, I M; Dunn, P H (1958) Susceptibility of some insect pests to infection by *Bacillus thuringiensis* Berliner in laboratory tests. *Journal of Economic Entomology,* 51(3): 296-298. Abstract only viewed.

Larson, L (1989) A new-generation pyrethroid insecticide for Midwest corn and alfalfa. *Down to Earth,* 45(2): 18-21. Abstract only viewed.

MPI (2012) Interceptions database accessed August 2012. Unpublished data.

[22] Relevance to the EPA Review: Benomyl, and carbofuran are carbamates under review.

Putnam, D H; Long, R; Reed, B A; Williams, W A (2001) Effect of overseeding forages into alfalfa on alfalfa weevil, forage yield and quality. *Journal of Agronomy and Crop Science,* 187(2): 75-81 Abstract only viewed.

Summers, C G (1975) Efficacy of insecticides and dosage rates applied for control of Egyptian alfalfa weevil and pea aphid. *Journal of Economic Entomology*, 68(6): 864-866. Abstract only viewed.

Summers, C G; Cothran, W R (1972) Egyptian alfalfa weevil: winter and early-spring treatments for control in California. *Journal of Economic Entomology,* 65(5): 1479-1481. Abstract only viewed.

Summers, C G; McLellan, W D (1975) Interaction between Egyptian alfalfa weevil feeding and foliar disease: impact on yield and quality in alfalfa. *Journal of Economic Entomology,* 68(4): 487-490. Abstract only viewed.

Hypera postica (Lucerne weevil)

Scientific Name: *Hypera postica* Gyllenhal, 1813 (Coleoptera: Curculionidae)
Synonyms:
Common Name: Lucerne weevil

Brief description:
H. postica is one of the most important insect pests of lucerne in America and Europe. Larvae feed on the leaves. In heavily infested fields, the growing tips are eaten off, the growth of the plants stunted, and the green part of the leaves eaten out to such an extent that the fields appear to be suffering from severe frost injury (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa), Trifoium pratense,* White clover (*Trifolium repens)* (main hosts) Ribwort plantain *(Plantago lanceolata)* (wild host)
Other plants: *Medicago falcata, M. lupulina, M. media, Melilotus alba, M. officinalis, Medicago varia, Trifolium hybridum. T. incarnatum, Astragalus bayonennsis, Phaseolus vulgaris, Solanum tuberosum, Brassica sp. Rubus vitis ideae, Trigonella ornithopoioides, Vicia angustifolia, V. villosa* and *Atriplex patula* (CPC 2012).

Current geographic distribution:

Asia: Afghanistan, Armenia, Azerbaijan, Brunei, China, India, Iran, Iraq, Israel, Japan, Lebanon, Malaysia, Mongolia, Pakistan, Philippines, Saudi Arabia, Tajikistan, Turkey, Turkmenistan, Uzbekistan.
Africa: Algeria, Egypt, Libya, Tunisia.
North America: Canada, USA.
Europe: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, France, Germany, Gibraltar, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Poland, Portugal, Romania, Russia, Spain, Sweden, Switzerland, Ukraine, UK, former Yugoslavia.
Oceania: American Samoa, Australia, Papua New Guinea, Samoa (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The adult weevils are mobile and overwinter in field margins or under the bark of trees. In Eastern Europe they have also been reported over-wintering in the soil close to the roots of host plants. They can fly long distances (possibly up to 15 miles) after emerging from pupae and after hibernation (CPC 2012).

Since host plant material is not imported into New Zealand (C. Black pers comm 2012) *H. postica* is most likely to enter New Zealand as a hitchhiker on inanimate pathways. Inanimate objects or timber stored in the vicinity of host plants may become infested with hibernating *H. postica*. Live adults and eggs of *H. postica* have been intercepted on fresh produce including grapes and pommeloes at the New Zealand border (MPI 2012). These interceptions may have been hitchhikers or may reflect a host association that has not been found in the literature searched during this hazard identification.

Used agricultural machinery contaminated with infested host plant material could transport the weevil. Hibernating adults or overwintering eggs could survive shipment to New Zealand. Early season eggs may be laid in litter lying on the soil surface, but eggs that have not over-wintered hatch in about 7 days (CPC 2012) and the emerging larvae would not survive shipment to New Zealand in the absence of fresh host material. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
H. postica has a very widespread distribution occurring from northern Europe to North Africa. The number of generations a year varies depending on the climatic conditions. Winters with low minimum temperatures and little snow cover are detrimental to the weevil and although they can survive they are rarely a pest in regions with this sort of climate e.g. Minnesota (CPC 2012). Given the widespread distribution of the weevil it is unlikely that there would be climatic barriers to it establishing in New Zealand. Lucerne is commonly grown in dryland pasture systems in New Zealand (Charlton & Stewart 1999) and clover species are widespread. There can be up to 3 generations a year in warm conditions and a female can lay hundreds of eggs a year (CPC 2012). These characteristics could result in the rapid build up and spread of a population. The beetle can spread locally by flying and could be spread over larger distances on plant material or machinery.

Potential Impact in NZ: High
H. postica has long been a serious pest of lucerne in Europe and the USA. Larvae feeding on leaves is particularly damaging since two-thirds of the food value of lucerne hay is in the leaves. In the USA commercial lucerne fields suffered losses ranging from 15 to 47%, while in Russia, *H. postica* may destroy the whole first crop of lucerne. The damaged plants are left only slightly foliated, so the forage harvested is made up predominantly of stems, impairing forage quality (CPC 2012). There are also reports that the lucerne weevil may spread pathogens such as *Verticillium albo-atrum* the causal agent of *Verticillium* wilt in lucerne (CPC 2012).

Possible methods of post-border management and surveillance:
<u>Surveillance:</u> Field-sampling methods include use of the shake-bucket and sweep-net to detect larvae (Hoff et al 2002). It might be possible to monitor established populations using an aggregation pheromone (Quinn et al 1999).

Visual inspection: Look for typical adult feeding damage to the leaves and stems of legumes. This consists of the parenchyma eaten from the leaves, smooth-edged notches eaten from the margins or occasionally the whole leaves eaten off, and feeding punctures in the stems. Small grey-brown weevils may be seen on the undersides of leaves (CPC 2012).

Small green, fat-bodied, legless larvae will be found during the daytime hidden away around the base of the legume plants, occasionally feeding on the leaves (CPC 2012).

<u>Post-border management:</u>
Cultural control methods may be effective, e.g. timing of cutting.

Biological control is available. *Peridesmia discus* has been reported destroying an average of 7.1% of eggs. The status of *H. postica* and its natural enemies was assessed on lucerne in West Virginia, USA, in 1985-86. The ichneumonid *Bathyplectes anurus* was the most common parasitoid, but *B. curculionis*, the braconids *Microctonus aethiopoides* and *M. colesi*, and the eulophid, *Oomyzus incertus* were also present. The ichneumonids *Bathyplectes curculionis*, *B. anurus* and *B. stenostigma* are important factors in control and have been reported to parasitize >90% of the larvae attacking the first crop of lucerne. However, they cannot be depended upon to entirely prevent damage by the weevil. *Microctonus aethiopoides* and other biocontrol agents are effective in some circumstances (CPC 2012).

Breeding pasture species for resistance may be a management option to consider for the future, as some hosts display host plant resistance (CPC 2012).

Chemical control is available[23]: EPA-registered rescue treatments include spraying with carbaryl, chlorpyrifos, malathion, dimethoate, methomyl and permethrin (CPC 2012). Integrated Pest Management (IPM) could be used. Overseas, *H. postica* is the key pest around which lucerne IPM programmes are designed (CPC 2012).

References:

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 23 May 2012, Crop Protection Compendium Report - *Hypera postica* http://www.cabi.org/cpc/?compid=1&dsid=28335&loadmodule=datasheet&page=868&site=161 , Accessed 3 August 2012.

Hoff, K M; Brewer, M J; Blodgett, S L (2002) Alfalfa weevil (Coleoptera: Curculionidae) larval sampling: comparison of shake-bucket and sweep-net methods and effect of training. *Journal of Economic Entomology* 95 (4): 748-753. Abstract only seen.

MPI (2012) Interceptions database accessed August 2012. Unpublished data.

Quinn, M A; Bezdicek, D F; Smart, L E; Martin, J (1999) An aggregation pheromone system for monitoring pea leaf weevil (Coleoptera: Curculionidae) in the Pacific Northwest. *Journal of the Kansas Entomological Society* 72 (3): 315-321. Abstract only seen

[23] Relevance to the EPA Review: carbaryl and methomyl are carbamates, and chlorpyrifos, malathion, & dimethoate are organophosphates under review.

Hypera zoilus (Clover leaf weevil)

Scientific Name: *Hypera zoilus* (Fabricius, 1763) (Coleoptera: Curculionidae)
Synonyms:
Common Name: Clover leaf weevil

Brief description:
The larvae of *Hypera zoilus* feed on the leaves of clovers and lucerne and cause defoliation. It has been reported causing serious damage in both Europe and the USA (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*, *Trifoium pratense*, White clover (*Trifolium repens)* (main hosts), Timothy (*Phleum pratense)* (other host)
Other plants: *Medicago falcata*, *Trifolium incarnatum* (main hosts). The adults feed on a great variety of flowers and have been observed in large numbers on goldenrod (*Solidago*), and also on wheat, maize, soyabeans and many common weeds and flowering plants (CPC 2012).

Current geographic distribution:
The weevil is probably native to southern Europe and has been accidentally introduced to the USA and subsequently Japan

Asia: Japan, Turkey.
Africa: Algeria, Ethiopia.
North America: Canada, USA.
Europe: Austria, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Gibraltar, Greece, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Sweden, Switzerland.

Potential pathways of entry into New Zealand (Commodity Association):
The adults feed on the stems or leaves of clovers and lucerne, while larvae feed on the leaves. Eggs are laid on the host plants or on the ground at the base of the plant. The larval stage is the main over wintering stage. The pupal cocoon occurs on the ground or in plant debris at the base of host plants (CPC 2012). Since host plant material is not imported into New Zealand (C. Black pers comm. 2012), *H. zoilus* is most likely to enter New Zealand as a hitchhiker on inanimate pathways such as used agricultural machinery contaminated with host plant debris. Over-wintering larvae could survive shipment to New Zealand even in the absence of fresh host material. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
H. zoilus has a widespread distribution occurring from northern Europe to North Africa. Given the widespread distribution of the weevil it is unlikely that there would be climatic barriers to it establishing in New Zealand. Lucerne is commonly grown in dryland pasture systems in New Zealand (Charlton & Stewart 1999) and clover species are widespread. The beetle can spread locally by flying and could be spread over larger distances on plant material or machinery.

Potential Impact in NZ: Moderate
H. zoilus sometimes causes serious injury to clover and lucerne. Rarely is a crop entirely lost in the USA, but considerable injury may result, especially in backward or dry seasons, before the larvae are killed by the almost universally prevalent fungus disease *(Zoophthora phytonomi*) to which they are susceptible (CPC 2012). The fungus is not known to occur in New Zealand (Landcare Research 2011) so the impact on New Zealand pastoral systems is uncertain.

Possible methods of post-border management and surveillance:
Surveillance: There were no records for *H. zoilus* in CAB abstracts. It is presumed that the surveillance methods described for *H. postica* would be applicable to *H. zoilus*.

Visual inspection: Look for typical adult feeding damage to the leaves and stems of legumes consisting of parenchyma eaten from the leaves and feeding punctures in the stems. Smooth-edged notches are also eaten from the leaf margins and occasionally the whole leaves eaten off. Small grey-brown, mottled weevils may be seen on the undersides of leaves (CPC 2012).

Larval damage consists of small holes and irregular patches eaten in the leaves. Small, green, fat-bodied, legless larvae will be found during the daytime hidden away around the base of the legume plants, occasionally feeding on the leaves (CPC 2012).

Post-border management:
Spraying infested fields in the spring when clover or lucerne is 5 - 15 cm high with malathion or carbaryl has been suggested as rescue treatment (CPC 2012)[24].

The ichneumonid parasitoid, *Bathyplectes tristis*, and the fungus *Zoophthora phytonomi* may be effective for biological control (CPC 2012).

Cultural control methods may be effective e.g. crop rotation (CPC 2012).

References:
Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Hypera zoilus*
http://www.cabi.org/cpc/?compid=1&dsid=28336&loadmodule=datasheet&page=868&site=161 Accessed 19 August 2012.

Landcare Research (2011) NZ Fungi. Last updated May 2011. Available online at: http://nzfungi.landcareresearch.co.nz/html/mycology.asp?ID= Accessed 19/8/12.

[24] Relevance to the EPA Review: malathion is an organo-phosphate, and carbaryl is a carbamate under review.

Limonius californicus (Sugarbeet wireworm)

Scientific Name: *Limonius californicus* (Mannerheim) (Coleoptera: Elateridae)
Synonyms: *Cardiophorus californicus* Mannerheim
Pheletes californicus (Mannerheim)
Common Name: Sugarbeet wireworm

Brief description:
Limonius californicus is a soil-associated click beetle whose larvae feed on seeds, roots, and tubers, destroying seedlings, and occasionally feeding on or in stems. It is primarily a pest of sugarbeet and potatoes (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa), Trifoium pratense* (main hosts)
Other plants: Beetroot, sugarbeet, beans, potato, wheat, maize (main hosts) (CPC 2012).

Current geographic distribution:
L. californicus is restricted to the Pacific coast, north-west USA, and the Prairie Provinces of Canada on irrigated land or where annual rainfall exceeds 460 mm.

North America: Canada, USA (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The females lay eggs in the soil, preferring soil shaded by vegetation, which maintains soil moisture. Depending on the moisture, temperature, and firmness of the soil, the eggs are oviposited from just below the soil surface to depths of 15 cm. Eggs laid in compact soil or near the soil surface can suffer high mortality if rapid fluctuations in moisture and temperature occur. The larvae feed on seeds, roots or germinating hosts. They feed only on underground plant parts. Soil temperature and moisture affect larval activity. Cool, wet weather brings the larvae nearer the surface. Dry, hot weather forces them deeper into the soil. The larvae take 3 years to develop, then form pupae in earthen chambers at depths of 5 to 10 cm (CPC2012). The transport of contaminated soil containing eggs and/or larvae or pupae on imported used machinery is a possible entry pathway. However, given the vulnerability of these life stages to dessication, they may be unlikely to survive transfer to New Zealand. Tubers containing larvae are probably the most likely entry pathway, but spread via this means has not been reported (CPC 2012).

Although the larvae can feed and burrow into seed, only seed in the ground is affected (CPC 2012). Thus seed for sowing and imported grains are not likely to be pathways for entry into New Zealand.

Potential to establish and spread in NZ: Moderate
L. californicus occurs in northern USA and southern Canada which is climatically similar to New Zealand, at least in places. Suitable hosts are widely grown in New Zealand. However, it is primarily a pest in low-lying, naturally moist or irrigated cultivated land. It does not survive in dryland cropping conditions (CPC 2012) which could restrict its potential distribution in New Zealand because lucerne is commonly grown in dryland pasture systems (Charlton & Stewart 1999). However, clovers are widespread. Adult beetles can fly so *L. californicus* would be able to spread naturally or through human assisted means if it established in New Zealand.

Potential Impact in NZ: Moderate
L. californicus is an important pest of sugarbeet, potatoes, irrigated crops, and small grains. Severe larval infestation can kill host crops. In the first year, larvae cause little damage due to

their small size. Second- and third-year larvae cause more significant damage. In general, wireworms are some of the best known soil-inhabiting crop pests (CPC 2012). No reports have been found of extensive damage in pastoral situations. The scale of the impact may be limited by the potentially restricted distribution in New Zealand. The impact on New Zealand pastoral systems is uncertain but likely to be moderate.

Possible methods of post-border management and surveillance:
Surveillance: No records were found in CAB abstracts about surveillance specifically for *L. californicus.* However, there is a record of Japanese-beetle trap being used to monitor another *Limonius* species (Horton & Landolt 2001). Soil samples can be taken and examined for larvae (wireworms). Samples should be taken to a depth of 15 cm when soil at that depth is 7°C or above. Careful observation during ploughing, or discing a field, especially following grass, clover (*Trifolium* spp.) or Lucerne *(Medicago sativa)* may also lead to the larvae being detected (CPC 2012). Note: A pheromone produced by females has been identified (El-Sayad 2012).

Post-border management: Much of the evidence about management of *L. californicus* relates to sugarbeet or potato crops. The chemicals used[25] to suppress *L. californicus* wireworm populations in potato crops include chlorpyrifos (at a rate between 0.3 and 0.4 kg of active ingredient per hectare) and diazinon (at a rate of between 0.6 and 0.7 kg of active ingredient per hectare). Fumigants injected into the soil can control wireworms (CPC 2012).

There are no current economic thresholds that assist in making decisions concerning pesticide applications for *L. californicus*, or any other wireworms.

Cultural control methods relevant to potato and sugarbeet crops have been described (CPC 2012).

References:
Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 27 March 2012, Crop Protection Compendium Report - *Limonius californicus*
http://www.cabi.org/cpc/?compid=1&dsid=31099&loadmodule=datasheet&page=868&site=161 Accessed 4 September 2012.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Horton, D R; Landolt, P J (2001) Use of Japanese-beetle traps to monitor flight of the Pacific coast wireworm, Limonius canus (Coleoptera: Elateridae), and effects of trap height and color. *Journal of the Entomological Society of British Columbia* .98: 235-242.Abstract only seen.

[25] Relevance to the EPA Review: Chlorpyrifos and diazinon are organophosphates under review.

Naupactus xanthographus (South American fruit tree weevil)

Scientific Name: *Naupactus xanthographus* (Germar) (Coleoptera: Curculionidae)
Synonyms: *Pantomorus xanthographus* (Germar)
Common Name: South American fruit tree weevil

Brief description:
The larvae of *Naupactus xanthographus* feed on the roots of host plants, causing the leaves to wilt. The flightless adults cause superficial damage to leaves (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host)
Other plants: apple, olive, apricot, sweet cherry, avocado, soyabean, kiwifruit, citrus, loquat, almond, plum, peach, pear, potato, grapevine (CPC 2012).

Current geographic distribution:
South America: Argentina, Brazil, Chile, Paraguay, Uruguay (CPC 2012)

Potential pathways of entry into New Zealand (Commodity Association):
Larvae occur in the soil or in roots of host plants. Pupae occur in the soil at depths of more than 30cm. Therefore, pathways involving soil such as used agricultural machinery are potential means of entry. There is unlikely to be sufficient soil on footwear for this to be a likely pathway. The flightless adult is reported to be a potential contaminant of fruit while it is being picked or standing in open bins (CPC 2012) and it has been intercepted with shipments of fresh blueberries to the US (APHIS 2007). Hitchhiker pathways may therefore be the most likely entry pathways.

Potential to establish and spread in NZ: Moderate
N. xanthographus occurs in South American countries which have, at least in places, similar climatic conditions to New Zealand. It is assumed that climate would not be a barrier to establishment over much of New Zealand. The weevil has a wide host range. Females can lay up to 850 eggs, and may retain viable sperm for 3.5 months. These traits are likely to facilitate rapid population build up. The adults are flightless so spread would be dependent on human mediated movement of infested host material or nursery stock.

Potential Impact in NZ: Low for the pastoral sector
N. xanthographus is primarily a pest of fruit trees and although lucerne is reported to be a main host (CPC 2012) no reports of significant impacts on lucerne have been found. It is assumed that infestation would result in reduced productivity due to damage to the root system rather than death of the plant. The impacts are likely to be higher on fruit crops.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance could include soil sampling for presence of lavae (CPC 2012) and/or visual inspection of the pasture. A suction sampling device (Vortis sampler) has been used to monitor for the adult life-stage of another *Naupactus* species in New Zealand pasture (Hardwick 2004).

Post-border management:
In Chile, compounds that have been used to control adults include dieldrin and carbofuran[26] (CPC 2012, Caballero 1972). Larvae of *N. xanthographus* were susceptible to strains of *Metarhizium anisopliae* (Deuteromycotina: Hyphomycetes) when the temperature was kept at 25°C (Ripa & Rodriguez 1989). Some strains were still effective at 16°C.

[26] Relevance to the EPA Review: carbofuran is a carbamate under review.

The insecticide azinphos-methyl was effective against *N. xanthographus* when pasted onto polyethylene strips which were wrapped around vine stems (Ripa & Berho 1990).

References:

APHIS (2007) Importation of fresh highbush and rabbit-eye blueberry (*Vaccinium corymbosum* L & *V. virgatum* Aiton) fruit into the Continental United States from Uruguay. A pathway initiated risk assessment. United States Department of Agriculture, Animal and Plant Health Inspection Service.

Caballero, V C (1972) Some aspects of the biology and control of *Naupactus xanthographus* Germar (Coleoptera: Curculionidae) on peach trees in Chile. *Revista Peruana de Entomologia*, 15: 190-194

CPC (2012) last modified 15 May 2012, Crop Protection Compendium Report - *Naupactus xanthographus* http://www.cabi.org/cpc/?compid=1&dsid=35771&loadmodule=datasheet&page=868&site=161 Accessed 19 August 2012.

Hardwick, S (2004) Colonisation of renovated pastures in Waikato by four coleopteran species. *New Zealand Plant Protection Society* 57 304-309.

Ripa, S; Berho, A P (1990) Evaluation of azinphos-methyl concentration and width of the INIA 82.2 barrier upon the control of fruit tree weevil *Naupactus xanthographus* (Gamar) (Coleoptera: Curculionidae) in vines. *Simiente*, 60(2): 138-142. Abstract only seen.

Ripa, S; Rodriguez, A F (1989) Susceptibility of the larvae of *Naupactus xanthographus* (Coleoptera: Curculionidae) to eight isolates of *Metarhizium anisopliae* (Deuteromycotina: Hyphomycetes). *Agricultura Tecnica*, 49(4): 336-340. Abstract only seen.

Oulema melanopus (Oat leaf beetle)

Scientific Name: *Oulema melanopus* (Linnaeus) (Coleoptera: Chrysomelidae)
Synonyms: *Chrysomela melanopus* Linnaeus
Lema atrata Waltl
Lema melanopa (Linnaeus)
Lema melanopoda Müller
Lema melanopus (Linnaeus)
Lema nigricans Westhoff
Lema waltli Heinze
Common Name: Oat leaf beetle

Brief description:
Adults and larvae of *Oulema melanopus* feed on the leaves of cereals and grasses. In the absence of natural enemies, they may cause considerable damage to crop plants (CPC 2012).

Indicative host range:
Priority Pasture Species: Tall Fescue *(Festuca arundinacea),* Timothy (*Phleum pratense)* (main hosts, CPC 2012); Perennial ryegrass (*Lolium perenne*) and Chicory (*Cichorium intybus*) (Bayram *et al* 2004).
Other plants: oats, wheat, maize, rye, canary grass, quack grass, barley, foxtail millet (CPC 2012).

Current geographic distribution:

Asia: Afghanistan, Azerbaijan, China, Iran, Israel, Kazakstan, Mongolia, Syria, Turkey, Turkmenistan, Uzbekistan.
Africa: Algeria, Morocco, Tunisia
North America: Canada, USA
Europe: Albania, Austria, Belarus, Belgium, Bulgaria, Czech Republic, Cyprus, Denmark, Finland, France, Germany, Gibraltar, Greece, Hungary, Ireland, Italy, Lithuania, Luxemburg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Slovenia, Spain, Sweden, Switzerland, Ukraine, UK (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
O. melanopus overwinters as an adult in sparse woodlands, fence rows, dense woodlands, small grain stubble, or near other topographic features which intercept wind movement. The adults appear to be gregarious (Clement & Elberson 2010). Given these characteristics, hitchhiker pathways may be the most likely means of entry into New Zealand. Adults are associated with leaves of host plants when they emerge from pupae, and larvae are also associated with host plant foliage. Fresh host plants are not imported into New Zealand (C. Black pers comm. 2012) and larvae would be unlikely to survive on dead plant material. The larvae pupate in the soil, but high pupal mortality has been reported so soil related pathways are unlikely entry pathways. Adults may be associated with plants during seed harvest and may enter on the seed for sowing pathway, but are unlikely to survive shipment in the absence of leaf material. Fresh host plant material associated with passengers is a possible pathway. There are three interception records for *O. melanopus* at the New Zealand border (MPI 2012). All were dead. One was associated with a new tractor from Mexico, one was with plant material from a non-host plant and the third was from seed for sowing. These interceptions provide supporting evidence for the pathways identified above.

Potential to establish and spread in NZ: High
O. melanopus is widely distributed in temperate parts of the northern hemisphere including countries such as the UK which have a similar climate to many parts of New Zealand. Neither

climate nor availability of suitable host plants are likely to be barriers to establishment in New Zealand. Adults can fly and would spread the beetle locally with long distance dispersal occurring through human mediated transport of infested plant material.

Potential Impact in NZ: Moderate
In the absence of natural enemies, *O. melanopus* may cause considerable damage to crop plants. Yield losses as high as 55% in spring wheat and 23% in winter wheat have been reported from heavily infested fields. In oats and barley, yields have been reduced by as much as 75%. No reports of yield reduction in pasture grasses have been found and they may be expected to be lower given the more extensive growing methods. *O. melanopus* has also been shown to vector a number of viruses.

Possible methods of post-border management and surveillance:
Surveillance:
O. melanopus can be visually surveyed or sweep-nets can be used. Adults are difficult to observe, so the use of a sweep-net gives a more accurate picture of the degree of infestation. Spring surveys should begin in succulent grain fields after a few days in which the temperature exceeds 9°C. Survey for summer adults should focus on succulent growth of maize, sudan, reed canary, and other grasses. The use of an aggregation pheromone in baited traps has been reported; it caught 3 times more beetles than the control trap in the trial (Rao *et al.* 2003). Further work would be needed to verify the efficacy of the pheromone trap.

Post-border management: Much of the literature about management and control of *O. melanopus* relates to grain crops (e.g. wheat, oats).

The biological control efforts in North America have been reviewed. Four European parasites, *Anaphes flavipes*, *Tetrastichus julis*, *Diaparsis temporalis* and *Lemophagus curtus*, have been successfully established. Failure of the parasitoids to spread with *O. melanopus*, unsuccessful adaptation to new environments and changes in farming practices have reduced the success of the programme. *Tetrastichus julis* was also established in Canada and was outstandingly successful in Ontario, by contrast to Michigan, as a result of differing climate and cultural practices (CPC 2012).

Host-Plant Resistance: Some research has been done on host-plant resistance. *O. melanopus* did not distinguish between Tall Fescue *(Festuca arundinacea)* lines with and without endophytes (CPC 2012).

Chemical Control*: Oulema melanopus* is susceptible to most insecticides, Control thresholds have been established for various crops (CPC 2012)

Integrated Pest Management: IPM programmes are being devised and implemented in North America and Europe (CPC 2012).

References:
Bayram, A. Doganlar, O. Can, F. Kornosor, S. (2004) The distribution and host plants of the cereal leaf beetle (Oulema melanopus (L.), Coleoptera: Chrysomelidae) in the East Mediterranean region of Turkey. Ziraat Fakultesi Dergisi, Mustafa Kemal Universitesi; 2004. 9: 1/2, 43-49

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Clement, SL; Elberson, LR (2010) Variable effects of Grass-neotyphodium associations on cereal leaf beetle (Coleoptera: Chrysomelidae) feeding, development and survival. *Journal of Entomological Science* 45 (3): 197-203

CPC (2012) last modified 15 November 2010, Crop Protection Compendium Report - *Oulema melanopus* http://www.cabi.org/cpc/?compid=1&dsid=30249&loadmodule=datasheet&page=868&site=161 Accessed 19 August 2012.

MPI (2012) Interceptions database. Unpublished data. Accessed 6/8/12.

Rao, S; Cosse, AA; Zilkowski, BW; Bartelt, RJ (2003) Aggregation pheromone of the cereal leaf beetle: field evaluation and emission from males in the laboratory. *Journal of Chemical Ecology* 29 (9): 2165-2175.

Sitona cylindricollis (Sweetclover Weevil)

Scientific Name:	*Sitona cylindricollis* Fåhraeus, 1840 (Coleoptera: Curculionidae)
Synonyms:	*Sitona alpinensis* Tanner, 1987
	Sitona meliloti Watson, J., 1846
	Sitones cylindricollis Fåhraeus, 1840
	Sitones procerus Casey, 1888
Common Name:	Sweetclover Weevil

Brief description: The larvae of *Sitona cylindricollis* feed on the roots of leguminous plants, particularly sweetclover. Adults feed on the clover foliage (CPC 2012).

Indicative host range:
Priority Pasture Species: White clover (*Trifolium repens),* Lucerne *(Medicago sativa)* (main hosts)
Other plants: *Melilotus officinalis* (sweetclover), *Vicia sativa* (main hosts). Sweetclover is apparently the primary host, but the weevil has been reported from a range of legumes (CPC 2012).

Current geographic distribution:
Asia: Afghanistan, China, Iran, Israel, Turkey, Turkmenistan, Uzbekistan
Africa: Morocco
North America: Canada (multiple regions), USA (many states)
Europe: Albania, Austria, Belgium, Bulgaria, Czechoslovakia (former), Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Russian Federation, Spain, Sweden, Switzerland, Yugoslavia (former) (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association): Since *S. cylindricollis* has life-stages occurring in soil, roots, and foliage, the most likely pathways of entry to New Zealand are on items that can be contaminated with infested soil or host-plant material. Since neither forage material nor nursery stock of pasture species are imported into New Zealand (C. Black pers comm. 2012), potential entry pathways include used farm machinery and passengers (footwear; plant material in luggage).

Potential to establish in NZ: High
As this species prefers cold climates, can overwinter as adults or eggs, and occurs in countries with climate similarities to New Zealand (CPC 2012), there is high potential that it could establish in New Zealand. Suitable hosts are widespread and the weevil would be able to spread naturally or through human assisted means.

Potential Impact in NZ: Moderate
Adults mainly attack sweetclover causing defoliation of young plants and affecting pasture production whereas larvae damage roots and root nodules (CPC 2012). They have also been reported as a major pest of lucerne in the USA. The larvae also damage root nodules (CPC 2012). Since the extent to which lucerne would be a preferred host in New Zealand is not known, there is uncertainty about potential impacts should it establish on lucerne.

Possible methods of post-border management and surveillance:
Surveillance: Juvenile life-stages of *Sitona* species can be surveyed by taking soil samples. Adults can be surveyed by using a suction insect sampler (e.g. Vortis sampler) (Gerard *et al.* 2010).

Post-border management: Procarb (Bayer 39007), dimethoate, and malathion in contact sprays gave control equal to that given by dieldrin (superseded). Procarb, dimethoate and malathion were also as effective as dieldrin in residual sprays. In formerly Soviet central Asia, effective control can be obtained by spraying with chlorinated pinene, trichlorphan (khlorofos), carbaryl and dimethoate and dusting with parathion-methyl (CPC 2012).[27]

Cultural Control: Crop rotation, which will put infested fields in a grass or cultivated crop, will drive out the weevils. If the land is ploughed late in the autumn or early in the spring, many of the weevils will be destroyed (CPC 2012).

Biological Control: Attempts at biological control in North America in the 1940s and 1950s using several parasitoid species were not successful (CPC 2012).

Host-Plant Resistance: Given that some species of *Medicago* are resistant to *S. cylindricolis* feeding (CPC 2012), there is some potential for breeding programmes to develop host-plant resistance in priority pasture species.

References:

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Sitona cylindricollis* http://www.cabi.org/cpc/?compid=1&dsid=50225&loadmodule=datasheet&page=868&site=161 , Accessed 19 August 2012.

Gerard, P J; Goldson, S L; Hardwick, S; Addison, P J; Willoughby, B E (2010) The bionomics of an invasive species Sitona lepidus during its establishment in New Zealand. *Bulletin of Entomological Research* 100: 3, 339-346

[27] Relevance to the EPA Review: dimethoate & malathion are organophosphates, and carbaryl is a carbamate under review.

Sitona hispidulus (Clover Weevil)

Scientific Name: *Sitona hispidulus* Gyllenhal, L. in Schnherr, CJ., 1834 (Coleoptera: Curculionidae)
Synonyms:
Common Name: Clover Weevil, Clover Root Curculio, Clover Root Weevil

Brief description: *Sitona hispidulus* is a weevil whose larvae feed on the root nodules of clover. Adults feed on the clover foliage (CPC 2012).

Indicative host range:
Priority Pasture Species: Clovers *(Trifolium* spp.); Lucerne *(Medicago sativa)*;
Other plants: *Lotus* sp. *Medicago varia* (variegated alfalfa); *Medicago lupulina* (black medick); *Melilotus alba* (honey clover); *Vicia* (vetch).

Current geographic distribution:
Asia: Iran, Israel, Japan, Korea, Taiwan, Turkey
North America: Canada (multiple regions), USA (many states)
Europe: Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, United Kingdom, Yugoslavia (former) (CPC 2012)

Potential pathways of entry into New Zealand (Commodity Association): As *S. hispidulus* is an insect that has life-stages occurring in soil, roots, and foliage, the most likely pathways of entry to New Zealand are on items that can be contaminated with infested soil or host-plant material. Since neither forage material nor nursery stock of pasture species are imported into New Zealand (C. Black pers comm. 2012), potential entry pathways include: farm machinery, farm vehicles, passengers (footwear; plant material in luggage).

Potential to establish in NZ: High.
As this species prefers cold climates, can overwinter as adults or eggs, and occurs in countries with climate similarities to New Zealand (CPC 2012), there is high potential that it could establish in New Zealand.

Potential Impact in NZ: High
Larvae are the most damaging life-stage. In one USA record, lucerne height was reduced by 23-39%; reduced harvest (kg/ha) was accompanied by significant increases in weed biomass, contributing to a reduction in total crude protein in the harvest. Weevil feeding on roots may increase fungal infection (*Fusarium* spp), causing problems with white clover persistence.

As lucerne and clover are main host plants, there is high potential that this pest could have an impact in NZ similar to *S. lepidus* (Clover root weevil, which has already established in NZ); i.e. declines in clover content & pasture quality; resulting in reduced nitrogen fixation, and increased need to apply high levels of nitrogen fertiliser (AgResearch, undated).

Possible methods of post-border management and surveillance:
Surveillance: Juvenile life-stages of *Sitona* species can be surveyed by taking soil samples. Adults can be surveyed by using a suction insect sampler (e.g. Vortis sampler) (Gerard *et al.* 2010). Note: An attractant of *S. hispidulus* has been reported (El-Sayad, 2012).

Post-border management:
Chemical control[28]: Metribuzin has been used against *S. hispidulus*. Chemical control methods, for example, chlorpyrifos used against other pasture pests such as *Tipulidae*, could be expected to reduce populations of *S. hispidulus*.

Biological control: 20 natural enemies (parasites and predators) are listed in CPC (2012). The efficacy of these has not been researched in this project. The egg parasite *Patasson lameerei* has been introduced from Europe to the USA as a potential biological control agent but has failed to establish. The myramid egg parasite *Aphanes diana* was also introduced to the USA and is tentatively established (CPC 2012).

Cultural control: Some methods of cultural control may reduce populations of the weevil, for example, heavy rolling and mob stocking, but these have limited application.

Host-plant resistance: Some commercially available cultivars of White clover (*Trifolium repens)* and Lucerne *(Medicago sativa)*have shown a small degree of resistance.

References:
Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC. 2012, last modified 17 May 2012, Crop Protection Compendium Report - *Sitona hispidulus* (clover weevil), http://www.cabi.org/cpc/?compid=1&dsid=50227&loadmodule=datasheet&page=868&site=161, Accessed 31 May 2012.

AgResearch, undated, A Weevil Pest of White Clover, http://www.agresearch.co.nz/our-science/biocontrol-biosecurity/pest-control/clover-root-weevil/docs/CRW%20biocontrol%20lifecycle.pdf, Accessed 31 May 2012.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Gerard, P J; Goldson, S L; Hardwick, S; Addison, P J; Willoughby, B E (2010) The bionomics of an invasive species *Sitona lepidus* during its establishment in New Zealand. *Bulletin of Entomological Research; 2010.100: 3, 339-346*

[28] **Relevance to the EPA Review:** None

Sphenophorus venatus confluens (Billbug)

Scientific Name: *Sphenophorus venatus confluens* Chittenden (Coleoptera: Curculionidae)
Synonyms:
Common Name: Western orchard grass billbug

Brief description: All life-stages of the weevil *Sphenophorus venatus confluens* are closely associated with orchard grass/cocksfoot (*Dactylis glomerata*). The larvae severely damage orchard grass by tunnelling up stems and into crowns. Heavy infestations may destroy entire plants. The adult weevils also feed on the grass and overwinter amongst the crowns (Rao & Anderson 2011).

Indicative host range:
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*) (Umble et al. 2005).
Other plants: Bent grasses *(Agrostis spp.)*, *Poa* spp.

Current geographic distribution:
America: Oregon state, USA (Umble et al. 2005). The hunting billbug, *Sphenophorus venatus* also occurs in Costa Rica, Honduras, Mexico and the West Indies (Anderson 2004).

Potential pathways of entry into New Zealand (Commodity Association):
Little information is available on the biology of *Sphenophorus venatus confluens.* However, it appears to have a small host range and spends its entire life-cycle in association with the host plant: eggs are laid in the stems, larvae develop in the stems and roots, pupae are laid at the base of the stems and adults overwinter in the crowns of the plants (Umble et al. 2005). Since orchard grass from the USA is not imported into New Zealand as fodder or nursery stock, the most likely means of entry is as a hitchhiker. Used agricultural machinery contaminated with infested orchard grass plant material could transport the weevil, although it is unlikely that any life-stage except perhaps the pupa which lasts about 6 weeks would survive shipment to New Zealand in the absence of fresh host material.

Alternatively, adults move around the fields in autumn and although no record has been found of overwintering away from host plants they could conceivably seek shelter in inanimate objects such as packing cases or machinery and be transported to New Zealand in a hibernating state. Passengers (plant material in luggage) is a possible pathway.

Potential to establish and spread in NZ: High
The only recorded location for *Sphenophorus venatus confluens* is Oregon in the north-west of the USA. This has a temperate climate that is likely to be similar to that in New Zealand, at least in some places. Orchard grass is widespread in New Zealand and host availability is not likely to limit the establishment or spread of *S. venatus confluens*. The beetle can spread locally by flying or walking and could be spread over larger distances on plant material, soil or machinery.

Potential Impact in NZ: Moderate
Sphenophorus venatus confluens is a pest of commercial orchard grass seed production crops in Oregon, USA. Yields are affected drastically, and stands decline and become unproductive if the weevils are not controlled (Gao & Anderson 2011). No information was found on its impacts in extensive pasture conditions. It is assumed that they would be lower than in conditions of intensive cultivation. However, impacts could be similar where Cocksfoot (*Dactylis glomerata*) is grown for seed production in New Zealand.

Possible methods of post-border management and surveillance:
Surveillance: *Sphenophorus venatus confluens* can be surveyed by analysing soil samples (Umble *et al.* 2005).

Post-border management: The accepted practice has been to apply insecticide in the spring to control overwintering adults. But a recent study recommends that management of this pest can be enhanced by using control measures in the autumn instead of in the spring (Umble *et al.* 2005). Rao & Anderson (2011) provide details about the use of chlorpyrifos[29], and bifenthrin, a recently registered chemical in Oregon. Crop rotation is discussed as an option (Rao & Anderson 2011).

References:
Anderson, R (2004) Dryohphthoridae of Costa Rica and Panama. Available online at: http://www.inbio.ac.cr/papers/Dryophthoridae/introduction.htm accessed 3/8/12.

Rao, S; Anderson, N (2011) Pacific Northwest Insect Management Handbook: grass seed pests. Available online at: http://insects.ippc.orst.edu/pnw/insects?10LEGU07.dat accessed 3/8/12.

Umble, J; Fisher, G; Rao, S (2005) Sampling methods and seasonal phenology of *Sphenophorus venatus confluens* Chittenden (Coleoptera: Curculionidae) in orchard grass (*Dactylis glomerata* L.) *Journal of Agricultural and Urban Entomology* 22: (2) 79-85.

[29] Relevance to the EPA Review: chlorpyrifos is an organophosphate under review

Tanymecus palliatus (Beet leaf weevil)

Scientific Name: *Tanymecus palliatus* (Fabricius) (Coleoptera: Curculionidae)
Synonyms: *Curculio palliatus* Fabricius
Common Name: Beet leaf weevil

Brief description: Very little information is available on the beet leaf weevil. Bogoyavlensky (1916) reports that the weevils can be found on sugar beet and a range of other plants including clovers and chicory, although it is uncertain whether all of these actually serve as food. Adult beetles gnaw shoots, cotyledons, and young first leafs but injury from this pest is usually not large. Pest harmfulness decreases after the appearance of the second pair of true leaves (David'yan 2008). Vanderwalle (1950) reports that adult *Tanymecus palliatus* beetles eat cultivated chicory (the vegetable form) leaves in dry seasons, but no recent reports of harm to any pasture species have been found. In the absence of recent evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Chicory *(Cichorium intybus)*, clovers (Bogoyavlensky 1916)
Other plants: *Beta vulgaris*, maize (CPC 2012)

Current geographic distribution:
Europe: Bulgaria, France, Romania, Russian Federation, Switzerland, Ukraine, Yugoslavia (former) (CPC 2012).

References:

Bogoyavlensky, SG (1916) Report of the work of the Entomological Department of the Myco Entomological Experimental Station of the All-Russian Society of Sugar-refiners in Smiela (govt of Kiev) for 1915. 6-23. (Only abstract accessed)

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Tanymecus palliatus*, http://www.cabi.org/cpc/?compid=1&dsid=54124&loadmodule=datasheet&page=868&site=161 , Accessed 19/8/12.

David'yan, GE(2008) *Tanymecus palliatus*. In ANAfonin; SL Greene; NI Dzyubenko; AN Frolov (eds.) Interactive Agricultural Ecological Atlas of Russia and Neighboring Countries. Economic Plants and their Diseases, Pests and Weeds [Online]. Available at: http://www.agroatlas.ru/en/content/pests/Tanymecus_palliatus/ accessed 19/8/12

Vanderwalle, R (1950) Diseases and pests of chicory. *Revue de l'Agriculture, Bruxelles*. 3: 832-42

6.3 Flies - Diptera

Agromyza frontella (Alfalfa blotch leafminer)

Scientific Name:	*Agromyza frontella* Rondani. (Diptera: Agromyzidae)
Synonyms:	*Agromyza drepanura* Hering
	Domomyza frontella
Common Name:	Alfalfa blotch leafminer

Brief description: The larvae of *Agromyza frontella* feed between the leaf surfaces in a mining fashion, eventually causing blotching of the leaf. Extensive mining may reduce forage quality, but yield loss is not expected unless significant leaf drop occurs (Jensen 1999).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host); Clovers (*Trifolium* spp.) may also be attacked
Other plants: *Medicago lupulina* (other host) (CPC 2012)

Current geographic distribution:
Originally a European species, *A. frontella* has been known in the USA and Canada since the 1970s (CPC 2012).
Asia: Afghanistan, Turkey
Americas: Canada, USA
Europe: Austria, Bulgaria, Denmark France, Germany, Italy, The Netherlands, Sweden, UK, Ukraine, former Yugoslavia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
A. frontella appears to have a small host range. Eggs are laid on the leaves of lucerne and the larvae feed in the leaves (CPC 2012). Infested fresh host material would be the most likely entry pathway. However, no fresh forage species are imported into New Zealand (C. Black pers comm. 2012) so this pathway is not relevant. Passengers (soil on footwear or plant material in luggage) are a possible pathway. The fly overwinters as a pupa in the top 2.5cm of soil so infested soil contaminating used agricultural machinery is another possible entry pathway.

Potential to establish and spread in NZ: High
A. frontella occurs in countries in Northern Europe with similar climates to New Zealand. There are likely to be few climatic barriers to establishment in New Zealand. Lucerne is its main host and clovers may also be a suitable host plant. These species are grown widely in pastoral areas of New Zealand. Jensen (1999) reports rapid spread of the fly through the state of Wisconsin and it would be expected to spread rapidly through New Zealand once established.

Potential Impact in NZ: Low
A. frontella is not normally a pest in Europe, where it appears to cause less leaf damage than it does in America. Reports of its impact in America differ, but generally it appears not to cause sufficient damage to impact yield significantly (CPC 2012). It is not known how the fly would behave in New Zealand so there is uncertainty about the potential impact in New Zealand, but it is likely to be low.

Possible methods of post-border management and surveillance:

Surveillance: Crops can be surveyed for *A. frontella* using a sweep net or a vacuum net (Plummer & Byers 1981). Note: a pheromone from *A. frontella* females has been identified (El-Sayad 2012).

Post-border management:
Biological control has been used successfully against *A. frontella*, primarily using the introduced parasitoid *Dacnusa dryas*. This species is well established as an effective biocontrol agent in Quebec, Ontario and north-eastern USA (CPC 2012). Several types of insecticide have been tested (pyrethroids, organophosphates and carbamates[30]). They reduced *A. frontella* damage significantly, but the treatments did not result in significant yield increases (CPC 2012). Aspects of cultural control are discussed in CPC (2012).

References:

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Agromyza frontella*, http://www.cabi.org/cpc/?compid=1&dsid=3655&loadmodule=datasheet&page=868&site=161 , Accessed 7/9/12.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Jensen, B (1999) Alfalva blotch leafminer. *A presentation given by Bryan Jenson, UW-Madison Integrated Pest Mgt. Program, at the 1999 Wisconsin Forage Production and Use Symposium.* Available online at: http://www.uwex.edu/ces/forage/wfc/JENSEN.html accessed 7/9/12.

Plummer, J A; Byers, R A (1981) Seasonal abundance and parasites of the alfalfa blotch leafminer, *Agromyza frontella*, in central Pennsylvania. *Environmental Entomology*; 1981.10: 1, 105-110.

[30] Relevance to the EPA Review: note that some of the carbamates and organophosphates tested may be under review.

Chromatomyia fuscula (Oat leafminer)

Scientific Name: *Chromatomyia fuscula* (Zetterstedt) (Diptera: Agromyzidae)
Synonyms: *Phytomyza avenae*
Phytomyza fuscula Zett.
Common Name: Oat leafminer

Brief description: The leaf mining fly *Chromatomyia fuscula* is a cereal pest in Northern Europe, but is more commonly associated with grasses in Canada (Andersen & McNeil 1995). The larvae feed inside the young leaves, reducing productivity.

Indicative host range:
C. fuscula breed on 14 species of cereal and grasses in experimental situations. Preferred hosts are Timothy (*Phleum pratense)*, oats, rye and *Festuca pratense* (Andersen 1995).
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*), Timothy (*Phleum pratense)*
Other plants: rye, wheat, oats, barley, meadow foxtail, English bluegrass, grasses (CPC 2012)

Current geographic distribution:
A quick search of the literature indicates that the distribution of *C. fuscula* is wider than listed below. There are papers relating to its occurrence in Poland, Switzerland, Turkey, and Quebec in Canada.
Asia: Japan
Europe: Austria, former Czechoslovakia, Hungary, Norway, Sweden (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid in host plants and larvae feed on the young leaves. Infested fresh host material would therefore be a possible entry pathway. However, cereals and grasses are only imported into New Zealand as seed for sowing or grains for consumption (C Black pers comm. 2012). Relatively little information was found on the biology of *C. fuscula* but there is no indication that any life-stage is associated with mature seed, so these are not likely pathways of entry. Adults overwinter in field margins (Hedene 1997) and could be transported as a hitchhiker in association with inanimate objects. However, there is no evidence of mass aggregation or other traits that would suggest a regular association with transported objects. Any hitchhikers are more likely to be isolated individuals. Plant material in passengers luggage or on imported used machinery could possibly transport eggs and/or larvae, but there is nothing to suggest that this would be a regular pathway. No information on pupation was found. If this occurred in the soil then pathways contaminated with soil might also be entry pathways.

Potential to establish and spread in NZ: High
C. fuscula occur in Northern and central Europe in countries with similar climates to those found in at least parts of New Zealand. The fly is able to breed on a wide range of cereals and grasses, several of which are widespread in New Zealand. Climatic conditions and host availability are not likely to be barriers to establishment in New Zealand. Adults are mobile and spread could also occur through movement of infested plant material.

Potential Impact in NZ: Low
C. fuscula is a cereal pest in Scandinavia (Andersen & McNeil 1995). However, no reports were found of it causing economic damage to forage crops, even in Canada where it is more often associated with grasses. Of the priority pasture species in New Zealand, Timothy (*Phleum pratense)* which is of moderate importance to the beef and sheep sector (Appendix 1) is the only reported preferred host species (Andersen 1995). While there is considerable uncertainty about the potential impacts should the fly establish in New Zealand they are likely to be low.

Possible methods of post-border management and surveillance:
Surveillance: *C. fuscula* can be monitored using yellow sticky traps (Roik & Wielkopolan 2011).

Post-border management:
Cyromazine (as Trigard 75 WP) and dimethoate (as FK Dimethoate) resulted in suitable protection against *C. fuscula*, especially after 2 treatments (Darvas & Anderson 1999). Spraying barley infested with *C. fuscula* with Fenitrothion or lambda-cyhalothrin at a particular stage increased yields (Andersen 1993)[31].

References:

Andersen, A. (1993) Effects of early and late spraying with phosphorus, pyrethroid and carbamate insecticides against the oatleaf miner fly in barley. [Norwegian] *Norsk Landbruksforsking* 7(1): 77-85. Abstract only seen

Andersen A (1995) Host plant preferences of *Chromatomyia fuscula* (Zett.) (Dipt., Agromyzidae) and the attack rate on various commercially grown cereal and grass species. *Norwegian Journal of Agricultural Sciences* 9: 211-216. Abstract only viewed.

Andersen, A; McNeil, JN (1995) Occurrence of *Chromatomyia fuscula* (Zett.) (Diptera: Agromyzidae) in cereals and grasses in Quebec. *The Canadian Entomologist* 127: 979-980. Abstract only viewed.

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Chromatomyia fuscula*, http://www.cabi.org/cpc/?compid=1&dsid=12989&loadmodule=datasheet&page=868&site=161 , Accessed 8/9/12.

Darvas, B; Anderson, A (1999) Effects of cyromazine and dimethoate on *Chromatomyia fuscula* (Zett.) (Dipt., Agromyzidae) and its hymenopterous parasitoids. *Acta Phytopathologica et Entomologica Hungarica*, 34(3): 231-239. Abstract only seen

Hedene, KA (1997) Leafminers on cereals in Western Sweden. *Vaxtskyddsnotiser* 6114-17. (in Swedish. Abstract only accessed).

Roik, K; Wielkopolan, B (2011) Monitoring of leaf miners (Agromyzidae) on winter wheat plantations in Wielkopolska as part of integrated pest management. In Lorencowicz, E; Uziak, J; Huyghebaert, B (ed) *V International Scientific Symposium: Farm machinery and process management in sustainable agriculture, Lublin, Poland, 23-24 November 2011.* Department of Machinery Exploitation and Management in Agricultural Engineering; Lublin; pp 123-126. [Abstract only].

[31] Relevance to the EPA Review: dimethoate and fenitrothion are organophosphates under review.

Liriomyza sativae (Vegetable leafminer)

Scientific Name:	*Liriomyza sativae* Blanchard 1938. (Diptera: Agromyzidae)
Synonyms:	*Agromyza subpusilla*
	Lemurimyza lycopersicae Pla & de la Cruz, 1981
	Liriomyza canomarginis Frick, 1952
	Liriomyza guytona Freeman, 1958
	Liriomyza minutiseta Frick, 1952
	Liriomyza munda Frick, 1957
	Liriomyza propepusilla Frost, 1954
	Liriomyza pullata Frick, 1952
	Liriomyza subpusilla
	Liriomyza verbenicola Hering, 1951
Common Name:	Vegetable leafminer

Brief description: *L. sativae* larvae mine the leaves of host plants which may cause seedlings to die and may introduce fungal infection. It has become a major pest of a wide variety of ornamental and vegetable crops, most notably tomatoes, chrysanthemums and celery, particularly under glass. Its importance has grown rapidly in the Americas since the 1970s, and distribution through commerce to other parts of the world is now producing serious problems, particularly in warmer climates (CPC 2012).

Indicative host range:
L. sativae is able to colonize a wide range of plants primarily, although not exclusively, in the Solanaceae, Fabaceae and Asteraceae
Priority Pasture Species: Lucerne *(Medicago sativa),* Clovers (*Trifolium* spp.) (main hosts).
Other plants: okra, onions, garlic, leeks, celery, peanut, sugarbeet, brassicas, capsicum, water melon, melon, cucumber, pumpkin, carrot, cotton, lettuce, sweet pea, tobacco, basil, beans, pea, raddish, tomato, aubergine, potato, spinach, cow pea, maize (main hosts) (CPC 2012)

Current geographic distribution:
Accurate distribution records are difficult to summarise because there is evidence that *L. sativae* is rapidly expanding its range and colonizing most habitats to which it is introduced (CPC 2012).
Asia: China, India, Indonesia, Iran, Israel, Japan, Jordan, Malaysia, Oman, Sri Lanka, Thailand, Turkey, Uzbekistan, Vietnam, Yemen
Africa: Cameroon, Nigeria, South Africa, Sudan, Zimbabwe
Americas: Canada, USA, Mexico, Antigua & Barbuda, Bahamas, Barbados, Costa Rica, Cuba, Dominica, Domican Republic, Guadeloupe, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines, Trinidad & Tobago, Argentina, Brazil, Chile, Colombia, French Guiana, Peru, Venezuela
Oceania: American Samoa, Cook Islands, French Polynesia, Guam, Federated States of Micronesia, New Caledonia, Northern Mariana Islands, Samoa, Vanuatu (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Multiple eggs of *L. sativae* are laid just under the surface of leaves and the larvae mine the leaves and also pupate in host plants. Adults also feed on host plants (CPC 2012). Infested fresh host material in the form of fresh produce, cut flowers or nursery stock would be the most likely entry pathways. Passengers (plant material in luggage) are a possible pathway. There have been hundreds of interceptions of *Liriomyza* sp. at the New Zealand border most of which have been on fresh produce, a few on cut flowers and a large number on basil from Fiji. There has been one interception of live *L. sativae* larvae on imported fresh produce from Fiji (MPI 2012). These records confirm the identification of possible entry pathways.

Potential to establish and spread in NZ: Low
L. sativae occurs mainly in countries with warmer climates than New Zealand. In colder areas it is apparently restricted to glass houses (Pitkin et al. 2012). It has a wide host range and suitable hosts are widespread in the warmer parts of New Zealand. The leafminer has spread widely elsewhere in recent years. For instance in China, it was first reported from Hainan Province in 1993 but has spread north and west to most Provinces since then. It is difficult to eradicate because of its ability to survive in many weed plants which normally occur in areas adjacent to crop fields (CPC 2012). Despite these traits, it is unlikely that *L. sativae* could establish in New Zealand except perhaps in protected greenhouse environments.

Potential Impact in NZ: Low for the pastoral sector
L. sativae is a serious pest of vegetable crops and if established in New Zealand has the potential to impact the horticultural sector. However, no reports were found of it causing economic damage to forage crops, and its limited potential range within New Zealand mean that the potential impact on the New Zealand pastoral sector is low if not negligible.

Possible methods of post-border management and surveillance:
Surveillance: Sticky traps placed close to the plant canopy have been successful at monitoring *L. sativae* (Robin & Mitchell 1987). Bright yellow opaque traps have been used to monitor in lucerne fields (Chandler 1981). *L. sativae* can also be surveyed using nets (CPC 2012). Note: several *L. sativae* attractants have been identified (El-Sayad, 2012).

Post-border management:
Chemical control[32]: Since 1950, with the rise in the use of largely oil-based insecticides, and chlorinated chemicals, many of the natural predators of *L. sativae* have been shown to be more susceptible to the insecticides than *L. sativae* itself. Consequently the survival of resistant strains (such as Agromyzidae) have had no enemies to control them, resulting in very large and damaging populations (CPC 2012). Preventive spraying of seedlings with residual insecticides such as abermectin or pyrethrum sprays to reduce early egg laying has been reported. The insecticides trichlorfon and diazinon have been used in an integrated control programme. Permethrin could significantly improve the yield of tomatoes, and the presence of a natural enemy of the genus *Opius*, which attacks the puparial stage, was an important regulator (CPC 2012). Armstrong *et al.* (1988) report that the following chemicals successfully controlled *L. sativae* in tomato crops: fenvalerate, permethrin, acephate, methamidophos, chlorpyrifos, carbofuran and ethoprophos.

The release of gamma-irradiated and hence sterile male *L. sativae* or Parasitica in glasshouses has been tested with considerable success (CPC 2012).

Biological control methods that have been studied include the release of the parasite *Opius dissectus* reared from *L. sativae*; and the use of entomogenous fungal strains on *L. sativae* pupae. The fungus resulted in great reductions (sometimes as much as 80%) in the emergence of adults (CPC 2012).

References:

Armstrong, A M; Cruz, C; Segarra, A (1988) Chemical control of Liriomyza sativae and of Lepidoptera larvae on tomato. *Journal of Agriculture of the University of Puerto Rico* 72 (1): 169-170.

[32] Relevance to the EPA Review: diazinon, acephate, methamidophos, chlorpyrifos are organophosphates, and carbofuran is a carbomate under review.

Chandler, L D (1981) Evaluation of different shapes and color intensities of yellow traps for use in population monitoring of dipterous leaf miners. *Southwestern Entomologist; 1981.6: 1, 23-27.*

CPC (2012) last modified 21 August 2012, Crop Protection Compendium Report - *Liriomyza sativae*, http://www.cabi.org/cpc/?compid=1&dsid=30960&loadmodule=datasheet&page=868&site=161 , Accessed 7/9/12.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

MPI (2012) Interceptions database. Unpublished data. Accessed August 2012.

Pitkin, B; Ellis, W; Plant, C; Edmunds R (2012) The leaf and stem mines of British flies and other insects. Available online at: http://www.ukflymines.co.uk/Flies/Liriomyza_sativae.php Accessed 7/9/12.

Robin, M R; Mitchell, W C (1987) Sticky trap for monitoring leafminers Liriomyza sativae and Liriomyza trifolii (Diptera: Agromyzidae) and their associated hymenopterous parasites in watermelon. *Journal of Economic Entomology* 80 (6): 1345-1347.

Liriomyza trifolii (American serpentine leafminer)

Scientific Name:	*Liriomyza trifolii* Burgess in Comstock, 1880. (Diptera: Agromyzidae)
Synonyms:	*Agromyza phaseolunata* Frost, 1943 *Liriomyza alliivora* Frick, 1955 *Liriomyza alliovora* Frick, 1955 *Liriomyza phaseolunata* (Frost, 1943) *Oscinis trifolii* Burgess in Comstock, 1880
Common Name:	American serpentine leafminer

Brief description: *Liriomyza trifolii* larvae mine the leaves of host plants. The adults also feed on foliage and the feeding punctures cause loss of vigour due to loss of photosynthetic capacity and mesophyll conductance of the foliage. It has become a major pest of a wide variety of ornamental and vegetable crops, particularly under glass. It is a relatively recent introduction to Europe (CPC 2012).

Indicative host range:
L. trifolii attacks a wide range of ornamental and vegetable crops.
Priority Pasture Species: Lucerne *(Medicago sativa),* White clover (*Trifolium repens)* (main hosts).
Other plants: okra, onions, garlic, leeks, peanut, sugarbeet, Chinese cabbage,daisy, chrysanthemum, capsicum, melon, cucumber, dahlia, carnation, cotton, soyabean, sunflower, lettuce, vetchling, beans, pea, sage, groundsel, tomato, aubergine, potato, spinach, marigold, vetch, Zinnia (main hosts). (CPC 2012)

Current geographic distribution:
L. trifolii has not yet been reported from many countries where it is believed to be present. It is generally recognized that all the countries bordering the Mediterranean have *L. trifolii* in varying degrees and that it occurs in all mainland states of the USA (CPC 2012).
Asia: China, India, Indonesia, Iran, Israel, Japan, Jordan, Israel, Republic of Korea, Lebanon, Oman, Phillipines, Saudi Arabia,Taiwan, Thailand, Turkey, Yemen
Africa: Benin, Cote D'ivoire, Egypt, Ethiopia, Guinea, Kenya, Madagascar, Mauritious, Morocco, Nigeria, Ssenegal, South Africa, Sudan, Tanzania, Tunisia, Zambia, Zimbabwe
Americas: Bermuda, Canada, USA, Mexico, Bahamas, Barbados, British Virgin Islands, Costa Rica, Cuba, Domican Republic, Guadeloupe, Guatemala, Martinique, Netherlands Antilles, Puerto Rico, Trinidad & Tobago, American Virgin Islands, Brazil, Colombia, Ecuador, French Guiana, Guana, Peru, Venezuela
Europe: Austria, Belgium, Bosnia-Herzegovnia, Croatia, Cyprus, Finland, France, Greece, Italy, Netherlands, Malta, Norway, Portugal, Romania, Russian Federation, Slovenia, Spain, Switzerland, Serbia &Montenegro
Oceania: American Samoa, Guam, Federated States of Micronesia, Northern Mariana Islands, Samoa, Tonga (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs of *L. trifolii* are laid just under the surface of leaves and the larvae mine the leaves. Pupation occurs on leaves or in the soil below host plants. Adults also feed on host plants (CPC 2012). Infested fresh host material in the form of fresh produce, cut flowers or nursery stock would be the most likely entry pathways. Passengers (plant material in luggage or soil on footwear) are a possible pathway. Infested soil contaminating used agricultural machinery is also a possible pathway. There have been hundreds of interceptions of *Liriomyza* sp. at the New Zealand border most of which have been on fresh produce, a few on cut flowers and a large number on basil from Fiji. There have been five interceptions of live *L. trifolii* larvae and one of live *L. trifolii* pupae on imported plant material from Fiji and Tonga, one of which

was in a passengers bag (MPI 2012). These records confirm the identification of possible entry pathways.

Potential to establish and spread in NZ: Low
L. trifolii occurs mainly in countries with warmer climates than New Zealand. In colder areas it is particularly a pest in glass houses and is apparently unable to overwinter in the open in the north European countries (CPC 2012). It has a wide host range and suitable hosts are widespread in the warmer parts of New Zealand. It is unlikely that *L. trifolii* could establish except in the warmest parts of in New Zealand or in protected greenhouse environments.

Potential Impact in NZ: Low for the pastoral sector
L. trifolii is now a major pest of the Compositae worldwide and causes major damage to vegetable crops in the USA. Fungal destruction of the leaf may occur as a result of infection introduced by *L. trifolii* from other sources during breeding activity. Wilt may occur, especially in seedlings. *L. trifolii* has the potential to impact the horticultural sector if established in New Zealand. However, no reports were found of it causing economic damage to forage crops, and its limited potential range within New Zealand mean that the potential impact on the New Zealand pastoral sector is low if not negligible.

Possible methods of post-border management and surveillance:
Surveillance: Field collection of the adult *L. trifolii* is done by netting. The use of sticky traps, especially yellow ones, placed near host plants is a very effective method of monitoring populations (CPC 2012).

Post-border management:
Chemical Control[33]: Some insecticides, particularly pyrethroids, are effective, but some individual strains of *L. trifolii* have become resistant to most insecticides, which makes control difficult (CPC 2012).

Biological Control: natural enemies periodically suppress leaf-miner populations and foliar applications of the entomophagous nematode *Steinernema carpocapsae* can significantly reduced adult development of *L. trifolii* (CPC 2012). A detailed list of the natural enemies of *Liriomyza* spp. and a summary of the results of the biological control introductions against L. trifolii is available (CPC 2012). Successful control of *L. trifolii* is reported with *Chrysonotomyia punctiventris* and *Ganaspidium hunteri*, *G. utilis* and *C. oscinidis* (CPC 2012).

References:
CPC (2012) last modified 10 August 2011, Crop Protection Compendium Report - *Liriomyza trifolii* http://www.cabi.org/cpc/?compid=1&dsid=30965&loadmodule=datasheet&page=868&site=161 , Accessed 7/9/12.

MPI (2012) Interceptions database. Unpublished data. Accessed August 2012.

33 Relevance to the EPA Review: none

Liriomyza trifoliearum (leafminer)

Scientific Name: *Liriomyza trifoliearum* Spencer. (Diptera: Agromyzidae)
Synonyms:
Common Name: leafminer

Brief description: *Liriomyza trifoliearum* is a leaf mining fly that feeds on lucerne and other legumes in the USA and Canada, but is maintained at a low population density by the activity of its natural enemies (Hendrickson 1979). Very little information is available on this fly, presumably because it is not of economic significance. Hendrickson & Keller (1983) state that it is not an economic pest. It might cause greater impacts in countries outside its natural range if transported without its natural enemies. However, there are no records of it having been introduced to any other countries and in the absence of evidence of it causing adverse impacts it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa),* White clover (*Trifolium repens)*
Other plants: *Pisum sativum, Trifolium incarnatum* (Spencer 1973).

Current geographic distribution:
Americas: Canada, USA (Hendrickson 1979).

References:

Hendrickson, RM Jnr. (1979) Field studies and parasites of *Liriomyza trifoliearum* (Diptera: Agromyzidae) in northeastern USA. *Journal of the New York Entomological Society* 87: 299-303. Abstract only viewed.

Hendrickson, RM Jnr., Keller, MA (1983) Observations on the biology of *Liriomyza trifoliearum* (Diptera: Agromyzidae). Proceedings of the Entomological Society of Washington. 85: 806-810. http://biostor.org/reference/55936 Abstract only viewed.

Spencer, KA (1973) Agromyzidae (Diptera) of economic importance. Available online at: http://books.google.co.nz/books?id=_uQd76hWWRkC&pg=PA23&lpg=PA23&dq=Liriomyza+trifoliearum&source=bl&ots=21wVoIsy2n&sig=rIXXRPymXeG-uFPhRF7QBShsc5g&hl=en#v=onepage&q=Liriomyza%20trifoliearum&f=false accessed 7/9/12.

Napomyza cichorii (Chicory Fly)

Scientific Name: *Napomyza cichorii* Spencer, 1966. (Diptera: Agromyzidae)
Synonyms:
Common Name: Chicory fly

Brief description: The larvae of *Napomyza cichorii* bore into the stems and leaves of cultivated vegetable chicory and it is considered a serious pest of this vegetable in Europe (Pitkin et al. 2012). Extensive mining may reduce productivity.

Indicative host range:
Priority Pasture Species: Chicory *(Cichorium intybus)*
Other plants: Endive, lettuce (Pitkin *et al.* 2012; Sant *et al.* 1975)

Current geographic distribution:
Europe: Belgium, Estonia, Finland, France, Germany, Italy, Lithuania, Spain, Switzerland, The Netherlands, UK, Ukraine (Pitkin *et al*. 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Little information is available on the biology of *Napomyza cichorii* in English. However, it appears to have a small host range and spends its entire life-cycle within the host plant. It pupates in the root (Pitkin *et al*. 2012). It is a serious pest of cultivated vegetable chicory in Belgium where it is apparently spread locally by infected roots (Desmet, 2003). Sant *et al*. (1975) report that it is able to overwinter as larvae or pupae in a variety of sites, including chicory roots remaining in the soil, in the soil itself and in the seeds of chicory. The most likely entry pathway is fresh produce imported from Europe. The only reported hosts are chicory, endive and lettuce. Chicory and endive are apparently not imported into New Zealand (Quancargo 2012). Imported fresh lettuce is a possible entry pathway but it is not known whether lettuce is a main host. Infested soil contaminating used agricultural machinery and seed for sowing are also possible pathways. Passengers (soil on footwear or plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
N. cichorii occurs in countries in Northern Europe with similar climates to New Zealand. There are likely to be few climatic barriers to establishment in New Zealand. The vegetable form of chicory is its main host. It is assumed that the pastoral form is equally susceptible and this is widely grown in pastoral areas of New Zealand. A potential barrier to establishment could be a paucity of exposure routes from imported infested produce to hosts in pastoral areas (see section 2.8.4).

Potential Impact in NZ: Low
Chicory is an important component of New Zealands' pastoral systems (Charlton & Stewart 1999). *N. cichorii* is reported to be a serious pest of cultivated chicory in Belgium and The Netherlands, presumably where it is grown intensively as a vegetable. The larvae mine the leaves extensively affecting the appearance of the vegetable. No information was found on its impacts in extensive pasture conditions. It is assumed that they would be lower than in conditions of intensive cultivation of the vegetable form of chicory[34], but there is considerable uncertainty in this assessment.

Possible methods of post-border management and surveillance:

[34] Impact on vegetable cultivation is due to damaged appearance of the vegetable; this would not have such a great impact in pastoral systems.

Surveillance: Yellow trap-boxes have been used to monitor the presence of *N. cichorii* (Desmet 2003).

Post-border management: Chemical control is referred to in Desmet (2003), but there are no details or chemicals named. In chemical control tests in Europe, diazinon and dimethoate[35] applied in various ways gave good results, especially as sprays applied once at the end of August and twice in September, but residues were found in heads treated with both compounds and in roots treated with diazinon. *N. cichorii* was parasitised by *Chorebus parvungulus* and *Dadnusa pubescens* (Sant *et al*. 1975)

References:

Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

Desmet, D (2003) Witloof miner fly (*Napomyza cichorii* Spencer) under control in Belgium thanks to a system of observation and warning. *Parasitica* 59: 119-128. Paper in Dutch only abstract viewed.

Pitkin, B; Ellis, W; Plant, C; Edmunds R (2012) The leaf and stem mines of British flies and other insects. Available online at: http://www.ukflymines.co.uk/Flies/Napomyza_cichorii.php Accessed 15/8/12.

Sant, LE van't; Bethe, JKC; Vijzelman, HE; Freriks, JC (1975) Observations on mining flies (*Napomyza* spp., Diptera, Agromyzidae) on Witloof chicory, carrots and camomile. *Verslagen van Landbouwkundige Onderzoekingen* 840 44 pp. Paper in Dutch only abstract viewed.

[35] Relevance to the EPA Review: both diazinon and dimethoate are organophosphates under review.

Napomyza lateralis (Calendula Fly)

Scientific Name: *Napomyza lateralis* Fallén, 1823. (Diptera: Agromyzidae)
Synonyms:
Common Name: Calendula fly

Brief description: Together with *Ophiomyia pinguis, Napomyza lateralis* is described as one of the most important pests of cultivated vegetable chicory (Vanderwalle 1950). However, Pitkin *et al.* (2012) do not list chicory as a host plan. Sant *et al*. (1975) indicate that *N. lateralis*, *N. carotae* and *N. chicorii* are closely related and had previously all been known as *N. lateralis*. The only other references to calendula fly feeding on chicory predate 1975. It is assumed that reference to *N. lateralis* in Vanderwalle (1950) and other early references should refer to *N. chicorii*. Therefore, *Napomyza lateralis*t is not considered to be a hazard for the pastoral sector in New Zealand sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Chicory *(Cichorium intybus)* (Vanderwalle 1950) but see above
Other plants: A range of wild hosts in the Asteraceae including *Lactuca sativa* (Pitkin et al. 2012)

Current geographic distribution:
Asia: Japan
North America: Canada
Europe: Common throughout much of Europe including Denmark, Finland, Norway, Sweden, Germany, Austria, Azores, Belarus, Belgium, Canary Is., Czech Republic, Estonia, European Turkey, French mainland, Hungary, Italian mainland, Latvia, Lithuania, Madeira, Poland, Sicily, Spanish mainland, Switzerland and Yugoslavia (Pitkin *et al*. 2012).

References:

Pitkin, B; Ellis, W; Plant, C; Edmunds R (2012) The leaf and stem mines of British flies and other insects. Available online at: http://www.ukflymines.co.uk/Flies/Napomyza_lateralis.php Accessed 27/8/12.
Vanderwalle, R (1950) Diseases and pests of chicory. *Revue de l'Agriculture, Bruxelles.* 3: 832-42.

Sant, LE van’t; Bethe, JKC; Vijzelman, HE; Freriks, JC (1975) Observations on mining flies (*Napomyza* spp., Diptera, Agromyzidae) on Witloof chicory, carrots and camomile. *Verslagen van Landbouwkundige Onderzoekingen* 840 44 pp. Paper in Dutch only abstract viewed.

Ophiomyia pinguis (Chicory Fly)

Scientific Name: *Ophiomyia pinguis* Fallén, 1820. (Diptera: Agromyzidae)
Synonyms:
Common Name: Chicory fly

Brief description: *Ophiomyia pinguis* is described as one of the most important pests of chicory (Vanderwalle 1950). The larvae live within the leaves and move between them through mines in the petioles (Pitkin *et al.* 2012). Extensive mining may reduce productivity.

Indicative host range:
Priority Pasture Species: Chicory *(Cichorium intybus)* (Pitkin *et al*. 2012)
Other plants: *Lactuca sativa, Leontodon* spp., *Taraxicum officinale*

Current geographic distribution:
Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Lithuania, Poland, Slovakia, Spain, Sweden, The Netherlands, European Turkey, UK, [fomer] Yugoslavia (Pitkin *et al.* 2012).
Africa: Egypt (Spencer 1973)

Potential pathways of entry into New Zealand (Commodity Association):
Little information is available on the biology of *Ophiomyia pinguis* and the mobility of the adult fly is unknown. However, it appears to have a small host range and spends its entire life-cycle within the host plant. It is a serious pest of cultivated chicory in Belgium and The Netherlands and is reportedly frequently introduced into Britain (Pitkin *et al.* 2012), presumably in association with imported chicory. The most likely entry pathway is fresh produce imported from Europe. Chicory is the main host, but it appears that chicory is not imported into New Zealand. Infested lettuce is a possible pathway. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
O. pinguis is widespread throughout Europe including countries in Northern Europe with similar climates to New Zealand. There are likely to be few climatic barriers to establishment in New Zealand. Chicory, which is its main host, is widely cultivated in pastoral areas of New Zealand. A potential barrier to establishment could be a paucity of exposure routes from imported infested produce to hosts in pastoral areas (see section 2.6.4). In warmer parts of Europe, *O. pinguis* has 3-4 generations a year (Spencer 1973). If this occurred in New Zealand it could result in faster build up of populations.

Potential Impact in NZ: Low
Chicory is an important component of New Zealands pastoral systems (Charlton & Stewart 1999). *O. pinguis* is reported to be a serious pest of cultivated chicory in Belgium and The Netherlands, presumably where it is grown intensively as a vegetable. In one reported case in Switzerland an entire crop was so badly infested as to be unsalable (Spencer, 1973). The larvae mine the leaves extensively causing a reddish discoloration. Vanderwalle (1950) suggests that the growth of the plant is not affected by the presence of fly larvae, the main impact being on the appearance of the vegetable. No information was found on its impacts in extensive pasture conditions. It is assumed that they would be lower than in conditions of intensive cultivation of the vegetable form of chicory, but there is considerable uncertainty in this assessment.

Possible methods of post-border management and surveillance:
Surveillance: No reports about surveillance or monitoring specifically of *O. pinguis* were found in CAB abstracts, but traps are likely to be effective; coloured traps (yellow, federal safety yellow and lime) coated with Tanglefoot (a sticky compound) were used to monitor another *Ophiomyia* species (Ferro & Suchak 1980).

Post-border management: There are no reports about *O. pinguis* in CAB abstracts from the last 30 years. For chemical control in European chicory crops (for use as a vegetable, not animal fodder) Suss (1970) recommended sprays of 0.02% dimethoate[36], to be applied to three times in mid August, September and in mid-October (i.e. in the Autumn).

References:

Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

Ferro, D N; Suchak, G J (1980) Assessment of visual traps for monitoring the asparagus miner, *Ophiomyia simplex*, Agromyzidae: Diptera. *Entomologia Experimentalis et Applicata; 1980.28: 2, 177-182.* (Abstract only)

Pitkin, B; Ellis, W; Plant, C; Edmunds R (2012) The leaf and stem mines of British flies and other insects. Available online at: http://www.ukflymines.co.uk/Flies/Ophiomyia_pinguis.php Last updated 2/6/12. Accessed 2/8/12.

Spencer, KA (1973) Agromyzidae (Diptera) of Economic Importance. 137-141. Available online at:
http://books.google.co.nz/books?id=_uQd76hWWRkC&pg=PA140&lpg=PA140&dq=Ophiomyia+pinguis&source=bl&ots=21wSnIoA8q&sig=k8w1PCE0770jEW3ZBcqsnlRWzQU&hl=en&sa=X&ei=2v0ZUI-KAo-uiQfAl4GACg&ved=0CGkQ6AEwDg#v=onepage&q=Ophiomyia%20pinguis&f=false

Suss, L (1970) *Ophiomyia pinguis* Fall. (Diptera Agromyzidae) in Lombardy. Biological and morphological observations. *Bollettino di Zoologia Agraria e di Bachicoltura* 10: 1, 43-84. (Abstract only)

[36] Relevance to the EPA Review: dimethoate is an organophosphates under review

Oscinella frit (Frit fly)

Scientific Name: *Oscinella frit* Linnaeus, 1758. (Diptera: Agromyzidae)
Synonyms: *Chlorops frit*
Musca frit
Oscinella avenae (Bjerkander)
Oscinella granarius (Curtis)
Oscinis frit Linnaeus
Oscinosoma frit
Common Name: Frit fly

Brief description: The larvae of *O. frit* feed on young grasses causing failure of establishment of new plantings and reduced productivity.

Indicative host range:
Priority Pasture Species: Annual (Italian) rye grass *(Lolium multiflorum)* (wild host), Timothy (*Phleum pratense)* (main host), Cocksfoot (*Dactylis glomerata*), Bent grasses (*Agrostis* spp.)
Other plants: *O. frit* is polyphagous on Poaceae. Reported main hosts include: *Avena satvia*, Fescues (*Festuca pratensis*, *Festuca rubra), Hordeum vulgare*, *Phalaris arundinacea*, *Poa pratensis, Secale cereale, Triticum aestivum,* Corn (*Zea mays)* (CPC 2012).

Current geographic distribution:
Asia: Afghanistan, India, Kazakhstan, Korea, Malaysia, Mongolia, Nepal, Pakistan, Turkey.
Africa: Tunisia
Americas: Canada, Mexico, USA, Costa Rica
Europe: Austria, Belarus, Belgium, Bulgaria, Cyprus, Czechoslovakia (former), Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, UK, Ukraine, [fomer] Yugoslavia
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid on the host plant or on the soil and hatch in a few days, burrowing into the shoot and destroying the growing point. In the UK, the second generation is associated primarily with seeds (CPC 2012). Eggs, larvae and pupae could be associated with host plant material. However, no host plant material is imported into New Zealand except as seeds for sowing and grain. These are possible entry pathways although the association of *O. frit* with seed appears weak. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
O. frit occurs from sea level to alpine areas and is widespread throughout Europe including countries in Northern Europe with similar climates to New Zealand. There are likely to be few climatic barriers to establishment in New Zealand. Its main hosts are widely distributed in pastoral areas of New Zealand (Charlton & Stewart 1999). Adults can rise to heights of 1000m which presumably aids dispersal by wind over long distances. Movement of infested plant material would also spread the fly.

Potential Impact in NZ: Moderate
In grasslands the effect of *O. frit* on permanent pasture is to reduce yield by a small amount, an effect that is probably more common than realized but not economically worth controlling. It is more important in preventing or reducing the establishment of new sowings of rye grass after planting in ground infested by larvae. It can cause serious loss of young plants of oats necessitating replanting and loss of production. In maize, it may cause loss of establishment and loss of yield (CPC 2012).

Possible methods of post-border management and surveillance:
Surveillance: *O. frit* has been surveyed using the sweep net method (Melecis *et al.* 2000). Suction traps in grasslands have been used to monitor adults (Umoru *et al.* 1990). Sweep-netting crops will provide an assessment of whether populations have reached an economic threshold for spraying (CPC 2012). For cereal crops a sample of shoots should be taken and if more than 10% are infested spraying should be commenced. (CPC 2012)

Post-border management: Much of the evidence for management of *O. frit* relates to cereal crops, particularly oats.

IPM Programmes: Little work has been done on IPM schemes for this pest. An exception is the determination of thresholds for commencement of spraying and in general it seems that unless at least 10% of young shoots are affected it is uneconomic to apply insecticides (CPC 2012).

Cultural Control and Sanitary Methods: Where grasslands are seeded they should be ploughed 4 weeks before seeding to allow larvae to die, and seedings in the spring are less vulnerable to attack as they can grow away from damage. It is considered that cutting or grazing grasslands increases the populations of *O. frit* because it increases the numbers of tillers for infestation (CPC 2012).

Host-Plant Resistance: There is evidence that some cereal varieties are more resistant *to O. frit* than others.The perennial rye grasses[*Lolium* spp.] are less susceptible (CPC 2012).

Biological Control: Although there are many recorded natural enemies of *O. frit*, biological control has not been used to any great extent and given the high population levels of the species in natural grasslands the chances of success seem limited. In Sweden, parasitism may reach 50% in the tiller generation (CPC 2012).

Chemical Control[37]: Chemical control of *O. frit* has been used for many years. Commonly used insecticides include dimethoate and permethrin. It is now only used in severe infestations or where there is a high chance of infestation from a previous crop. For winter cereals an insecticide spray should be used if the crop has more than 10% of shoots infested. This will not save the infested shoots but will prevent further damage. For wheat and maize granular insecticides may be applied at drilling or seed pelleted with insecticides may be planted (CPC 2012).

References:
Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 17 May 2012, Crop Protection Compendium Report – *Oscinella frit* http://www.cabi.org/cpc/?compid=1&dsid=37996&loadmodule=datasheet&page=868&site=161 Accessed 13 August 2012.

Melecis, V; Karpa, A; Spungis, V (2000) Assessment of the strategy used for insect population monitoring in the Lake Engures (Engure) Nature Park, Latvia. (Specialised Issue: Biological resources of the Lake Engures region in Latvia). *Proceedings of the Latvian Academy of Sciences* Seton B, Natura Eat an Ae Senes-197-202.

[37] Relevance to the EPA Review: dimethoate is an organophosphate under review

Umoru, P A; Bale, J S; Shorrocks, B (1990) Predicting the time of emergence of frit fly (*Oscinella frit* L.) (Dipt., Chloropidae) in northern England. *Journal of Applied Entomology;* 109 (4): 377-384

Tipula paludosa (European crane fly)

Scientific Name: *Tipula paludosa* Meigen. (Diptera: Tipulidae)
Synonyms: *Tipula fimbriata* Meigen 1818
Tipula flavolutescens Pierre 1921
Tipula wollastoni Lackschewitz 1936
Common Name: European crane fly

Brief description: The larvae (known as leatherjackets) of *T. pauldosa* feed on the stem bases and roots of grasses and are considered a serious pest of permanent grassland (CPC 2012) and spring cereals (Oosterbroek undated).

Indicative host range:
Priority Pasture Species: Rye grass *(Lolium perenne)*, Lucerne *(Medicago sativa)* (main hosts) White clover (*Trifolium repens)* (other host)
Other plants: Reports of leatherjacket damage from a variety of crops suggests that they are polyphagous in their feeding habits. Most of these reports, however, have not confirmed identification by, for example, rearing larvae through to adults. Reported main hosts include: sugarbeet, brassicas, leguminous plants, barley, grasses, potato and wheat (CPC 2012).

Current geographic distribution:
Europe: Andorra, Austria, Belarus, Belgium, Czechoslovakia (former), Denmark, Estonia, Faroe Islands, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, UK, Ukraine, [former] Yugoslavia
Americas: Canada, USA (CPC 2012; Oosterbroek undated).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid among grasses and the larvae feed on the bases of stems but primarily on the roots. They usually spend a minimum of 9 months in the soil and pupate at the soil surface (CPC 2012). Larvae could enter New Zealand in soil but it would need to be associated with roots of host plants to survive. This is only likely to occur on heavily contaminated used agricultural machinery. There is evidence that larvae are sensitive to desiccation (CPC2012), so the likelihood of entry appears low. Adults would be unlikely to survive transfer to New Zealand.

Potential to establish and spread in NZ: High
In general, *T. paludosa* is found in temperate zones of Europe. Its spread to the east coast of North America indicates a potential to colonize other areas (CPC 2012). It is widespread throughout Europe including countries in Northern Europe with similar climates to New Zealand. There are likely to be few climatic barriers to establishment in New Zealand. Its main hosts are widely distributed in pastoral areas of New Zealand (Charlton & Stewart 1999). Adults are capable of spread over short distances by flying and movement of infested soil would spread the crane fly over longer distances.

Potential Impact in NZ: High
Larvae damage both reseeds and established grassland. However, autumn reseeds with cultivations coinciding with the *T. paludosa* flight and oviposition period are far less vulnerable than spring reseeds, especially where the latter follows a ley. One study estimated that the larvae, known as leatherjackets, were responsible for in excess of £15m worth of damage in grassland in Northern Ireland alone in 1985. The majority of this was attributed to insidious feeding in populations below the economic threshold (CPC 2012).

Possible methods of post-border management and surveillance:
Surveillance: *T. paludosa* adults can be recovered from most traps designed to sample flying insects. They have been shown, however, to favour green water traps over other colours (CPC 2012). Most methods for sampling larvae in grassland involve the collection of soil (CPC 2012).

Post-border management:
Work has been done to calculate economic thresholds (CPC 2012). The timing of control is important in that early insecticide applications will result in greater spring herbage yields.

Chemical Control[38]: Organo-phosphate insecticides such as fenitrothion and quinalphos are approved for use in grassland but chlorpyrifos is probably the chemical most favoured by growers and advisers. Larvae are easily controlled in grassland by a single insecticide application. There have been few studies comparing the efficacy of approved insecticides, but experimental kill rates of > 90% are reported with chlorpyrifos (CPC 2012).

Cultural Control: In agricultural systems it has been demonstrated that although attacks are frequent on crops which follow grass in the rotation, these attacks can be prevented (in Northern Hemisphere) if the grass is ploughed in July or early August and the herbage is well buried (CPC 2012). Soil cultivation is the one procedure that is known to reduce numbers of larvae and markedly reduce the incidence of damage (CPC 2012).

Biological Control: *Bacillus thuringiensis* and predatory nematodes have been tested as control methods for larvae. Significant population reductions can be achieved in the field but application costs are presently substantially higher than with conventional insecticides and may only be justified if chemicals are prohibited and there is a high risk of crop failure resulting in, for example, the need to re-establish a sward (CPC 2012).

References:
Charlton, JFL; Stewart, AV (1999) Pasture species and cultivars used in New Zealand – a list. *Proceedings of the New Zealand Grassland Association* 61: 147–166.

CPC (2012) last modified 27 April 2011, Crop Protection Compendium Report – *Tipula paludosa*
http://www.cabi.org/cpc/?compid=1&dsid=54013&loadmodule=datasheet&page=868&site=161 Accessed 13 August 2012.

Oosterbroek P (undated) Catalogue of the craneflies of the world. Available online at: http://ip30.eti.uva.nl/ccw/detail.php accessed 13/8/12.

[38] Relevance to the EPA Review: fenitrothion and chlorpyrifos are organophosphates under review.

6.4 Grasshoppers - Orthoptera

Dichroplus elongatus (A South American grasshopper)

Scientific Name:	*Dichroplus elongatus* Giglio-Tos, 1894 (Orthoptera: Acrididae)
Synonyms:	*Dichroplus araucanus* Liebermann, 1942
	Dichroplus cinereus Bruner, 1900
	Dichroplus elongatus araucanus Liebermann, 1943
	Trigonophymus elongatus (Giglio-Tos, 1894) Kirby, 1910
Common Name:	A South American grasshopper

Brief description: *D. elongatus* is frequently the dominant species in grasshopper assemblages in South America. It is polyphagous and was historically regarded as the most damaging grasshopper in Argentina and Brazil.

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa), Trifolium* spp., Poaceae spp. (main hosts) (CPC 2012). Ribwort plantain *(Plantago lanceolata)* (preferred host) (Zapata 1987).
Other plants: sunflower, maize (main hosts); potato, tomato, rice, water melon, crab apple (other hosts) (CPC 2012). New stems and flowers of vegetable crops are consumed. Zapata 1987) reported that adults highly preferred the following species: *Datura stramonium, Raphanus sativus, Digitaria sanguinalis, Chenopodium album, Taraxacum officinale, Rumex crispus,* Ribwort plantain *(Plantago lanceolata)* and *P. major*.

Current geographic distribution:
South America: Argentina, Brazil, Uraguay (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Relatively little information is available on the biology of *D. elongatus*. Eggs are laid in pods with an average of 24 eggs per pod (CPC 2012), but no information on location of pods was found. Nymphs and adults feed on a range of plants and can be associated with all parts of food plants. It is assumed that both nymphs and adults are highly mobile. Given this life cycle, *D. elongatus* is most likely to enter New Zealand as a hitchhiker. Nymphs and adults could become accidentally associated with a range of commodities originating from prairie habitat. However, accidental hitchhikers are less likely to be able to establish in New Zealand than those with a predictable association with a commodity (see section 4) and the most likely entry pathway would be as egg cases in soil or plant debris contaminating inanimate objects such as used agricultural machinery. The paucity of information on the biology of this grasshopper means that there is considerable uncertainty about the most likely pathways for entry.

Potential to establish and spread in NZ: High
D. elongatus is common in prairie habitats in South America. It prefers relatively moist areas, and is seldom found in abundance in dry areas (CPC 2012). It is assumed that similar habitats and climatic conditions occur in at least some regions of New Zealand. Given the polyphagous feeding habits of this grasshopper there would be no shortage of available food plants in New Zealand. The mobile nature of the grasshopper and its high reproductive capacity would facilitate rapid population build up and spread to all suitable habitat in New Zealand.

Potential Impact in NZ: Moderate
D. elongatus is frequently the dominant species in grasshopper assemblages in South America. It is polyphagous and was historically regarded as the most damaging grasshopper

in Argentina and Brazil (CPC 2012). However, some recent observations suggest that the damage attributed to *D. elongatus* may actually have been caused by *D. exilis* (Bardi *et al.* 2011). Nonetheless one study under semi-controlled conditions estimated losses on lucerne and sorghum of *D. elongatus* of 1002 and 330 kg/ha, respectively (Bulacio *et al.* 2005). On the basis of this limited information it is assumed that if the grasshopper were to establish in New Zealand it would be likely to cause some, but not significant productivity losses of lucerne, ribwort plantain and possibly some clover and grass species.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance could involve periodical field surveys for detection of nymphs and adults (CPC 2012). Sweep nets can be used to monitor for grasshoppers (Lutinski *et al.* 2011).

Post-border management: Management information is based on practices in South America. There is no continuous monitoring of the status of the pest so control measures are reactive, not preventive. Actions are taken when outbreaks occur. Ploughing for egg pod destruction still seems to be a relatively common practice among farmers. When outbreaks occur, chemical control is still the only available alternative. Organophosphorus compounds[39] are by far the commonest choice employed (CPC 2012).

Biological Control: *Nosema locustae* was introduced from North America as a grasshopper control agent in the late 1970s and early 1980s in the Buenos Aires, La Pampa, Chubut and Neuquén provinces of Argentina. The short term impact of these introductions remains unknown but the pathogen became established in at least 13 species of grasshoppers in western Buenos Aires and eastern La Pampa. *D. elongatus* is one of the affected species with registered prevalence as high as 33%. *N. locustae* seems to be acting as an additional, long term regulator of the abundance of *D. elongatus* and other Melanoplinae in certain areas (CPC 2012).

References:
Bardi, C; Mariottini, Y; Wysiecki, M L de; Lange, C E (2011) Postembryonic development, fecundity and food consumption of *Dichroplus exilis* (Orthoptera: Acrididae) under controlled conditions. [Spanish] *Revista de Biologia Tropical* 59 (4): 1579-1587. Only abstract viewed.

Bulacio, N; Luiselli, S; Salto, C (2005) Potential damage of *Dichroplus elongatus* and *Orphulella punctata* (Orthoptera: Acrididae) in sorghum and alfalfa. [Spanish]. *Revista de la Facultad de Agronomia* (Universidad de Buenos Aires) 25(3): 199-206. Only abstract viewed.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Dichroplus elongatus*
http://www.cabi.org/cpc/?compid=1&dsid=18092&loadmodule=datasheet&page=868&site=161 Accessed 26 August 2012.

Lutinski, C J; Lutinski, J A; Costa, M. K. M. da; Garcia, F R M (2011) Faunistic analyses of grasshoppers in the National Forest of chapeco, Santa Catarina, Brazil. *Pesquisa Florestal Brasileira* 31 (65): 43-50.

Zapata, C S (1987) Food habits of *Dichroplus elongatus* Giglio-Tos (Orthoptera, Acrididae, Catantopinae). [Spanish] *Acta Entomologica Chilena*. 14: 59-63. Only abstract viewed.

[39] Relevance to the EPA Review: unknown, but some of the organophosphates used in other countries may include those under review in NZ.

Melanoplus bivittatus (Two striped grasshopper)

Scientific Name: *Melanoplus bivittatus* Say (Orthoptera: Acrididae)
Synonyms: *Acrydium flavo-vittatum* Harris, 1841
Caloptenus femoratus Burmeister, 1836
Gryllus bivittatus Say, 1825
Melanoplus bivittatus Scudder, 1874
Melanoplus bivittatus femoratus Morse, 1894
Common Name: Two striped grasshopper

Brief description: *Melanoplus bivittatus* is a polyphagous grasshopper that defoliates plants and causes serious losses to crops of cereals, lucerne and maize in North America (Pfadt 1994).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host); Red clover (*Trifolium pratense)* and Chicory *(Cichorium intybus)* (other) (CPC 2012).
Other plants: *M. bivittatus* is polyphagous, feeding mainly on forbs but it also eats grasses in areas where forbs occur. Potato, barley, wheat and maize are recorded as main hosts (CPC 2012). In experiments, the following forbs resulted in rapid development of nymphs: mustards, flixweed and pepperweed; broadleaf plantain; legumes (alfalfa and red clover); and composites (greenflower, dandelion, chicory, prickly lettuce, giant ragweed, and arrowleaf butterbur). The grasshopper also feeds on dry litter found on the ground (Pfadt 1994).

Current geographic distribution:
North America: Canada, USA (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Pods containing 50-108 eggs are laid on the crowns of grasses or roots of weeds. *M. bivittatus* over-winters in the egg stage (Pfadt 1994). Nymphs and adults feed on a wide range of plants and can be associated with all parts of food plants. *M. bivittatus* is common in urban areas and disturbed habitats as well as more intensively cropped habitats. Both nymphs and adults are highly mobile, moving large distances to find new food sources (Pfadt 1994). Given this life cycle, *M. bivittatus* is most likely to enter New Zealand as a hitchhiker. Nymphs and adults could become accidentally associated with a range of commodities including passengers' luggage. There has been one interception of a single adult *Melanoplus* sp. grasshopper on grapes (MPI 2012), which provides supporting evidence for hitchhiker pathways. However, accidental hitchhikers are less likely to be able to establish in New Zealand than those with a predictable association with a commodity (see section 4) and the most likely entry pathway would be as egg cases in soil or plant debris associated with inanimate objects such as used agricultural machinery.

Potential to establish and spread in NZ: High
Melanoplus bivittatus is common across the USA and Canada and occurs at a wide range of elevations (CPC 2012). Climates in many of these areas also exist in NZ. It prefers relatively moist areas, and is seldom found in abundance in dry areas. It shows a preference for rank and succulent vegetation. In America, this type of vegetation is generally located in bottom lands, edges of streams, marshes, roadsides, cultivated fields, the margins of woodlands, and shaded mountain slopes. It is also found associated with open weedy areas and cultivated land that has been deserted for a number of years. Similar habitats are widespread in New Zealand and there would be no shortage of available food plants. The highly mobile nature of the grasshopper and its large reproductive capacity would facilitate rapid population build up and spread to all suitable habitat in New Zealand.

Potential Impact in NZ: High
The two striped grasshopper is a major crop pest causing much damage to small grains, alfalfa, and corn in North America. During outbreaks, it may completely destroy crops (Pfadt 1994). It is one of the most important grasshopper pests (CPC 2012). If it were to establish in New Zealand it would be expected to result in greatly reduced productivity of lucerne and possibly clovers and chicory. It could also have impacts on a range of other sectors and home gardeners because in outbreak years it has been reported devastating vegetable and fruit crops as well as shelterbelt trees (Pfadt 1994).

Possible methods of post-border management and surveillance:
Surveillance:
The monitoring of *M. bivittatus* populations should begin when soil temperatures reach 16°C; Weekly sampling establishes definite areas of infestation and areas that may require control. Sweep nets will provide information on which species are present, their stage of development, and which areas are infested. Visual inspections require close examination of the base of plants and surrounding soil (CPC 2012).

Post-border management:
Control measures should not be considered until most of the population has reached the third instar. During the early nymphal stages, grasshoppers are susceptible to adverse climatic conditions and damage from feeding is usually not considered of economic importance. First- and second- instar nymphs may be controlled naturally if a period of hot weather that promotes egg hatch is followed by cool, wet weather. The hot weather ensures a complete and uniform hatch and the cool weather causes nymphs to restrict their movement and feeding activity often to starvation or increases their susceptibility to diseases and predation. If temperatures drop below freezing, many of the nymphs are killed outright. A cool summer and early autumn delay the maturation of grasshoppers, thus shortening the egg-laying period which helps to reduce populations the following year.

Biological Control: There are over 200 natural enemies (diseases, predators, and parasitoids) of grasshoppers. Research has been conducted on fungal, protozoan, and viral diseases of grasshoppers (see Natural Enemies). *Nosema locustae* bait is registered for commercial use. The costs of the bait can vary considerably. Third- and fourth- instar nymphs should be targeted for control by this method because by the time third- and fourth- instars are visible, the bulk of the population should have hatched. Nymphs spend much of their time on the soil surface and are more likely to come into contact and feed on the bait than adults which spend more time in the plant canopy feeding. Grasshoppers begin dying within 2-3 weeks of becoming infected. The disease is passed from infected grasshoppers to others when they feed on the infected individuals. There is also evidence that the disease can be passed via the egg to next year's population, although the infection level is quite low. If populations reach outbreak levels, the disease is unable to act rapidly enough to reduce population sizes to below an economic threshold before considerable damage has occurred. Applying protozoa-impregnated wheatbran to hot spots (areas of localized high populations) before widespread infestations occur has been suggested but never formally evaluated. These areas might serve as foci of infection which would reduce the build-up of grasshopper populations to outbreak levels (CPC 2012).

Cultural Control: An early study found that grasshopper populations are highest in areas where canopy cover is less than 40%. In areas susceptible to grasshopper outbreaks it might be helpful to modify grazing regimes to increase canopy cover. Improved cover tends to increase the relative humidity and decrease temperature and solar radiation within the plant canopy, thus improving the microhabitat for grasshopper pathogens. Increased canopy cover also improves the microhabitat for grasshopper predators and parasites (CPC 2012).

Chemical Control: Three insecticides have been registered for use on rangeland in the USA:

malathion, carbaryl and acephate[40]. Malathion and acephate are applied as sprays, and carbaryl can be applied as a bait or spray. Controls should be considered when the majority of the population reaches the third instar. At this stage grasshoppers will consume significant amounts of forage that will not be replaced by regrowth, and the probability of large numbers of grasshoppers being killed by natural causes during this and succeeding life stages is low. At this point, chemical control may be the only tool available to avoid economic damage. (CPC 2012). Chemical control of adults should be avoided whenever possible for the following reasons:

- Forage consumption has already reached damaging levels.
- Adults are less susceptible to chemical control.
- Adult grasshoppers are mobile and can move out of treated areas.
- A larger area will require treatment because the mobile adults will move from hatching areas.
- Egg laying has already begun.

It is important to monitor grasshoppers before they reach the adult stage. Early sampling allows the identification of areas where controls may be warranted, and provides time to select the control method that best suits individual needs. Sampling should be repeated after control to determine how successful the control method was (CPC 2012).

References:

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Melanoplus bivittatus* http://www.cabi.org/cpc/?compid=1&dsid=33400&loadmodule=datasheet&page=868&site=161 Accessed 26 August 2012.

MPI (2012) Interceptions database. Accessed August 2012.

Pfadt, RE (1994) *Melanoplus bivittatus* (Say) Twostriped Grasshopper. Wyoming Agricultural Experiment Station Bulletin 912 Species Fact Sheet. Available online at: http://keys.lucidcentral.org/keys/grasshopper/nonkey/html/FactSheets/2striped.htm#Economic Accessed 26/8/12.

[40] Relevance to the EPA Review: malathion and acephate are organophosphates, and carbaryl is a carbamate under review.

6.5 Moths - Lepidoptera

Agrotis segetum (turnip moth)

Scientific Name:	*Agrotis segetum* Denis & Schiffermüller (Lepidotera: Noctuidae)
Synonyms:	*Agrotis fucosa* Butler *Agrotis segetis* Hübner *Euxoa segetis* *Euxoa segetum* Denis & Schiffermüller *Euxoa segetum* form albiptera Turati *Feltia segetum* Denis & Schiffermüller *Noctua segetum* Denis & Schiffermüller *Scotia segetum* Denis & Schiffermüller
Common Name:	turnip moth

Brief description: The larvae of the turnip moth feed on the leaves, stems, roots and tubers of a range of crops causing significant production losses in some areas and some seasons (CPC 2012). Few reports of significant damage to priority pasture species have been found.

Indicative host range:
A. segetum is polyphagous and attacks cultivated plants in more than 15 families.
Priority Pasture Species: Lucerne *(Medicago sativa),* Clovers (*Trifolium* spp.) (main hosts)
Other plants: Okra, leek, garlic, dill, celery, peanut, oats, asparagus, sugarbeet, swede, cauliflower, cabbage, Chinese cabbage, rape, tea, hemp, capsicum, caraway, daisy, chickpea, endive, coffee, fennel, carrot, carnation, freesia, soyabean, cotton, sun flower, rubber, barley, sweet potato, lettuce, flax, mint, tobacco, rice, parsley, Sitka spruce, Scots pine, radish, black currant, rye, sesame, potato, tomato, turnip, spinach, wheat, grapevine, maize (main hosts) (CPC 2012).

Current geographic distribution:

Asia: Afghanistan, Azerbaijan, Bangladesh, Bhutan, China, Republic of Georgia, India, Iran, Indonesia, Iraq, Israel, Japan, Jordan, Kazakhstan, Korea DPR, Republic of Korea, Kirgizstan, Lebanon, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Syria, Taiwan, Tajikistan, Turkey, Turkmenistan, Uzbekistan, Vietnam, Yemen

Africa: Algeria, Angola, Benin, Botswana, Cape Verde, Congo Democratic Republic, Cote d'Ivoire, Egypt, Ethiopia, Kenya, Libya, Malawi, Mali, Morocco, Mozambique, Namibia, Saint Helena, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe

Europe: Austria, Belarus, Belgium, Bulgaria, Croatia, Cypress, Czechoslovakia (former), Denmark, Estonia, Finland, France, Ireland, Italy, Latvia, Lithuania, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Macedonia, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, Yugoslavia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The eggs of *A. segetum* are laid singly or in small batches on dry plant residues or on lumps of soil. Under dry conditions, the larvae make short feeding visits to host plant foliage during the day and hide in the uppermost 1-3 mm of the soil for the rest of the time. Third-instar larvae begin to eat roots at the surface and exhibit negative phototaxis. This change in biology is reinforced in the fourth, fifth and sixth instars which feed voraciously on roots and the bases of stems, and cause severe damage. In cold climates, the sixth-instar larvae overwinter

3-7 cm below the soil surface and move up to the top 1-3 cm of soil for pupation in the spring. The adult moth is a strong flier (CPC 2012). Given these characteristics and the diverse host range, fresh produce, cut flowers and nursery stock are the most likely entry pathways. Passengers (plant material in luggage) are a possible pathway. Used agricultural machinery contaminated with soil or plant debris containing eggs, larvae or pupae could also be entry pathways.

Potential to establish and spread in NZ: High
A. segetum occurs in parts of Europe such as the UK with similar climate to New Zealand. It has a very diverse host range and neither climate nor availability of suitable hosts are likely to be barriers to establishment in New Zealand. The adult moths are strong flyers and there would be few barriers to its spread by natural dispersal or movement of infested host material.

Potential Impact in NZ: Moderate
Crop losses have been reported in a range of crops including maize, cotton, potatoes, carrots, lettuce and beetroot. The first two larval instars are sensitive to cold conditions and moist soil and because of this, high mortality generally occurs in the northern and southern areas of distribution in Europe, Asia and Africa (CPC 2012). High populations may therefore not occur in some parts of New Zealand, but may occur in others. Even in areas with generally lower populations due to larval mortality, attack levels may rise sharply in years with low mortality due to favourable warm and dry weather conditions during the life of the first two larval instars. If two favourable seasons follow one another, catastrophic attack levels may occur as was the case in north-west Europe in 1976 (CPC 2012). However, although lucerne and clovers are described as 'main hosts', few reports of economic damage to any of New Zealands' priority pasture species have been found. According to Camprag *et al.* (2005), the moth occasionally occurs in mass numbers in certain areas where it causes damage in lucerne and clovers, but it rarely spreads across a large area in Serbia and Montenegro.

Possible methods of post-border management and surveillance:
Surveillance: Pheromone traps are used to detect and monitor *A. segetum,* particularly in geographical areas with extreme fluctuations such as north-west Europe. The number of moths caught and the subsequent weather conditions may influence the type and timing of control treatment (CPC 2012). Pheromone traps are presently considered as the most effective monitoring system of *A. segetum* males (Garnis & Dabrowski 2008).

Post-border management: Much of the information about management of *A. segetum* relates to vegetable crops.

Chemical Control: The use of synthetic pyrethroids directed against first-, second- and third-instar cutworms has proved to be very easy and it is highly efficient when based on information from pheromone traps (CPC 2012). The insecticide Nurelle D550 EC (chlorpyrefos + cypermethrin)[41] showed a persistent control efficacy against larvae of *A. segetum* when applied at 0.3 litre/hectare (Jakubowska 2006). The synthetic insecticide lambdacyhalothrin was effective against *A. segetum* when applied in the laboratory as either a spray or a drench (Chandel & Kumar 2009).

Biological Control: Many experiments on the different types of biological control carried out against *A. segetum* have been described but there is no review of biological control for this species. Details are available on CPC (CPC 2012). *Agrotis ipsilon* nucleopolyhedrovirus shows high virulence towards *Agrotis segetum,* and appears to be a suitable candidate as a biological control agent against this species ((El-Salamouny *et al*. 2003).

[41] Relevance to the EPA Review: chlorpyrifos is an organophosphate under review.

Pheromonal Control: A classical field trial on mating disruption with fixed-position females has been carried out in Sweden. However, the problem of gravid females flying into the area remains (CPC 2012).

Integrated Pest Management has been put into practice in Denmark and Sweden (CPC 2012).

References:

Camprag, D; Keresi, T; Sekulic, R (2005) Other insect pests of alfalfa and clover. (Special issue: Protection of alfalfa and clover) [Serbian]. Biljni Lekar (Plant Doctor) 33 (5): 542-546. Abstract only accessed.

Chandel, P K; Kumar, Y S S (2009) Evaluation of some insecticides for the management of *Agrotis segetum. Indian Journal of Agricultural Sciences,* 79(3): 235-239. Abstract only seen.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Agrotis segetum* http://www.cabi.org/cpc/?compid=1&dsid=3797&loadmodule=datasheet&page=868&site=161 Accessed 3 September 2012.

El-Salamouny, S; Lange, M; Jutzi, M; Huber, J; Jehle, J A (2003) Comparative study on the susceptibility of cutworms (Lepidoptera: Noctuidae) to *Agrotis segetum* nucleopolyhedrovirus and *Agrotis ipsilon* nucleopolyhedrovirus. *Journal of Invertebrate Pathology,* 84(2): 75-82. Abstract only seen.

Garnis, J; Dabrowski, Z T (2008) Effect of crop plant species on the efficacy of pheromone traps for monitoring of the turnip moth (*Agrostis segetum* [Schiff.]) (Lep., Noctuidae). *Vegetable Crops Research Bulletin,* 68: 81-91. Abstract only seen.

Jakubowska, M (2006) Reduction of *Agrotis segetum* Schiff. and *A. exclamationis* L. populations by Nurelle D 550 EC. [Polish]. *Progress in Plant Protection*, 46(2): 358-362. Abstract only seen.

Autographa gamma (Silver Y moth)

Scientific Name: *Autographa gamma* (Linnaeus) (Lepidotera: Noctuidae)
Synonyms: *Phytometra gamma* Linnaeus
Plusia gamma Linnaeus
Common Name: Silver-y moth

Brief description: *Autographa gamma* is a migratory moth and adults undertake seasonal migrations to areas in which they are unable to breed continuously. The larvae feed on host plants and can cause defoliation. Impacts are usually only significant during outbreaks of the moth (CPC 2012).

Indicative host range:
A. gamma can feed on at least 224 plant species, including 100 weeds, from 51 families (CPC 2012)
Priority Pasture Species: Lucerne *(Medicago sativa)*; Red clover (*Trifolium pratense)* and Chicory *(Cichorium intybus)*are main hosts.
Other plants: A large number of brassicas including cabbage, cauliflower, broccoli, kohlrabi, Brussels sprouts and Chinese cabbage are main hosts. In addition a wide range of vegetables including beetroot, sugar beet, carrots, sunflowers, lettuce, parsley, potato, spinach as well as tobacco, wheat, maize, cotton, soyabean, flax, chickpea and grapevines are also main hosts (CPC 2012).

Current geographic distribution:
Asia: Azerbaijan, China, India, Iran, Iraq, Israel, Japan, Kazakhstan, Korea, Saudi Arabia, Syria, Turkey, Uzbekistan
Africa: Algeria, Egypt, Libya, Morocco
Europe: Austria, Belgium, Bulgaria, Croatia, Czechoslovakia (former), Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Moldova, Netherlands, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, Ukraine, United Kingdom (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs of *A. gamma* are laid on the underside of leaves of host plants. Larvae tend to drop off the host plant when disturbed (CPC 2012) and any larvae present on a host plant grown for export is unlikely to remain on the plant during the harvest and packaging processes. Pupae occur on the underside of leaves (Venette *et al.* 2003). The most likely means of entry is therefore eggs or pupae on imported fresh produce or cut flowers belonging to host plants. It is regularly intercepted entering the USA on imported vegetables and cut flowers (Venette *et al.* 2003). Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: Moderate
A. gamma is able to complete 2-3 generations a year in the UK which has a similar climate to much of New Zealand. However, it is thought that few caterpillars survive the winter and its continued presence there is dependent on immigration of adults each year (Butterfly Conservation 2012). However, Venette *et al.* (2003) predict that large parts of the USA including northern areas would be eco-climatically suitable for permanent establishment. Whilst there is uncertainty about the ability of the moth to establish a permanent population in New Zealand, northern and coastal north island may provide suitable habitats for caterpillars to survive the winter. The adult moths are strong flyers and the species regularly migrates seasonally in other countries, so adults emerging from overwintered caterpillars will then have the potential to migrate into other areas during the spring-autumn period. There would be few barriers to its spread by natural dispersal or movement of infested host material.

In the absence of establishment in New Zealand, regular natural immigration is not likely because *A. gamma* is not established in any nearby countries.

Potential Impact in NZ: High
First and second instar larvae of *A. gamma* feed on the leaf surface while third instar larvae will eat through the entire leaf (Venette et al. 2003). A female can lay more than a thousand eggs (CPC 2012) enabling populations to build up rapidly. In outbreak years, defoliation has resulted in reduced yields of a range of vegetable and field crops in Europe and Africa. Host species are widely grown in New Zealand and the migratory nature of the moth means that all parts of New Zealand under pastoral production would be susceptible. The economic impact if the species were to establish permanently in New Zealand could be large.

Possible methods of post-border management and surveillance:
Surveillance: Much of the surveillance information for *A. gamma* relates to surveillance in vegetable crops. Light traps have been used to monitor adult *A. gamma*. Much research has been done also to develop pheromone traps for monitoring *A. gamma* adults. Pheromone traps are now widely available and the use of light traps has been superseded in most cases (CPC 2012). In Russia, soil and vegetation sampling are used to establish the extent of larval occurrence, numbers, parasitism etc. and assess migratory intensity, fecundity, crop infestation and damage CPC 2012)

Post-border management: The information about management of *A. gramma* primarily relates to vegetable crops.

Biological Control*: Trichogramma evanescens* has been used against *A. gamma* in Bulgaria and Russia and evaluated as a control method in the Netherlands (CPC 2012).

Chemical Control: *A. gamma* can be controlled with *Bacillus thuringiensis* (*Bt*). Susceptibility depends on the strain of *Bt* used. A wide range of conventional insecticides have been applied, most recently they have included pyrethroids (deltamethrin, lambda-cyhalothrin) or organophosphates (e.g. chlorpyrifos[42]). Young caterpillars are more susceptible to insecticides than older ones (CPC2012)

References:
Butterfly Conservation (2012) Silver-Y moth. http://www.butterfly-conservation.org/Moth/440/Moth.html?MothId=113 accessed 6/8/12.

CPC (2012) last modified 3 November 2010, Crop Protection Compendium Report – *Autographa gamma*
http://www.cabi.org/cpc/?compid=1&dsid=46179&loadmodule=datasheet&page=868&site=161 Accessed 7 August 2012.

Venette, RC; Davis, EE; Heisler, H; Larson, M (2003) Mini Risk Assessment Silver Y Moth, *Autographa gamma* (L.) [Lepidoptera: Noctuidae]. Available online at: http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/downloads/pra/agammapra.pdf accessed 7/8/12.

[42] Relevance to the EPA Review: chlorphyrifos is an organophosphate under review.

Chrysoteuchia culmella (garden grass-veneer)

Scientific Name: *Chrysoteuchia culmella* (Linnaeus 1758) (Lepidotera: Crambidae)
Synonyms:
Common Name: Garden grass-veneer

Brief description: *Chrysoteuchia culmella* is a common 'grass' moth. The larvae feed on the stems of various types of grasses, usually at the base (Kimber 2012). It appears to damage pastures during periodic outbreak years.

Indicative host range:
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*), Timothy (*Phleum pratense)* (Gamboc & Milevoj 1994),
Other plants:

Current geographic distribution:
Europe: Widespread including UK, Slovenia, former USSR

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid in masses of 6-9 on the soil surface, at the base of stalks and on leaves and hatch within 6-10 days. Larvae over-winter in the soil at a depth of 10-15 cm (Abdullaev *et al*. 1977). Therefore, pathways contaminated with soil such as used agricultural machinery or footwear are possible entry pathways.

C. culmella appears to have a host range restricted to grasses and fresh grass is not imported into New Zealand.

Potential to establish and spread in NZ: High
There is little information available on the distribution of *C. culmella.* However it is widespread in the UK (Kimber 2012) which has a similar climate to parts of New Zealand. The grass species it feeds on are widespread throughout New Zealand so neither climate nor host availability are likely to be a barrier to establishment. The adult moth can fly and it could spread through natural dispersal as well through movement of infested host material or soil.

Potential Impact in NZ: Moderate
C. culmella does not appear to be a major pest species. However, an outbreak reportedly caused die off of Cocksfoot (*Dactylis glomerata*) and Timothy (*Phleum pratense)* in Slovenia (Gamboc &Milevoj 1994) and an outbreak in the former USSR destroyed mountain pastures. It is not known what causes an outbreak. It is assumed that population outbreaks would occur periodically in New Zealand and in such instances there could be a significant impact on productivity of pasture species.

Possible methods of post-border management and surveillance:
Surveillance: No reports relating to surveillance of *C. culmella* were found in CAB abstracts. Given that larvae over-winter in the soil (Abdullaev *et al.* 1977), and adults are attracted to light (Kimber 2012), a programme of soil sampling or light traps might be considered as generic surveillance techniques.

Post-border management[43]: The only source of information about management of *C. culmella* dates back to the 1970s, in the former USSR. During 1972-73, sprays of 80% trichlorphon (chlorophos) at 1.5 kg/ha and 2.5% methyl-parathion (metaphos) at 20 kg were applied against the larvae. Effectiveness was 87 and 73%, respectively (Abdullaev *et al.* 1977).

[43] Relevance to the EPA Review: none of the named chemicals are under review

References:

Abdullaev, AN; Suleimanov, MS; Shikhakhmedov, SG (1977) The steppe pyralid in Dagestan. [Russian]. *Zashchita Rastenii* 4: 53. (abstract only accessed)

Gomboc, S; Milevoj, L (1994) *Chrysoteuchia culmella culmella* L. (Lep., Crambidae, Pyralidae, Crambinae) a possible pest of grasslands in Central Europe. *Zbornik Biotehniske Fakultete Univerze v Ljubljani, Kmetijstvo* 63: 213-221. Abstract only accessed.

Kimber, I (2012) UK Moths 1293 *Chrysoteuchia culmella.* Available online at: http://ukmoths.org.uk/show.php?id=2301 Accessed 28/8/12.

Chrysoteuchia topiaria (Cranberry girdler)

Scientific Name: *Chrysoteuchia topiaria* Zeller (Lepidotera: Crambidae)
Synonyms: *Chrysoteuchia hortuellus*
Crambus hortuellus (Hb.)
Crambus topiaria
Crambus topiarius Zeller
Common Name: Cranberry girdler

Brief description: *Chrysoteuchia topiaria* is a sod webworm, common across the USA and southern Canada. The larvae feed on the stems of various types of grasses. It appears to damage pastures during periodic outbreak years. There is some confusion about the identity of this species which according to most references is restricted to North America. Reference to it in the UK (as *Crambus Hortuellus*) (Thompson, 1942) may in fact refer to *Chrysoteuchia culmella* which is common in Europe and appears very similar.

Indicative host range:
Priority Pasture Species: Fescues (*Festuca* spp.*),* Bent grasses (*Agrostis* spp.) (Thompson 1942)
Other plants: Meadow grass, Douglas fir, blueberry, cranberry (CPC 2012) *Alopecurus pratensis, Agrostis alba* (Roland 1990)

Current geographic distribution:
North America: Canada, USA (CPC 2012)
Europe: UK (Thompson, 1942) although this may be *C. cumella*

Potential pathways of entry into New Zealand (Commodity Association):
Larvae occur in the soil and feed on roots or stems of host plants (Roland, 1990). Therefore pathways contaminated with soil such as used agricultural machinery or footwear are possible entry pathways. It is not known whether larvae feed on fruit of blueberry or cranberry but it is assumed that imported fresh fruit of these species could be a potential entry pathway[44].

Potential to establish and spread in NZ: High
C. topiaria is widespread throughout the USA and southern Canada which has a similar climate to parts of New Zealand. The grass species it feeds on are widespread throughout New Zealand so neither climate nor host availability are likely to be a barrier to establishment. The adult moth can fly and it could spread through natural dispersal as well through movement of infested host material or soil.

Potential Impact in NZ: Moderate
Twelve species of crambids are of economic importance in North America all with similar habits. The relative prevalence of these species varies from season to season and in different parts of the country. There are many records of injury to grassland caused by caterpillars of the genus *Crambus* in Canada and the United States, where they are known commonly as ‘sod webworms’. Attacks take place every year, but the degree of injury varies from season to season and in certain years attacks of abnormal severity occur (Thompson 1942). It is not known what causes an outbreak. *Chrysoteuchia topiaria* is the only species of eleven sod webworms found to cause damage to lawn turf in Canada (Rochefort *et al.* 2003). While it does not appear that *C. topiaria* is a major pasture pest, it is assumed that population outbreaks would occur periodically in New Zealand and in such instances there could be a significant impact on productivity of multiple pasture species.

[44] MPI notes that fresh blueberries and cranberries are currently not imported.

C. topiaria adults have also been reported to migrate into nurseries of Douglas fir (*Pseudotsuga menziesii)*, where eggs were laid and the hatching larvae fed on tap-roots, reducing seedling quality and vigour and in some cases killing the seedlings (Yaris 1983). Establishment in New Zealand could potentially impact the forestry sector.

Possible methods of post-border management and surveillance:
Surveillance: Pheromone-bated traps for *C. topiaria* have been commercialised and can be used for determining the presence or absence of the pest (Arbico-organics 2012).

Post-border management: Information about management of *C. topiaria* relates to cranberry crops or Douglas fir nurseries. Insecticides[45] applied to control adults (diazinon) and larvae (chlorpyrifos) in Douglas fir nurseries can eliminate the damage caused by *C. topiaria* (Yarris 1983). There are some reports about the use of insecticidal nematodes in the management options for *C. topiaria* (Cowles et al 2005; Polavarapu 1999).

References:

Arbico-organics (2012) http://www.arbico-organics.com/category/insect-traps-lures-pheromone-lures. Accessed October 2012.

Cowles, R S; Polavarapu, S; Williams, R N; Thies, A; Ehlers, R U (2005) Soft fruit applications. In Grewal, P S; Ehlers, R U; Shapiro-Ilan, D I (ed) CABI Publishing; Wallingford; Abstract only seen.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Chrysoteuchia topiaria* 2012http://www.cabi.org/cpc/?compid=1&dsid=15862&loadmodule=datasheet&page=868&site=161 Accessed 31 August 2012.

Polavarapu, S (1999) Insecticidal nematodes for cranberry pest management. *Optimal use of insecticidal nematodes in pest management. Proceedings of a workshop, New Brunswick, New Jersey, USA, 28-30 August, 1999.* 79-90. Abstract only seen.

Rochefort, S; Carriere, Y; Shetlar, D; Brodeur, J (2003) Seasonal abundance of the sod webworm species (Lepidoptera: Crambidae) associated with turfgrass in Quebec. [French] *Phytoprotection* 84 (2): 69-75. Abstract only accessed.

Roland, J (1990) Use of alternative plant species as a monitoring tool for the cranberry girdler (Lepidoptera: Pyralidae). *Environmental Entomology*. 19 (3): 721-724. Abstract only accessed.

Thompson HW (1942) *Crambus hortuellus* Hb. as a Grassland Pest. *Annals of Applied Biology* 29 (4): 393-398.

Yarris, L (1983) Cranberry girdlers eat trees, too. *Agricultural Research*, USA. 31 (12): 14-15. Abstract only accessed.

[45] Relevance to the EPA Review: chlorpyrifos and diazinon are organophosphates under review.

Epichoristodes acerbella (South African carnation tortrix)

Scientific Name: *Epichoristodes acerbella* Walker (Lepidotera: Tortricidae)

Synonyms: *Depressaria acerbella* Walker, 1864
Epichorista acerbella Walker
Epichorista ionephela (Meyr.)
Epichoristodes ionephela (Meyrick)
Epychoristodes acerbella
Proselena ionephela Meyrick, 1909
Tortrix iocoma Meyrick, 1908
Tubula acerbella Walker

Common Name: South African carnation tortrix

Brief description: All life stages of the moth *Epichoristodes acerbella* are associated with host plants. It is primarily a pest of carnations but has been recorded from a range of plants including lucerne (CPC 2012). However, no reports no reports of adverse impacts on lucerne have been found. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
E. acerbella is a polyphagous pest on a range of crops but its principal hosts are carnations and chrysanthemums.
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host)
Other plants: strawberry, carnation, chrysanthemum, pelargonium, roses, stonefruit (main hosts) (CPC 2012).

Current geographic distribution:

Africa: Kenya, Madagascar, South Africa
Europe: Bulgaria, Croatia, France, Italy, Serbia, Slovenia, Spain (CPC 2012).

References:
CPC (2012) last modified 4 September 2012, Crop Protection Compendium Report – *Epichoristodes acerbella* http://www.cabi.org/cpc/?compid=1&dsid=21538&loadmodule=datasheet&page=868&site=161 Accessed 11 September 2012.

Glyphipterix simpliciella (Cocksfoot moth)

Scientific Name: *Glyphipterix simpliciella* (Stephens, 1834) (Lepidoptera: Glyphipterigidae)
Synonyms: *Glyphipterix cramerella*
Glyphipterix fischeriella (Zeller)
Common Name: Cocksfoot moth

Brief description: The larval stages of *Glyphipterix simpliciella* feed on the seeds of grasses. Although it is said to be a very common species in much of Britain (Kimber 2012), there is little information available on this moth. Severe attacks reportedly seriously reduce seed production (Carter 1984). However, the only record of economic damage was from the Soviet Union, where the moth damaged seed crops of species of Fescues (*Festuca*) (Degrave and Dolgodvorova 1974).

Indicative host range:
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*), Tall Fescue *(Festuca arundinacea)* (Kimber 2012).
Other plants: *Ranunculus* spp. (Kimber 2012), Umbelliferae (de Prins & Steeman 2012)

Current geographic distribution:
Its range extends across Europe to North Africa and Asia Minor (Carter 1984)
Europe: Former USSR, UK (CPC 2012), Belgium (de Prins & Steeman 2012)

Potential pathways of entry into New Zealand (Commodity Association):
Eggs of *Glyphipterix simpliciella* are laid in a floret of a host species, larvae feed on the seeds and pupate over winter in the stem of grasses (Carter 1984). Adults are often found on the flowers of *Ranunculus* spp. and Umbellifers (de Prins & Steeman 2012). Larvae are only a few mm long. Since fodder plants are not imported into New Zealand (C. Black pers. comm. 2012), grass seed for sowing is the most likely entry pathway. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
G. simpliciella appears to be widespread in the temperate zone of Europe, including in the UK which is climatically similar to parts of New Zealand. Cocksfoot and fescues are widespread in New Zealand in the regions where the climate is suitable and *Ranunculus* spp. and umbellifers are widespread to provide nectar sources for adults. Although small (9mm wingspan (Carter 1984) the adults are mobile. There would be few barriers to its spread by natural dispersal or movement of infested host material. There is uncertainty about the lifecycle of this moth, and although the larval stage may last some months (Carter 1984) there is no apparent means of exposure to vulnerable hosts via the seed for sowing pathway (see section 2.8.4).

Potential Impact in NZ: Low to moderate
The larvae feed on seeds primarily of cocksfoot and can result in reduced seed production. This could have an impact on pastoral production systems in New Zealand. However, the only reported instance of economic damage caused by this moth was of seed production in the USSR in 1974. The assessment of impact should *Glyphipterix simpliciella* establish in New Zealand is uncertain due to the lack of available information. However, it is assumed that it would only become a problem in the seed production areas of New Zealand (mainly Canterbury and South Canterbury; some in Marlborough/Nelson, and Wairarapa; (C. Black pers. com. 2012)).

Possible methods of post-border management and surveillance:
Surveillance: There were only six articles about *G. simpliciella* on CAB abstracts and none of them dealt with surveillance, but pheromone-baited sticky traps may be an option (Alford 1978). Note: An attractant of *G. simpliciella* has been reported (El-Sayad 2012).

Post-border management[46]: Degrave & Dolgodvorova 1974 reported that fescue plantings should be sprayed first with 0.2% trichlorphon (chlorophos) at 2 kg/ha during the flight of the adults and then with 0.1% dimethoate (Rogor) at 0.8-1 kg/ha at the beginning of hatching. The yield in plantings of 18 ha treated in this way was satisfactory, with only individual seeds damaged, and was five times as great as in untreated ones.

References:
Alford, D (1978) Observations on the specificity of pheromone-baited traps for Cydia funebrana (Treitschke)(Lepidoptera: Tortricidae). *Bulletin of entomological research* 68(01): 97-103. (Abstract only seen).

Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Carter, DJ (1984) Pest Lepidoptera of Europe: With Special Reference to the British Isles. Accessed 12/8/12. Available online at:
http://books.google.co.nz/books?id=TnnbtVISjUAC&pg=PA75&lpg=PA75&dq=Glyphipterix+simpliciella++pest&source=bl&ots=6ysnBAtH-y&sig=nzPX6HmtTe218NvYbZgHz5LN2zo&hl=en&sa=X&ei=rh8nUP_yLuuWiQeq84HoCw&ved=0CEcQ6AEwAg#v=onepage&q=Glyphipterix%20simpliciella%20%20pest&f=false

Claridge, JH (1966) Production of Pasture Seed, from An Encyclopaedia of New Zealand, Ed. McLintock, updated 23-Apr-09. Accessed 12/8/12. Available online at:
URL: http://www.TeAra.govt.nz/en/1966/farming-arable/4

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Glyphipterix simpliciella*
http://www.cabi.org/cpc/?compid=1&dsid=25372&loadmodule=datasheet&page=868&site=161 Accessed 12 August 2012.

De Prins, W; Steeman, C (2012) Catalogue of the Lepidoptera of Belgium. Online at:
http://webh01.ua.ac.be/vve/Checklists/Lepidoptera/Lepmain.htm accessed 12/8/12

Degrave, I G; Dolgodvorova, N B (1974) Pests of fescue grown for seed. *Zashchita Rastenii* 11: 47. Abstract only accessed.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals.
http://www.pherobase.com

Kimber I (2012) UK Moths: *Glyphipterix simpliciella* (Stephens, 1834) available online at:
http://ukmoths.org.uk/show.php?id=907 accessed 12/8/12.

[46] Relevance to the EPA Review: dimethoate is an organophosphate under review.

Helicoverpa punctigera (Native budworm)

Scientific Name:	*Helicoverpa punctigera* (Wallengren, 1860) (Lepidoptera: Noctuidae)
Synonyms:	*Chloridea marmada* Swinhoe, 1918 *Heliothis punctigera* Wallengren, 1860
Common Name:	native budworm

Brief description: *Helicoverpa punctigera* is a migratory moth and one of the most significant insect pests of extensive agriculture in Australia (CPC 2012). Larvae feed on the growing points and leaves, but particularly on developing flower buds, flowers and fruits resulting in reduced productivity.

Indicative host range:
H. punctigera is highly polyphagous, with Australian host records from some 270 plant species in 47 families. The vast majority of *H. punctigera* hosts are dicotyledons with the predominant families being Asteraceae, Fabaceae, Malvaceae, Solanaceae, Amaranthaceae and Brassicaceae. Many hosts are ephemeral native plants which flower in inland Australia in response to autumn and winter rains. Larvae feed on the developing flower buds, flowers and fruits. In cropping areas of eastern and western Australia, *H. punctigera* feeds on cotton, sunflowers, linseed (flax) and many legumes including chickpeas, lupins, cowpeas, faba beans.
<u>Priority Pasture Species:</u> Lucerne *(Medicago sativa)*, Red clover (*Trifolium pratense)*, White clover (*Trifolium repens)*, Subterranean clover (*Trifolium subterranium)* (main hosts) (CPC 2012).

Current geographic distribution:
H. punctigera is endemic to Australia and is widespread in both natural habitats and in cropping regions and occurs in Tasmania as well as Victoria. It has been recorded as an occasional migrant to New Zealand, but the existence of breeding populations has not been established (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid on or near buds or growing tips of host plants which are subsequently eaten by developing larvae. Therefore, fresh produce, cut flowers and nursery stock are likely entry pathways. Fresh host material in passengers' luggage is also a possible entry pathway. There have been 8 interceptions of live *H. punctigera* larvae on fresh produce at the New Zealand border. In addition, live adult moth(s) have been intercepted in a used vehicle imported from Australia (MPI 2012). The mass migratory behaviour of the moth means that multiple adults can become trapped in inanimate objects such as vehicles or the holds of vessels. Vessels loading at night may be particularly likely to be infested at particular times of year and there are periodic reports of 'mothy' ships with hundreds of moths on board, arriving in New Zealand waters (MAF BNZ unpublished data). Arrival of large numbers of hitchhiking moths at the same time increases the likelihood of successful entry.

Potential to establish and spread in NZ: High
H. punctigera is widespread in Australia including southern regions with a similar climate to New Zealand, although optimal development reportedly occurs at 35°C for all stages with a developmental threshold of 10°C. Some parts of New Zealand may be too cold for populations to build up. It has a wide host range including many cropped species but it is not known whether non-cropping plants in New Zealand would be able to provide suitable reservoirs as they do in Australia. The moth appears to be an obligate migrant, moving on every generation regardless of the climate conditions (CPC 2012). It is not known whether a suitable sequence of flowering periods is available in New Zealand. *H. punctigera* has a

complex diapause strategy and is highly fecund, with a potential to lay 1500-1800 eggs over a reproductive period of 10-12 days. Together with its polyphagous nature these traits enable *H. punctigera* to rapidly increase in numbers when conditions are favourable and exploit widely dispersed ephemeral resources (CPC 2012). If it is able to establish in New Zealand it would be expected to spread rapidly.

Potential Impact in NZ: Moderate
H. punctigera and *Helicoverpa armigera* combined, represent the most significant insect pests of extensive agriculture in Australia. Estimating the proportion of the damage caused by *H. punctigera* is difficult, since both species feed on many crops (CPC 2012). *H. armigera* is already present in New Zealand. Much of the cost of control and damage on grain legumes in Western Australia, Victoria, and South Australia is apparently due to *H. punctigera* and amounts to millions of Australian dollars. However, many of the extensive crops attacked by *H. punctigera* are relatively low in value and significant losses to budworms may often not be recorded (CPC 2012).

Possible methods of post-border management and surveillance:
Surveillance: Sweep netting is used to monitor for *H. punctigera* in crops such as lucerne, or shake tray or 'beat' sampling is used in many legume crops (CPC 2012). Light trapping and pheromone traps could also be used for surveillance (CPC 2012). Note: A number of pheromones from female *H. punctigera* have been identified (El-Sayad 2012).

Post-border management: In most crops, control relies mostly on chemicals. A number of chemical pesticides are registered for *H. puncitgerna* control in Australia and they cover the major classes of insecticides[47]: organochlorines, synthetic pyrethroids, organophosphates and carbamates. Chemical control is most effective at the time of egg hatch and when larvae are small. Of the range of agronomic practices suggested, cultivation has the greatest management impact on *H. punctigera*. *H. puncitgera* is attacked by a range of generalist parasitoids and predators, but they do not play a role in controlling high density infestations (CPC 2012).

References:
CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Helicoverpa punctigera* http://www.cabi.org/cpc/?compid=1&dsid=26772&loadmodule=datasheet&page=868&site=161 Accessed 3 September 2012.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

MPI (2012) Interceptions database. Accessed August 2012.

[47] Relevance to the EPA Review: some of the chemicals used may be the same as those under review.

Hydraecia micacea (Potato stem borer)

Scientific Name: *Hydraecia micacea* (Esper) (Lepidoptera: Noctuidae)
Synonyms: *Gortyna micacea* Esper
Hydroecia micacea
Common Name: Potato stem borer

Brief description: *Hydraecia micacea* is a moth with stem boring caterpillars that can kill host plants. The larvae bore into the stems of grasses in early instars, moving out to larger stem diameter crops/weeds to feed and complete their development, usually beside or in roots or stems below the soil surface. Grasses such as orchard grass do not have sufficient stem mass to support the larvae throughout their development (Giebink et al 1999). Production damage and death of plants appears to occur in later season hosts rather than grasses (CPC 2012).

Indicative host range:
Exhaustive surveys of the potential host range of *H. micacea* have not been made, however the larvae are quite mobile and able to feed on a large variety of species from many plant families.
<u>Priority Pasture Species</u>: Cocksfoot (*Dactylis glomerata*), Timothy (*Phleum pratense)* (wild hosts)
<u>Other hosts:</u> onions, sugar beet, barley, hops, rhubarb, raspberry, potato, tomato, wheat, maize (main hosts) (CPC 2012).

Current geographic distribution:
H. micacea was introduced into North America around the turn of the twentieth century and has slowly has spread from initial establishment in Eastern Canada across the Great Lakes region of North America and Canada (CPC2012).
<u>Asia:</u> Japan
<u>Americas</u>: Canada, USA
<u>Europe</u>: Czech Republic, Finland, former USSR, Germany, Poland, Sweden, Switzerland, UK (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The eggs of *H. micacea* are laid in masses (1-6 cm in length) of about 30-300, usually between the leaf sheath and stem of grasses (Giebink *et al.* 1999). The eggs are the over-wintering stage which would increase the likelihood of them surviving transfer to New Zealand on host plants. Larvae feed on grasses for their early instars and then switch to other hosts (CPC 2012). Therefore, fresh produce and nursery stock are likely entry pathways. Fresh host material in passengers' luggage is also a possible entry pathway. The pupae are found 2-4 cm below the surface of the ground near the last host fed upon in earthen cells, which are about 1 cm diameter and 2.5 cm in length (CPC 2012). Soil contamination infested with pupae on imported agricultural machinery is a possible pathway but the amount of contamination would need to be large given the size of the pupal cells.

Potential to establish and spread in NZ: High
H. micacea is widespread across the northern USA and southern Canada, as well as parts of Europe such as the UK with a similar climate to New Zealand. It has a wide host range and neither climate nor availability of suitable hosts are likely to be barriers to it establishing in New Zealand. It has spread steadily across the American continent and would presumably spread if established in New Zealand.

Potential Impact in NZ: Low

In Europe *H. micacea* is primarily a pest of hops, while in the USA it damages maize, although significant damage hasn't been reported since 1985 (Giebink et al. 1999). No reports of it causing economic damage to grasses have been found and death of plants appears to occur in later season hosts rather than grasses (CPC 2012).

Possible methods of post-border management and surveillance:
Surveillance: Pheromones have been identified, and could be used in detection programmes (CPC 2012; El-Sayad 2012).

Post-border management: The information on CPC about management relates to maize, hops or potato crops. Recent articles describing chemical control are in foreign languages (Russian or Czech) so no details about the chemical name can be ascertained without translation. An early record describes the used of dimethoate[48] on potato crops (Berim & Tatarintseva 1976).

Cultural practices that prevent or reduce oviposition may also be helpful. Given that eggs are laid along the sides of grass stems and larvae bore into grass stems (CPC 2012), it may be that heavy grazing can control *H. micacea*. In Europe, parasites such as *Lydella stabulans* kill up to 57% of *H. micacea* larvae, and another species *Lydella radicis*, may kill up to 61% of the larvae in maize fields in Canada (CPC 2012).

References:

Berim, N G; Tatarintseva, L E (1976) Control of the potato noctuid on hops. *Zashchita Rastenii* .6, 22. Abstract only seen.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Hydraecia micacea*
http://www.cabi.org/cpc/?compid=1&dsid=28097&loadmodule=datasheet&page=868&site=161 Accessed 3 September 2012.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Giebink, BL; Scriber, JM; Webert, J (1999) Survival and growth of two *Hydraecia* species (Noctuidae: Lepidoptera) on eight midwest grass species. *Great Lakes Entomologist.* 32 (4): 247-256.

[48] Relevance to the EPA Review: dimethoate is an organophosphate under review.

Junonia coenia (Common buckeye)

Scientific Name: *Junonia coenia* Hübner, (1822) (Lepidoptera: Nymphalidae)
Synonyms:
Common Name: Common buckeye

Brief description: *Junonia coenia* is a migratory butterfly whose larvae feed on the leaves of host plants including Ribwort plantain *(Plantago lanceolata).* However, despite being a specialist feeder on Ribwort plantain *(Plantago lanceolata)* (Adler *et al.* 1995), no reports of adverse impacts on plantain have been found. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Larvae feed on plants in the snapdragon, plantain and acanthus families. Adults feed on nectar from a range of Compositae including Chicory *(Cichorium intybus)* (Opler *et al.* 2012). Adler *et al.* (1995) indicate that the butterfly is a specialist feeder on Ribwort plantain *(Plantago lanceolata.)*
Priority Pasture Species: Ribwort plantain *(Plantago lanceolata)*

Current geographic distribution:
Adults from the first brood of butterflyies migrate north in late spring and summer to temporarily colonize most of the United States and parts of southern Canada.
Americas: USA, Mexico, Bermuda, Cuba, Canada (summer only)

References:

Adler, LS; Schmitt, J; Bowers, MD (1995) Genetic variation in defensive chemistry in *Plantago lanceolata* (Plantaginaceae) and its effect on the specialist herbivore *Juonia Coenia* (Nymphalidae). Oecologia 101 (1): 75-85. Abstract only accessed.

Opler, Paul A., Kelly Lotts, and Thomas Naberhaus, coordinators (2012). Butterflies and Moths of North America. http://www.butterfliesandmoths.org/species/Junonia-coenia Accessed 11/9/12.

Papaipema nebris (Common stalk borer)

Scientific Name: *Papaipema nebris* Guenée, 1852 (Lepidoptera: Noctuidae)
Synonyms: *Gortyna nebris*
Gortyna nitela
Papaipema nitella
Common Name: Common stalk borer

Brief description: *Papaipema nebris* is a moth whose larvae tunnel the stalks of grasses and grains as well as a wide range of weeds and other crop plants, causing stems to break and leaves to wilt and die. Damage from this pest is sporadic (Sorensen & Baker 2012).

Indicative host range:
Stalk borers tunnel in almost any large-stemmed plant. Their host range encompasses at least 44 families and 176 species of plants.
<u>Priority Pasture Species:</u> Tall Fescue *(Festuca arundinacea),* Cocksfoot (*Dactylis glomerata*) (preferred hosts) (Highland & Roberts 1989), Lucerne *(Medicago sativa)* (Sorensen & Baker 2012)
<u>Other plants</u>: oats, maize, cotton, potato, tomato, rye, barley, pepper, spinach, beet, sugarbeet and many weedy species (Sorensen & Baker 2012).

Current geographic distribution:
<u>Americas</u>: Canada, USA (Sorensen & Baker 2012)

Potential pathways of entry into New Zealand (Commodity Association):
The borer passes the winter in the egg stage. The eggs are laid on the leaves of grasses or weeds, hatch in early spring and the larvae tunnel into nearby plants, becoming full grown in mid summer. They then pupate, usually just below the soil surface, and emerge as moths in late summer. The moths deposit eggs in late summer in weeds and grassy patches, particularly along fencerows, ditch banks, and grass waterways (Sorensen & Baker 2012). Fresh produce, cut flowers and nursery stock are likely entry pathways. Fresh host material in passengers' luggage is also a possible entry pathway. Soil containing pupae could enter on used agricultural machinery or footwear.

Potential to establish and spread in NZ: High
P. nebris occurs throughout the eastern part of North America from southern Canada to the Gulf states (Sorensen & Baker 2012). Some of these areas have a similar climate to parts of New Zealand. The borer has a wide host range including garden and grassland plants which are widely distributed in New Zealand. Neither climate nor host availability are likely to be barriers to establishment in New Zealand. The adult moth can fly and other life stages can be transported in infested plant material or contaminated machinery. *P. nebris* would therefore be likely to spread if it established in New Zealand

Potential Impact in NZ: Moderate for the pastoral sector
Larvae of *P. nebris* that enter the plant through the lower stalk tunnel upwards, severing the leaves from below and causing apparently healthy green leaves to wilt and die. Other larvae climb plants, enter from the top, and feed on buds and rolled leaves. As they unfurl, new leaves display ragged holes which increase in size as leaves develop. Both forms of injury result in destruction of tassels, production of suckers, and deformation of the upper plant. Soon after borers enter the seedlings, the stems often break. Once past the "whorl" stage, corn is somewhat resistant to stalk borer and recovers more readily from damage. Damage is sporadic (Sorensen & Baker 2012) and appears to depend on the proximity of grasses and weeds which act as a source of infestation. No reports of reduced productivity of grasses in pasture situations were found. The potential impact of the borer is uncertain but several

priority pasture species are likely to be affected especially when allowed to grow tall as for hay. The impacts for the horticultural sector and home gardners could be greater.

Possible methods of post-border management and surveillance:
Surveillance: Pitfall traps and plant samples were used to monitor *P. nebris* populations in corn-growing areas in the USA (Lasack & Pedigo 1986). Ultraviolet-light traps have also been used (Bailey et al. 1985).

Post-border management: Much of the evidence about control of *P. nebris* is from studies in corn crops. Stalk borers cannot be controlled once they have entered the plant; therefore, control measures are strictly preventative (Sorensen & Baker 2012). Chemicals used[49] to control *P. nebris* include chlorpyrifos and cyfluthrin (Reed *et al.* 1990) and carbofuran and carbaryl (Rubink & McCartney 1982). Application of chemicals needs to be timed with to coincide with egg hatch (Rice & Davis 2010). Cultural practices (e.g. tillage) in autumn and/or spring that prevent or reduce oviposition are recommended (Levine 1993). Given that larvae tunnel into the stems of grasses (Rice & Davis 2010), it may be that heavy grazing can control *P. nebris*.

References:

Bailey, W C; Buntin, G D; Pedigo, L P (1985) Phenology of the adult stalk borer, Papaipema nebris (Guenee), (Lepidoptera: Noctuidae) in Iowa. *Environmental Entomology* 14: 3, 267-271. Abstract only accessed

Highland, HB; Roberts, JE (1989) Oviposition of the stalk borer *Papaipema nebris* (Lepidoptera: Noctuidae) among various plants and plant characteristics for ovipositional preference. *Journal of Entomological Science* 24: 70-77. Abstract only accessed

Lasack, P M; Pedigo, L P (1986) Movement of stalk borer larvae (Lepidoptera: Noctuidae) from noncrop areas into corn. *Journal of Economic Entomology* 79 (6): 1697-1702. Abstract only accessed

Levine, E (1993) Effect of tillage practices and weed management on survival of stalk borer (Lepidoptera: Noctuidae) eggs and larvae. *Journal of Economic Entomology* .86: 3, 924-928. Abstract only accessed

Reed, J P; Hall, F R; Willson, H R (1990) Influence of nozzle type upon the control of the stalkborer using chlorpyrifos and cyfluthrin. *Journal of Environmental Science and Health* Part B, Pestes, Foo ontamnants, an Agrutura Wastes-137-150. Abstract only accessed

Rice, M E; Davis, P (2010) Stalk borer (Lepidoptera: Noctuidae) ecology and integrated pest management in corn. *Journal of Integrated Pest Management* 1(1): C1-C6.

Rubink, W L; McCartney, D A (1982) Controlling stalk borer damage in field corn. *Ohio Report on Research and Development* 67: 1, 11-13

Sorensen, KA; Baker, JR (2012) Insects and related pests of vegetables. Some important, common and potential pests in southeastern United States. Stalk borer. Available online at: http://ipm.ncsu.edu/ag295/html/stalk_borer.htm accessed 12/9/12.

[49] Relevance to the EPA Review: chlorpyrifos is an organophosphate, and carbofuran & carbaryl are carbamates under review.

Spodoptera frugiperda (Fall armyworm)

Scientific Name: *Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae)
Synonyms: *Caradrina frugiperda*
Laphygma frugiperda Guenee, 1852
Laphygma inepta Walker, 1856
Laphygma macra Guenee, 1852
Noctua frugiperda J.E. Smith
Phalaena frugiperda Smith & Abbot, 1797
Prodenia autumnalis Riley, 1870
Prodenia plagiata Walker, 1856
Prodenia signifera Walker, 1856
Trigonophora frugiperda Geyer, 1832
Common Name: Fall armyworm

Brief description: *Spodoptera frugiperda* is a moth with the capacity for locally severe infestations in some areas. Damage results from leaf-eating and healthy plants usually recover quite quickly, but a large pest population can cause defoliation especially of maize; the larvae then migrate to adjacent areas (CPC 2012).

Indicative host range:
S. frugiperda is polyphagous but has a preference for the Poaceae. It is most commonly recorded from wild and cultivated grasses (CPC 2012). Most larvae are conditioned to the host on which they first feed, usually the plant on which the eggs were laid (EPPO
Priority Pasture Species: Lucerne *(Medicago sativa)*, Poaceae, *Trifolium* spp. (main hosts), Timothy (*Phleum pratense)*, Red clover (*Trifolium pratense)*, White clover (*Trifolium repens)* (other host).
Other plants: Main hosts include: onion, groundnut, beetroot, sugarbeet, cauliflower, turnip, bell pepper, chrysanthemum, cucumber, carnation, soyabean, cotton, sweet potato, banana, tobacco, rice, pelargoniums, beans, sugarcane, tomato, aubergine, potato, sorghum, spinach, maize, ginger (CPC 2012).

Current geographic distribution:
Americas: Bermuda, Canada, Mexico, USA, Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guadalupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Panama, Puerto Rico, Saint Kitts & Nevis, Saint Vincent & the Grenadines, Lucia, Saint , Trinidad & Tobago, United States Virgin Islands, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, French Guiyana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela.
Europe: Germany (CPC 2012), but EPPO report it as absent from Europe.

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid in masses of 100-300 on leaves. Larvae are reported to arrive in Europe most years on air freighted vegetables or fruit from the New World; sometimes they also come on herbaceous ornamentals (EPPO). Fresh produce, cut flowers and nursery stock are likely entry pathways. Fresh host material in passengers' luggage is also a possible entry pathway.

Potential to establish and spread in NZ: Low
S. frugiperda is a tropical and subtropical species that regularly migrates to cooler regions in the summer (EPPO). Suitable temperatures for development (egg to adult) of *S. frugiperda* range between 16 and 35 °C (Barfield *et al.* 1978). The optimum temperature for larval development is reported to be 28°C, but is lower for both oviposition and pupation. In the tropics, breeding can be continuous with four to six generations per year, but in northern

regions only one to two generations develop; at lower temperature, activity and development cease, and when freezing occurs all stages are usually killed. In the USA, *S. frugiperda* usually overwinters only in southern Texas and Florida (EPPO). A closely related species, *S. exigua* has the same developmental temperature range as *S. frugiperda*, eco-climatic modelling indicates that development of this species is possible in northern New Zealand (Zheng *et al.* 2012). It is likely that the moth could only establish permanently in New Zealand in protected environments or the north of New Zealand. *S. frugiperda* does not occur in Oceania, so regular natural immigration would not occur.

Potential Impact in NZ: Low
The pest is of variable importance in areas where is occurs. Locally severe infestations occur sporadically, and some areas seem to be more at risk than others. Damage results from leaf-eating and healthy plants usually recover quite quickly, but a large pest population can cause defoliation; the larvae then migrate to adjacent areas in true armyworm fashion. Its potential impacts in New Zealand are likely to be low because distribution in New Zealand is likely to be limited.

Possible methods of post-border management and surveillance:
Surveillance: *S. frugiperda* can be monitored by the use of pheromone traps (CPC 2012).

Post-border management: Much of the information about management of *S. frugiperda* relates to its occurrence in maize crops; integrated pest management programmes are used (CPC 2012). Freezing temperatures cause high larval mortality.

Biological control: Braconid wasps are an important control agent that parasitize the larvae of *S. frugiperda* (CPC 2012).

Host-plant resistance: improved resistance of maize to *S. frugiperda* has been achieved (CPC 2012). A similar approach might be considered for other host plants.

Chemical control[50]: Recommended insecticides for *Spodoptera* spp. include esfenvalerate, carbaryl, chlorpyrifos, malathion, permethrin, lambda-cyhalthrin (CPC 2012).

Pheromonal control: Mating disruption may be possible given the successes observed for another *Spodoptera* species (CPC 2012).

References:
Barfield, CS; Mitchell, ER; Peob, SL (1978) A temperature-dependent model for fall armyworm development. *Annals of the Entomological Society of America.* 71**:** 70-74

CPC (2012) last modified 7 August 2012, Crop Protection Compendium Report – *Spodoptera frugiperda* http://www.cabi.org/cpc/?compid=1&dsid=29810&loadmodule=datasheet&page=868&site=161 Accessed 30 August 2012.

EPPO Data sheets on quarantine pests: *Spodoptera frugiperda*. Prepared by CABI and EPPO for the EU under Contract 90/399003. Available online. Accessed 30/8/12 http://www.eppo.int/QUARANTINE/insects/Spodoptera_frugiperda/LAPHFR_ds.pdf

Zheng, X L; Wang, P; Cheng, W J; Wang, X P; Lei, C L (2012) Projecting overwintering regions of the beet armyworm, *Spodoptera exigua* in China using the

[50] Relevance to the EPA Review: chlorpyrifos & malathion are organophosphates, and carbaryl is a carbamate under review.

CLIMEX model.. *Journal of Insect Science* 12-13 available online:
http://www.insectscience.org/12.13/i1536-2442-12-13.pdf

Spodoptera littoralis (Cotton leafworm)

Scientific Name: *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae)
Synonyms: *Hadena littoralis* Boisduval
Noctua gossypii
Prodenia littoralis (Boisduval)
Prodenia litura Fabricius sensu auctorum
Prodenia retina (Freyer)
Prodenia testaceoides Guenee
Common Name: Cotton leafworm

Brief description: *Spodoptera littoralis* is one of the most destructive agricultural moths within its subtropical and tropical range. It can attack numerous economically important crops throughout the year. The larvae feed extensively on leaves, fruit and seeds often leading to complete stripping of the plants (CPC 2012).

Indicative host range:
The host range of *S. littoralis* covers over 40 families, containing at least 87 species of economic importance. In many of the published reports of host plants, it is difficult to distinguish between *S. littoralis* and *S. litura* but the data below refer entirely to records of the former (CPC 2012).
<u>Priority Pasture Species</u>: Lucerne *(Medicago sativa),* Poaceae (main hosts), White clover (*Trifolium repens)* (other host).
<u>Other plants</u>: Main hosts include: okra, onion, amaranth, groundnut, beetroot, sugarbeet, cauliflower, Chinese cabbage, tea, bell pepper, chrysanthemum, water melon, citrus, coffee, jute, pumpkin, globe artichoke, carrot, carnation, fig, daisy, soyabean, cotton, sunflower, Jerusalem artichoke, sweet potato, lettuce, mulberry, plantain, tobacco, rice, avocado, beans, pea, plum, guava, pomegranate, radish, rose, sugarcane, tomato, aubergine, potato, sorghum, spinach, cocoa, wheat, broad bean, cow pea, grapevine, maize (CPC 2012).

Current geographic distribution:
<u>Asia</u>: Bahrain, Iran, Iraq, Israel, Jordan, Lebanon, Oman, Pakistan, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen
<u>Africa</u>: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verdi, Central African Republic, Chad, Comoros, Congo, Congo Democratic Republic, Cote d'Ivoire, Egypt, Equatorial, Guinea, Ethiopia, Eritrea, Gambia, Ghana, Guinea, Kenya, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, St Helena, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda.
<u>Europe</u>: Cyprus, Greece (Crete), Italy (Sicily), Malta, Portugal, Spain (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid in masses of 20-1000 on the lower surface of young leaves. *S. littoralis* first appeared in UK glasshouses in considerable numbers in 1963. Eggs were being introduced on imported cuttings, especially chrysanthemums and carnations (CPC 2012). Cut flowers and nursery stock are therefore likely entry pathways.

Imported fresh produce is another entry pathway since larvae are present on host plants. Vegetables such as lettuce and tomatoes are hosts. Fresh host material in passengers' luggage is also a possible entry pathway. The moth pupates in the soil, so items contaminated with large clods of soil such as used agricultural machinery are possible entry pathways.

Potential to establish and spread in NZ: negligible

The northern limit of *S. littoralis* in Europe corresponds to the climatic zone in which winter frosts are infrequent. This boundary is probably the extent of migrant activity only, with over-wintering occurring to the south (CPC 2012). It is likely that the moth could only establish permanently in New Zealand in protected glasshouse environments. *S. littoralis* does not occur in Oceania, so regular natural immigration would not occur. It is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

References:

CPC (2012) last modified 26 March 2012, Crop Protection Compendium Report – *Spodoptera littoralis* http://www.cabi.org/cpc/?compid=1&dsid=51070&loadmodule=datasheet&page=868&site=161 Accessed 28 August 2012.

6.6 Plant Bugs - Hemiptera

Adelphocoris lineolatus (Lucerne bug)

Scientific Name: *Adelphocoris lineolatus* Goeze (1778) (Hemiptera: Miridae)
Synonyms: *Adelphocoris binotata* Goeze
Common Name: Lucerne bug

Brief description: *Adelphocoris lineolatus* is described as one of the main insect pests of lucerne crops. Feeding damage can result in reduced seed production and quality. It is widespread throughout the temperate areas of the northern hemisphere (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*; Red clover (*Trifolium pratense)* and White clover *(Trifolium repens)*are main hosts (CPC 2012).
Other plants: *A. lineolatus* is polyphagous. Host plants include forage and oilseed crops, flowers, vegetables and various fruits, trees, shrubs and weeds. A wide range of fruit and vegetable crops are affected including apples, pears, tomatoes and cucumbers. In China wild plants in 32 families are affected (CPC 2012).

Current geographic distribution:

Asia: Azerbaijan, China, Iran, Japan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkestan, Turkey, Uzbekistan
North America: Canada, USA
Europe: Albania, Andorra, Austria, Belarus, Belgium, Bosnia-Herzegovnia, Bulgaria, Croatia, Czechoslovakia (former), Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lichtenstein, Lithuania, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, Yugoslavia (former) (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The entire life-cycle of *A. lineolatus* is completed on the host plant – eggs are laid in the stem and the nymphs feed on the growing plant. CABI (2012) reports symptoms on both fruit and seeds, although CPC indicates that fruit and seeds are not known to carry this bug in trade. The most likely entry pathway would be fresh host plant material. However, no fodder plants are imported into New Zealand except as seed for sowing (C. Black pers. comm. 2012). Imported fresh fruit such as pears is a possible entry pathway. It is not known whether nymphs would feed on mature seed, but it appears unlikely that they would be present on grass seed at harvest. Adult bugs may be present in large numbers in crop fields of the main hosts during harvest of seed of lucerne or clover for export. They may be present as a contaminant in the seed, but it is unlikely that they would survive processing and shipment to New Zealand. Cuttings of some hosts such as *Malus* and *Pyrus* are permitted into New Zealand (MPI 2012). It is unlikely that cuttings would be infested with *A. lineolatus* nymphs which are 1.5 to 5 mm long (depending on the instar) (CPC 2012) and thus readily detectable. Passengers (plant material in luggage) is a possible pathway.

Potential to establish and spread in NZ: High
A. lineolatus is widespread in the temperate zone of the northern hemisphere. Climates in many of these areas also exist in NZ at a regional level. It thrives under cool, wet conditions, and is adversely affected by warm, dry weather. Many of the reported hosts are widespread in New Zealand in the regions where the climate is suitable. It most often has 2 generations a year, so populations could build up rapidly. Adults fly well, but not over long distances (CPC

2012). There would be few barriers to its spread by natural dispersal or movement of infested host material.

Potential Impact in NZ: High
Plant bugs have piercing-sucking mouthparts and damage the plant by puncturing the host tissue and sucking the sap. The plants react to the toxic saliva injected by the insects when they feed. In lucerne and other forage crops, these bugs suppress stem growth and cause excessive branching, small, distorted leaves and necrosis of the leaf margin. Feeding on the buds and blossoms causes chlorosis and the buds and blossoms shrivel, turn greyish-white and drop. Seeds shrivel and turn brown when *A. lineolatus* feeds on seeds in the pods (CABI 2012). Grichanov & Ovsyannikova (2008) also report destruction of leaf and flower buds and damage young, not yet hardened beans and seeds. The main impact appears to be on seed production. Since lucerne and clovers are important fodder crops in New Zealand and *A. lineolatus* is expected to be able to establish in most pastoral areas of New Zealand, the economic impact if the species were to establish permanently in New Zealand could be large.

Possible methods of post-border management and surveillance:
Surveillance: Fields can easily be sampled on a regular basis using a standard insect sweep net, starting at the bud stage. *A. lineolatus* can also be monitored with light traps (CPC 2012)

Post-border management: Much of the evidence about control of *A. lineolatus* is in relation to lucerne seed crops.

Chemical control[51] - Insecticides registered for the control of *A. lineolatus* in the USA include dimethoate, trichlorfon and deltamethrin. Suitable insecticides reported in other countries include malathion, diazinon, butonate, phosalone and most pyrethroids. However, a Canadian study recommended that deltamethrin is not recommended for control of *A. lineolatus* in seed lucerne fields. Bio-insecticides based on *Bacillus thuringiensis* were found to be ineffective against plant bugs when applied alone, but were 100% effective when mixed with carbaryl or trichlorfon or phosalone (CPC 2012).

Cultural control – includes burning lucerne stubble and straw in the spring, before regrowth begins, to destroy the overwintering eggs. Weed control may also help to reduce local populations of *A. lineolatus* (CPC 2012).The abundance of plant bugs can be reduced by various cultural practices including harrowing crops in the spring, increasing the frequency of cutting, reducing cutting height to 4-6 cm, removing weeds and providing spatial isolation (minimum 1.0-1.5 km) between new and old seed crops (CPC 2012).

Mechanical control - Border stands of different plants (fennel, maize, *Pimpinella anisum*, hemp and *Coriandrum sativum*) grown alongside lucerne can reduce the damage caused by plant bugs and significantly increase the number of healthy seeds (CPC 2012).

References:
Black, C. (2012), MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CABI (2012) Plantwise: lucerne bug (*Adelphocoris lineolatus*) Available online at: http://www.plantwise.org/?dsid=3290&loadmodule=plantwisedatasheet&page=4270&site=234 Accessed 12/8/12.

CPC (2012) last modified 1 August 2012, Crop Protection Compendium Report – *Adelphocoris lineolatus*

[51] Relevance to the EPA Review: dimethoate, malathion & diazinon are organophosphates under review.

http://www.cabi.org/cpc/?compid=1&dsid=3290&loadmodule=datasheet&page=868&site=161 Accessed 12 August 2012.

Grichanov, IYA; Ovsyannikova, EI (2008) Interactive Agricultural Ecological Atlas of Russia and Neighboring Countries. Economic Plants and their Diseases, Pests and Weeds: *Adelphocoris lineolatus* Goeze - Lucerne Plantbug. Available online at: http://www.agroatlas.ru/en/content/pests/Adelphocoris_lineolatus/ accessed 12/8/12.

MPI (2012) Standard 155.02.06. Importation of nursery stock. Available online at: http://www.biosecurity.govt.nz/files/ihs/155-02-06.pdf accessed 12/8/12.

Empoasca fabae (Potato leaf hopper)

Scientific Name: *Empoasca fabae* (Harris) (Hemiptera: Cicadellidae)
Synonyms: *Chloroneura malefica* Walsh
Empoa fabae (Walsh)
Empoasca albopicta Forbes
Empoasca consobrina Walsh
Empoasca flavescens (Fabricius)
Empoasca mali (LeBaron)
Empoasca viridescens Walsh
Typhlocyba photophila Berg
Common Name: Potato leaf hopper

Brief description: *E. fabae* is a serious pest of potato and lucerne. The leafhopper feeds on host plants reducing plant height and crude protein levels (CPC 2012).

Indicative host range:
The reported host plant list includes 220 species in 100 genera and 26 families. Fabaceae represented 47% of the genera and 62% of the species.
Priority Pasture Species: Lucerne *(Medicago sativa), Trifolium* spp. main hosts.
Other plants: potato, vetches, leguminous plants (main hosts) (CPC 2012).

Current geographic distribution:
In the USA, *E. fabae* only overwinters along the Gulf Coast. The insect undergoes mass movements northward in the spring and early summer and becomes established in many areas of the country. North-eastern and mid-western states suffer the greatest forage loss from this pest due to the concentration of lucerne and clover in these areas. The leafhopper is generally distributed northward by wind. Although it does not overwinter in northern areas, it may complete several generations in these areas (CPC 2012).

Asia: India
Americas: Canada, USA, Cuba (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
All life-stages of *E. fabae* are associated with host plants. Fresh host material would be required for entry into New Zealand and imported fresh produce e.g. fruit or tomato would be the most likely entry pathway. No fresh lucerne (a reported main host) is imported into New Zealand (C. Black pers comm. 2012). Passengers (fresh plant material in luggage) are a possible entry pathway. *E. fabae* can apparently be found in dry beans (CPC 2012) which is a possible entry pathway. Adult leafhoppers migrate northwards in spring and could become trapped as a hitchhiker on a range of commodities. However, the likelihood of entering New Zealand as an accidental hitchhiker is generally low (section 4).

Potential to establish and spread in NZ: Moderate
In the USA, *E. fabae* reportedly only overwinters along the Gulf Coast (CPC 2012) which has a more tropical climate than any part of New Zealand. However, it undergoes mass movements northward (via wind current) in the spring and early summary and becomes established in many areas of the USA. However, Sidumo *et al.* (2005) used geographic information systems to estimate the over-winter range of the leafhopper. The minimum winter temperature was estimated by overlaying minimum temperature isolines with potato leafhopper collection data taken during the winter. This gave a best estimate minimum survival temperature of -9°C and estimated overwintering range that is larger and covered areas further north than previously estimated and included Missouri, Kansas, Kentucky, Virginia, and Maryland. Based on the Sidumo et al (2005) study, *E. fabae* may be able to survive the winter in northern parts of New Zealand. There would be no shortage of available

hosts and it could potentially establish temporary seasonal populations throughout much of New Zealand. In conclusion, it considered that there is a moderate potential for *E. fabae* to establish in New Zealand. Some uncertainty is associated with this conclusion.

Potential Impact in NZ: High
E. fabae is a serious pest of potato and lucerne. The leaf hopper feeds on host plants reducing plant height and crude protein levels (CPC 2012). However, controversy exists as to the relative importance of direct injury by mechanical occlusion of phloem cells, indirect injury by toxigenic secretions, or the induction of abnormal tissue growth surrounding the phloem. Whatever the mechanism, economic injury occurs at extremely low leafhopper densities indicating that the effect is not merely mechanical. The economic threshold for leafhoppers in lucerne varies depending on plant height. As the crop increases in height, the number of leafhoppers required for economic injury also increases (CPC 2012). Lucerne and clovers are important fodder crops in New Zealand and if *E. fabae* can over-winter in New Zealand it is expected to be able to establish temporary populations in most pastoral areas of New Zealand. The economic impact to the pastoral sector if the species were to establish permanently in New Zealand could be large. In addition, there would be impact for the vegetable growing sector.

Possible methods of post-border management and surveillance:
Surveillance: Monitoring for *E. fabae* in Canadian crops typically involves sweep net sampling and the use of yellow sticky cards (Appleton *et al.* 2003). Yellow sticky traps are used to monitor *E. fabae* in Lucerne fields in Iowa (DeGooyer *et al.* 1998).

Post-border management: Plant resistance to *E. fabae* has been documented in lucerne (CPC 2012). Much of the evidence collated by CPC about control of *E. fabae* was related to potato crops. Insecticides provide good control of the nymphs and adults[52]. In potato crop and vineyard settings some success in managing *E. fabae* is reported with systematic neonicotinoid insecticides, or soil applied thiamethoxam (Ghidiu *et al.* 2011; Timmeren *et al.* 2011), but this may not be applicable to pasture settings. Foliar treatments based on economic thresholds may be a preferred management strategy. Biological control is not a viable management option for leafhoppers (CPC 2012).

References:

Appleton, E S B; Gillard, C; Schaafsma, A W (2003) Biology and management of the potato leafhopper, Empoasca fabae (Harris) (Homoptera: Cicadellidae) on field crops in Ontario. *Journal of the Entomological Society of Ontario; 2003.134: 3-17*

Black, C. (2012) MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Empoasca fabae*
http://www.cabi.org/cpc/?compid=1&dsid=20860&loadmodule=datasheet&page=868&site=161 Accessed 27 August 2012.

DeGooyer, T A; Pedigo, L P; Rice, M E (1998) Development of sticky trap sampling technique for potato leafhopper adults. *Journal of Agricultural Entomology; 1998.15: 1, 33-37*

Ghidiu, G M; Douches, D S; Felcher, K J; Coombs, J J (2011) Comparing host plant resistance, engineered resistance, and insecticide treatment for control of Colorado potato

[52] Relevance to the EPA Review: unclear.

beetle and potato leafhopper in potatoes. *International Journal of Agronomy; 2011.2011: Article ID 390409.* Abstract only seen.

Sidumo, AJ; Shields, EJ; Lembo, A Jr. (2005) Estimating the potato leafhopper *Empoasca fabae* (Homoptera: Cicadellidae) overwintering range and spring premigrant development by using geographic information system. *Journal of Economic Entomology* 98 (3): 757-764.

Timmeren, S v; Wise, J C; VanderVoort, C; Isaacs, R (2011) Comparison of foliar and soil formulations of neonicotinoid insecticides for control of potato leafhopper, Empoasca fabae (Homoptera: Cicadellidae), in wine grapes. *Pest Management Science* 67 (5): 560-567. Abstract only seen.

Lygus lineolaris (Tarnished plant bug)

Scientific Name: *Lygus lineolaris* Palisot de Beauvois, 1818 (Hemiptera: Miridae)
Synonyms: *Capsus flavonotatus* Provancher, 1872
Capsus lineolaris Palisot de Beauvois, 1818
Capsus oblineatus Say, 1832
Capsus strigulatus Walker, 1873
Lygus pratensis var. rubidus Knight, 1917
Common Name: Tarnished plant bug

Brief description: *Lygus lineolaris* is a very common pest on a wide variety of commodities in North America. Its food-plants include at least 130 of economic importance. *L. lineolaris* feeds on all aerial plant parts, but favours leaf and flower buds, flowers, fruits and seeds. Damage is due to nymphs and adults piercing and sucking nutrient-rich juices from plant tissues. Feeding on buds and new growth can cause yellowing and distortion of the growing points. Heavy feeding may cause dwarfing, blackening, or die-back of shoots. Fruits can become blemished or distorted. The injection of saliva by feeding *L. lineolaris* can also cause indirect damage through changes to plant physiology. These effects result in reduced crop yields (CPC 2012).

Indicative host range:
L. lineolaris has a very wide host range, being most attracted to flowering plants in the families Asteraceae and Brassicaceae.
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host)
Other plants: other main hosts include rape, cauliflower, strawberry, celery, cotton, lima bean, common bean, peach, potato, crimson clover, common vetch, maize (CPC 2012).

Current geographic distribution:

Asia: Republic of Georgia
North America: Canada, USA
Central America: Mexico, El Salvador, Guatemala, Honduras (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
L. lineolaris is a generalist plant feeder. Both nymphs and adults suck the juices of plant tissues. Reproductive tissues, such as buds, flowers and fruits are especially favoured. Adults overwinter in dead plants and wood litter. As adults of *L. lineolaris* are very active, they are unlikely to be included in commodity shipments. Nymphs are reclusive, and could potentially hide in certain commodities, such as cut flowers. Eggs are very small and inserted into plant tissues, making it unlikely that they would be detected during inspections of agricultural commodities (CPC 2012). Taking account of its biology the most likely entry pathway are fresh produce and cut flowers. Passengers (plant material in luggage) are a possible entry pathway.

Potential to establish and spread in NZ: High
L. lineolaris occurs in all agricultural areas of North America from low to relatively high elevations, from east central Alaska southeast to Newfoundland and south to southern Mexico (CPC 2012). Climates in many of these areas also exist in at least parts of New Zealand. Many of the reported hosts are widespread in New Zealand in the regions where the climate is suitable. Considering that *L. lineolaris* is a very common pest on a wide variety of commodities, but its distribution is limited to North America it would appear that this pest does not pose a large phytosanitary risk. However, the reasons for failure to establish in other regions is not known and could relate to factors such as natural enemies or competition that might not be relevant in New Zealand. There would be few barriers to its spread by natural dispersal or movement of infested host material.

Potential Impact in NZ: Moderate
L. lineolaris can cause yield loss in lucerne in North America, but the main economic impact appears to be on cotton. Impacts on lucerne occur particularly when young plants are infested. As the stand matures, infestation encourages lateral shoot growth which offsets yield reduction. *L. lineolaris* can significantly effect seed production (CPC 2012).

Infestations of *L. lineolaris* on immature fruits can result in abscission of the fruit. Damaged fruit may have shrivelled seeds or seeds without embryos. Apples, peaches, and other fruits can develop dimpling around the feeding sites (CPC 2012). Establishment of this bug in New Zealand would be expected to have adverse impacts on the horticultural sector as well as the pastoral sector.

Possible methods of post-border management and surveillance:
Surveillance: White sticky traps have been used to monitor *L. lineolaris* near and in affected crops (Fleury et al. 2010; CPC 2012).

Post-border management: Insecticides are commonly used to control *L. lineolaris*, however, resistance to pyrethroids has been documented. Organophosphate and carbamate[53] are also used (CPC 2012). CPC states that economic thresholds for insecticidal treatment for L. lineolaris have been developed for many crops (CPC, 2012), but lucerne was not one of them. The success of biological control using parasitoid *Peristenus digoneutis* is unclear, with CPC stating it has been ineffective (CPC, 2012), but a recent study in strawberry crops reported that *L. lineolaris* populations are markedly reduced by the parasitoid (Day & Hoelmer 2012)

References:
CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report *Lygus lineolaris* http://www.cabi.org/cpc/?compid=1&dsid=31791&loadmodule=datasheet&page=868&site=161 Accessed 26 August 2012.

Day, W H; Hoelmer, K A (2012) Impact of the introduced parasitoid Peristenus digoneutis (Hymenoptera: Braconidae) on tarnished plant bug (Hemiptera: Miridae) infesting strawberries in northwestern New Jersey, USA. *Biocontrol Science and Technology* 22: 8, 975-979

[53] Relevance to the EPA Review: unclear – some of the chemicals used effectively may be the same as those under review.

Piezodorus hybneri (Legume stink bug)

Scientific Name: *Piezodorus hybneri* (Gmelin) (Hemiptera: Pentatomidae)
Synonyms: *Cimex flavescens* Fabricius
Cimex rubrofasciatus Fabricius
Nezara pellucida Ellenrieder
Piezodorus rubrofasciatus (Fabricius)
Rhaphigaster extenuatus Walker
Rhaphigaster flavolineatus (Westwood)
Rhaphigaster oceanicus Montrouzier
Rhaphigaster pallescens Walker
Rhaphigaster virescens Amyot & Serville
Common Name: Legume skink bug

Brief description: *P. hyberni* is a stink bug that feeds on leguminous plants, particularly lucerne, causing reduction in seed quality and quantity (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*main host.
Other plants: potato, tomato, pea, soyabean, okra, chilli (other hosts) (CPC 2012).

Current geographic distribution:
P. hybneri has a palaeotropical range, and is widely distributed in Asia. It is also likely to be distributed widely in Africa, although the current distribution is difficult to ascertain due to difficulties of correctly identifying the different species of *Piezodorus* (CPC 2012).

Asia: Bangladesh, Cambodia, China, India, Indonesia, Japan, Republic of Korea, Malaysia, Pakistan, Philippines, Thailand, Vietnam
Africa: Tanzania
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Very little information is available on the biology of *P. hyberni* but it is assumed that all life-stages are associated with host plants. If this is the case, fresh host material would be required for entry into New Zealand and imported fresh produce e.g. tomatoes would be the most likely entry pathway. No fresh lucerne (the reported main host) is imported into New Zealand (C. Black pers comm. 2012). Passengers (plant material in luggage) are a possible entry pathway.

Potential to establish and spread in NZ: Low
P. hybneri has only been reported from countries with tropical climates (CPC 2012). However, its distribution within these countries is not known and it is possible that it might occur at high altitudes. It is highly unlikely that the climate is suitable for it to establish anywhere in New Zealand, but insufficient information has been accessed to describe the potential for establishment as negligible (section 2.4.1).

Potential Impact in NZ: Low
Most reports of detrimental impacts of *P. hyberni* are on soybean (Search of CAB abstracts 26 August 2012). No specific reports of economic damage to lucerne have been found. Since its distribution in New Zealand is likely to be very restricted if it establishes at all, the impact on the New Zealand pastoral sector is likely to be very small.

Possible methods of post-border management and surveillance:
Surveillance: No records were found that addressed surveillance specifically for *P. hybneri*. Other stink bug species have been monitored using pheromone-baited traps in soybean fields

(Borges *et al.* 2011) and a similar strategy might be possible for *P. hybneri* (Leal *et al.* 1998). Light traps can also be used to monitor for stinkbugs (Cherry & Wilson 2011). Other generic techniques for monitoring invertebrates might also be employed. Note: An attractant of *P. hybneri*, and three pheromone compounds from male *P. hybneri* have been identified (El-Sayad 2012).

Post-border management: Much of the evidence about management of *P. hybneri* is in relation to control within soybean crops. Use of egg parasitoids has some potential for control of *P. hybneri* (Lim *et al.* 2007; Mizutani 2001). In Australian pulse crops, *P. hybneri* has been controlled using insecticides (chemicals not specified) (Ingram 1998).

References:

Black, C. (2012) MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Borges, M; Moraes, M C B; Peixoto, M F; Pires, C S S; Sujii, E R; Laumann, R A (2011) Monitoring the Neotropical brown stink bug *Euschistus heros* (F.) (Hemiptera: Pentatomidae) with pheromone-baited traps in soybean fields. *Journal of Applied Entomology; 2011.135: 1/2, 68-80.* Abstract only reviewed

Cherry, R; Wilson, A (2011) Flight activity of stink bug (Hemiptera: Pentatomidae) pests of Florida rice. *Florida Entomologist*; 2011.94: 2, 359-360.8 ref

CPC (2012) last modified 22 March 2012, Crop Protection Compendium Report – *Piezodorus hybneri*
http://www.cabi.org/cpc/?compid=1&dsid=41174&loadmodule=datasheet&page=868&site=161 Accessed 12 August 2012.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Ingram, B F (1998) Possible alternative host plants for some major pod sucking bug pests of pulse crops in the South Burnett region of Queensland. *General and Applied Entomology;* 28: 101-108. Abstract only reviewed

*L*eal, W S; Kuwahara, S; Shi XiongWei; Higuchi, H; Marino, C E B; Ono, M; Meinwald, J (1998) Male-released sex pheromone of the stink bug Piezodorus hybneri. *Journal of Chemical Ecology* 24: 11, 1817-1829. Abstract only reviewed

Lim UnTaek; Park KyungSoo; Mahmoud, A M A; Jung ChulEui (2007) Areal distribution and parasitism on other soybean bugs of *Trissolcus nigripedius* (Hymenoptera: Scelionidae), an egg parasitoid of Dolycoris baccarum (Heteroptera: Pentatomidae). *Korean Journal of Applied Entomology 46: 1, 79-85.* Abstract only reviewed

Mizutani, N (2001) Host-parasitoid interaction between the egg parasitoid Ooencyrtus nezarae ISHII (Hymenoptera: Encyrtidae) and phytophagous bugs in soybean fields. *Bulletin of the National Agricultural Research Center for Kyushu Okinawa Region* 39, 15-78 Abstract only reviewed

Sitobion avenae (Grain aphid)

Scientific Name:	*Sitobion avenae* (Fabricius, 1775) (Hemiptera: Aphidoidea)
Synonyms:	*Amphorophora avenae* (F.) *Aphis avenae* Fabricius, 1775 *Aphis cerealis* Kaltenbach, 1843 *Aphis granaria* Kirby, 1798 *Macrosiphon avenae* (F.) *Macrosiphum allii* Jackson, 1918 *Macrosiphum avenae* (Fabricius) Markkula, 1963 *Macrosiphum cerealis* (Kaltenbach) *Macrosiphum granarium* (Kirby) *Nectarophora cerealis* (Kaltenbach) *Siphonophora cerealis* (Kaltenbach) *Sitobion cerealis* (Kaltenbach) *Sitobion granarium* (Kirby, 1798) Mordvilko, 1914 *Sitobium avenae* (F.)
Common Name:	Grain aphid, wheat aphid

Brief description: *S. avenae* is found on numerous species of Gramineae worldwide, and is a pest of cereal crops in temperate regions. It causes direct damage by feeding on fruits, leaves, stalks and ears, and indirect damage by excreting honeydew and transmitting viruses. *S. avenae* mainly impacts cereal yields by removing plant nutrients and reducing photosynthesis via honeydew accumulations (CPC 2012).

Indicative host range:
<u>Priority Pasture Species:</u> Cocksfoot (*Dactylis glomerata*), *Poaceae* spp. (wild hosts).
<u>Other plants:</u> oats, barley, wheat (main hosts); rice, rye, maize (other hosts) (CPC 2012).
S. avenae sampled in southern England fell into three genotypic groups, one of which was found only on Cocksfoot (*Dactylis glomerata*)(Blackman & Eastop 2007). It is not known how widespread this difference is.

Current geographic distribution:
S. avenae is widespread in areas with temperate, Mediterranean or steppic climate. It is absent or rare in tropical areas. Occurrence in Australia is uncertain. Confusions with *S. miscanthi* are probable in the Far-Eastern and Australian records (CPC 2012).

<u>Asia:</u> Afghanistan, China, Republic of Georgia, India, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Lebanon, Myanmar, Pakistan, Saudi Arabia, Syria, Tajikistan, Thailand, Turkey, Turkmenistan, Uzbekistan, Yemen
<u>Africa:</u> Algeria, Burundi, Egypt, Ethiopia, Kenya, Libya, Morocco, Mozambique, South Africa, Tunisia, Zimbabwe
<u>Americas:</u> Canada, USA, Cuba, Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay
<u>Europe:</u> Albania, Andorra, Austria, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden Switzerland, Ukraine, UK, former Yugoslavia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Unlike some aphids, there is no host alteration in *S. avenae* and it spends the entire year on grasses and cereals. Fresh host material would be an entry pathway into New Zealand. However, no fresh fodder plants are imported (C. Black pers comm. 2012). The aphid feeds on the inflorescences of host plants and might be associated with seeds at harvest. However, it

is unlikely to be able to survive shipment on mature dry seeds. Seed for sowing, grain imported for human or animal consumption and passengers (fresh host material in luggage) are possible but not likely pathways.

Potential to establish and spread in NZ: High
S. avenae is widely distributed in countries with temperate climates. It feeds on grasses which are widely distributed in New Zealand. Neither climate nor host availability are likely to be a barrier to establishment. It has a very rapid life-cycle and large reproductive capacity which would facilitate rapid build up of populations. It alternates between winged and non-winged forms and would be expected to spread through natural dispersal as well as on infested plant material.

Potential Impact in NZ: Low
S. avenae is described as a pest of cereals. No specific reports of economic damage to pasture grasses have been found. It is assumed that it would reduce yields of pasture grasses by removing plant nutrients and reducing photosynthesis via honeydew accumulations, as it does in cereals, but populations may not build up to the extent that they do in cereals grown as monocultures. If there is a specific strain restricted to Cocksfoot (*Dactylis glomerata*)it might be expected to have greater impacts, but this is currently unknown.

The aphid vectors barley yellow dwarf luteovirus (BYDV), which is present in New Zealand. It is a minor vector of maize dwarf mosaic virus (MDMV), bean yellow mosaic potyvirus (BYMV), pea mosaic potyvirus, beet western yellows luteovirus and rice giallume, a virus closely resembling BYDV and an important disease of rice in Italy (CPC 2012). These viruses are either already present in New Zealand or affect crops that are not important in New Zealand.

In the absence of information on impacts in extensive pasture situations the impact on the potential New Zealand pastoral sector is assessed as low, but there is uncertainty about this assessment.

Possible methods of post-border management and surveillance:
Surveillance: Populations of *S. avanae* have been monitored using yellow traps or yellow water pan traps, and aspirators or suction traps in areas where cereal crops are grown (Galezewski 2007; Vialette *et al.* 2007; Kuroli & Lantos 2006). Note: an attractant molecule and a pheromone molecule have been identified (El-Sayad 2012).

Post-border management: Much of the evidence about management of *S. avenae* relates to cereal crops such as barley and wheat. Many insecticides are effective on aphids, e.g. carbamates[54] and pyrethroids, but most of them are also harmful to parasitoids and predators (CPC 2012). Satisfactory control of *S. avanae* in South American countries has been achieved by the use of biological control methods, utilising parasitoids and predators of the aphid (CPC 2012).

References:
Black, C. (2012) MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Sitobion avenae* http://www.cabi.org/cpc/?compid=1&dsid=51737&loadmodule=datasheet&page=868&site=161 Accessed 26 August 2012.

[54] Relevance to the EPA Review: some of the carbamates may include those under review.

Blackman, RL; Eastop, VF (2007) in Aphids as crop pests. Van Emden, H; Harrington, R (eds) CAB International.

El-Sayad, AM (2012) The Pherobase: Database of Pheromones and Semiochemicals. http://www.pherobase.com

Galezewski, M (2007) Autumn aphids - a greater and greater threat to winter crops. *Ochrona Roslin* 52: 7/8, 50-51. Abstract only seen

Kuroli, G; Lantos, Z (2006) Long-term study of flight activity and abundance of wheat colonizing aphid species. *Cereal Research Communications* 34: 2/3, 1093-1099. Abstract only seen

Vialatte, A; Plantegenest, M; Simon, J C; Dedryver, C A (2007) Farm-scale assessment of movement patterns and colonization dynamics of the grain aphid in arable crops and hedgerows. *Agricultural and Forest Entomology* 9: 4, 337-346. Abstract only seen

6.7 Thrips - Thysanoptera

Thrips angusticeps (Cabbage thrips)

Scientific Name: *Thrips angusticeps* Uzel, 1895 (Thysanoptera: Thripidae)
Synonyms:

Common Name: Cabbage thrips

Brief description: Thrips are tiny winged insects. *Thrips angusticeps* is a common thrips in temperate Eurasia occurring on many plant species without economic damage. Damage is caused by feeding and can cause stunting and death of seedlings (CPC 2012).

Indicative host range:
T. angusticeps is highly polyphagous (CPC 2012).

Priority Pasture Species: Lucerne *(Medicago sativa)* (main host), *Trifolium* spp. (other host)
Other plants: oats, sugar beet, barley, flax, beans, peas, rye, potato, wheat (main hosts) (CPC 2012).

Current geographic distribution:
T. angusticeps is found across most of Europe and around the Mediterranean, where it appears to be native. Although it has been intercepted frequently in the USA, mainly in vegetables from Europe, it does not appear to have established there (CPC 2012).

Asia: Azerbaijan, Republic of Georgia, Iran, Israel, Turkey
Africa: Egypt, Libya, Morocco, Tunisia
Europe: Austria, Belgium, Bulgaria, Cyprus, former Czechoslovakia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia, Spain, Sweden, Switzerland, UK , Ukraine (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are too small to see with the naked eye and are inserted into plant tissue. Larvae and adults feed on the leaves and stems of the plant by sucking the contents of cells, but tend to hide within small spaces or between leaves, so they are not obvious. Full-grown larvae pupate in a small space on the plant or drop to the soil and pupate in the soil. *T. angusticeps* overwinters as flightless adults in the soil (CPC 2012). *T. angusticeps* could enter New Zealand on fresh host plant material. Since fodder plants are not imported into New Zealand (C. Black pers. comm. 2012), imported fresh produce is the most likely entry pathway. Passengers (plant material in luggage) are a possible pathway as is infested soil on used agricultural machinery or footwear. CPC (2012) reports that *T. angusticeps* has been found on cut flowers in passenger baggage and is frequently intercepted by the USA, mainly in vegetables (lettuce, parsley, watercress, mustard greens, cabbage and endive) from Europe. *Thrips* species have been intercepted hundreds of times at the New Zealand border most often on cut flowers and fresh produce (MPI 2012). *T. angusticeps* has not been intercepted but these records indicate the potential of these pathways to transport live thrips.

Potential to establish and spread in NZ: High
T. angusticeps occurs in temperate countries in Europe which have a similar climate to New Zealand. The field thrips has a wide range of host plants which are widely grown in New

Zealand. Natural dispersal would be slow, but there would be few barriers to its spread through movement of infested host material.

Potential Impact in NZ: Low
Plants attacked by *T. angusticeps* show a wide range of symptoms, depending on the species and stage of attack. In spring, seedlings and young plants are distorted, stunted and sometimes killed. Leaves and stems can show the typical thrips 'silvering' produced by feeding. These areas may then turn yellow or brown or necrotic. In some crops, multiple secondary shoots may appear and produce bushy plants. The damage is exacerbated by cold or dry weather. Economic damage is variable and relatively infrequent (CPC 2012). Although lucerne is reported to be a main host, no reports of economic damage to any of New Zealands priority pasture species were found.

Possible methods of post-border management and surveillance:
Surveillance: Chromatic traps can be used to survey and monitor thrips species, including *T. angusticeps* (Navarro *et al*. 2008).

Post-border management: Crop rotation is an effective form of control, although this has mainly been used to control infestations in flax or linseed crops (CPC 2012). Chemical control using systemic insecticides such as fenitrothion[55] have given consistent levels of control. However, the use of insecticides is not always worthwhile because at moderate infestation levels although the signs of damage are reduced, it may not have a significant effect on yield (CPC 2012).

References:
Black, C. (2012) MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

CPC (2012) last modified 13 September 2012, Crop Protection Compendium Report – *Thrips flavus*
http://www.cabi.org/cpc/?compid=1&dsid=53727&loadmodule=datasheet&page=868&site=161 Accessed 16 September 2012.

MPI (2012) Interceptions database. Accessed August 2012.

Navarro, C; Pastor, M T; Ferragut, F; Garcia Mari, F (2008) Thrips (Thysanoptera) associated with citrus orchards in the Comunidad Valenciana (Spain): abundance, seasonal trend and spatial distribution. *Boletin de Sanidad Vegetal, Plagas* 34: 1, 53-64. Abstract only seen.

[55] Relevance to the EPA Review: fenitrothion is an organophosphate under review.

Thrips flavus (Honeysuckle thrips)

Scientific Name: *Thrips flavus* Schrank (Thysanoptera: Thripidae)
Synonyms:
Common Name: Honeysuckle thrips

Brief description: Thrips are tiny winged insects. Larvae and adults of *T. flavus* suck the sap from petals and reproductive parts of flowers, causing lesions which have a detrimental effect on the quantity and quality of fruit set. On cucurbits, larvae and adults suck the plant sap within shoots and flowers causing the stunting of shoots and retarding terminal growth (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host)
Other plants: *Thrips flavus* is highly polyphagous. Reported main hosts include: dill, oats, beetroot, mustard, cauliflower, Chinese cabbage, turnip rape, marigold, daisy, water melon, coriander, cucumber, ornamental gourd, fennel, barley, crab apple, black medick, daffodil, pea, apricot, plum, pear, radish, aubergine, potato, verbena (CPC 2012).

Current geographic distribution:
Asia: China, India, Iran, Japan, Malaysia, Nepal, Pakistan, Philippines, Taiwan, Thailand
Europe: Austria, Bulgaria, Czech Republic, France, Germany, Italy, Lithuania, Norway, Poland, Russian Federation, Spain, Sweden, Switzerland, UK
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Eggs are laid on flower buds or on the lower surface of leaves and larvae and adults occur on both foliage and flowers, but are found in larger numbers on flowers. *T. flavus* could enter New Zealand on fresh host plant material. Since fodder plants are not imported into New Zealand (C. Black pers. comm. 2012), imported fresh produce or cut flowers are the most likely entry pathways. Passengers (plant material in luggage) are a possible pathway. Live *Thrips flavus* have been intercepted twice at the New Zealand on cut flowers / foliage, one of which was associated with passengers (MPI 2012).

The prepupa and pupa are found up to a depth of 5-10 cm in the soil. This stage lasts only 2-3 days (CPC 2012), and the emerging larvae require fresh host plants to feed, so soil contamination on inanimate objects or footwear is unlikely to be a viable entry pathway.

Potential to establish and spread in NZ: High
T. flavus occurs in temperate countries in Europe which have a similar climate to New Zealand, at least in some regions. Climate is therefore not expected to be a barrier to it establishing in New Zealand. The flower thrips has a wide host range including fruit, vegetables and ornamental plants which are widely grown in New Zealand. *T. flavus* has between two and ten generations a year and reproduces sexually as well as by arrhenotokous parthenogenesis. These traits would facilitate rapid population build up. Natural dispersal would be slow, but there would be few barriers to its spread through movement of infested host material.

Potential Impact in NZ: Low
A significant loss in the yield of different crops has reportedly been observed by different workers, but exact estimations of losses have not been determined (CPC 2012). Despite being reported as a primary host, the only report found of economic damage to lucerne is of crops grown for seed production in Czechoslovakia (Rotrekl 1985).

T. flavus is thought to be the vector of a number of economically important crop diseases (CPC 2012), but no reports of it vectoring diseases of lucerne were found. Consequently, although uncertain, the likely impact of *T. flavus* on the pastoral sector of New Zealand is expected to be low, but the consequences for the horticultural sector could be much higher.

Possible methods of post-border management and surveillance:
Surveillance: White or blue sticky traps have been used to detect thrips populations, including *T. flavus* (Perrotta & Conti 2008; Garcia et al. 2003; Conti et al 2003).

Post-border management: Chemical control of *T. flavus* has been well studied, albeit in horticultural crops rather than in pastoral settings. Effective chemicals[56] include phenthoate, permethrin, chlorpyriphos, fenthion, isofenphos, fenvalerate, fenitrothion, phosalone. Isofenphos is considered the best product for controlling thrips, in view of safety to pollinators (CPC 2012).

References:

Black, C. (2012) MPI Senior Advisor; personal communication to Sandy Toy about importation of host-plant material.

Conti, F; Tumminelli, R; Fisicaro, R; Perrotta, G; Marullo, R; Liotta, G (2003) An IPM system for new citrus thrips in Italy. *Bulletin OILB/SROP* 26: 6, 203-208. Abstract only seen.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – *Thrips flavus* http://www.cabi.org/cpc/?compid=1&dsid=53732&loadmodule=datasheet&page=868&site=161 Accessed 26 August 2012.

Garcia, S; Wong, E; Marquez, A L; Garcia, E; Olivero, J (2003) Thrips flavus Schrank incidence on Primofiori lemon in Malaga province (Spain). *Bulletin OILB/SROP* 26: 6, 209 Abstract only seen.

MPI (2012) Interceptions database. Accessed August 2012.

Perrotta, G; Conti, F (2008) A threshold hypothesis for an integrated control of thrips infestation on citrus in south eastern Sicily. *IOBC/WPRS Bulletin* 38: 204-209 Abstract only seen.

Rotrekl, J (1985) The harmfulness of thrips (Thysanoptera: Terebrantia) to seed lucerne. [Czech] *Sbornik UVTIZ, Ochrana Rostlin*. 21 (4): 255-260. Abstract only viewed.

[56] Relevance to the EPA Review: chlorpyriphos and fenitrothion are organophosphates under review.

6.8 Wasps - Hymenoptera

Pachynematus clitellatus (Wheat sawfly)

Scientific Name: *Pachynematus clitellatus* (Serville 1823) (Hymenoptera: Tenthredinidae)

Synonyms:

Common Name: Wheat sawfly

Brief description: The sawfly *Pachynematus clitellatus* appears to be a periodic pest of cereals in parts of Europe. Little information is available on this species. Some of New Zealands' Priority pasture species have been shown to be primary hosts (Haris 1994) but a search of CAB abstracts found no reports of economic damage to pasture species. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Timothy (*Phleum pratense)* (main host) Cocksfoot (*Dactylis glomerata*), Tall Fescue *(Festuca arundinacea),* Rye grass*(Lolium perenne)* (secondary host)
Other plants: *Agrostis alba, Festuca rubra* (main hosts), *Typhoides arundinacea, Bromus internis* (secondary hosts) (Haris 1994), barley, wheat.

Current geographic distribution:
A search of CAB abstracts indicates that *Pachynematus clitellatus* occurs in Europe including the UK, Lithuania, Germany, Bulgaria, Russia and Kazakhstan.

References:

Harris, A (1994) Preliminary examinations on food choice of *Pachynematus clitellatus* Lepeletier (Hymenoptera, Tenthredinidae). *Acta Phytopathologica et Entomologica Hungarica* 29: 329-334. Abstract only accessed.

6.9 Bacteria

Xanthomonas axonopodis pv. *alfalfae* (Alfalfa leaf spot)

Scientific Name: *Xanthomonas axonopodis* pv. *alfalfae* (Riker et al. 1935) Vauterin et al., 1995 (Xanthomonadales: Xanthomonacea)
Synonyms: *Bacterium alfalfae Riker, Jones & Davies 1935*
Phytomonas alfalfae Riker, Jones & Davies 1935
Pseudomonas alfalfae Riker, Jones & Davies 1935
Xanthomonas alfalfae (Riker et al.) Dowson 1943
Xanthomonas campestris pv. *alfalfae (Riker et al.) Dye 1978*
Xanthomonas phaseoli f.sp. alfalfae (Riker et al.) Sabet 1959
Common Name: Bacterial alfalfa leaf spot

Brief description:
Bacterial leaf spot of lucerne causes stunting, poor establishment and reduced fodder quality. The identity of the causal agent of bacterial spot of lucerne has been questioned for decades. Current literature has retained this bacterium in the genus *Xanthomonas*, but has reclassified within the species '*axonopodis*' from the original '*campestris*'. The pathovars are distinguished based on phytopathogenic specialization on a wide variety of host plants (CPC 2012).

Indicative host range:
The disease occurs naturally on lucerne but other leguminous species show symptoms on inoculation.
Priority Pasture Species: Lucerne *(Medicago sativa)*, White clover (*Trifolium repens)*, Red clover (*Trifolium pratense)*
Other plants: Soyabean, common bean, pea, vetches (CPC2012)

Current geographic distribution:
Asia: Republic of Georgia, India, Syria
Africa: Sudan
Americas: USA, El Salvador
Europe: Romania
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
X. axonopodis pv. *alfalfae* enters lucerne plants through stomata or wounds. The bacteria are dispersed through the field by rain splash and windblown infested soil particles. *X. axonopodis* pv. *alfalfae* overwinters on lucerne debris on or in the soil. It can survive for several years in hay or in infected plant debris with stored seed, but is not seed-borne (CPC 2012). Xanthomonads are capable of multiplication and survival for at least several weeks on the surfaces of host species without inciting symptoms. This makes transport of the disease from field to field possible in apparently healthy lucerne plants (CPC 2012). Since no fodder crops are imported into New Zealand either as hay or nursery stock (C. Black pers comm. 2012) the only likely entry pathway is contaminated plant material or soil on inanimate pathways such as used agricultural machinery or in association with passengers.

Potential to establish and spread in NZ: Low
Hot, rainy weather is conducive to *X. axonopodis* pv. *alfalfae* development in the field. This bacterium can also become severe under hot and dry conditions unfavourable for most other foliar pathogens. Its current distribution is restricted to countries with much hotter climates than New Zealand and in Australia it has only been reported from Queensland. It is very

unlikely that it would be able to establish in New Zealand but insufficient information has been accessed to rule it out completely.

Potential Impact in NZ: Low

The bacterium causes spots and lesions on the leaves and stems of infected plants. This can cause defoliation and stem breakage. This disease may also decrease the forage quality of lucerne plants by affecting the concentrations of monophenolic compounds in the plants. Generally, *X. axonopodis* pv. *alfalfae* does not cause large overall losses, but locally the disease can be severe, especially in hot, moist environments. However, since its distribution in New Zealand is likely to be very restricted if it establishes at all, the impact on the New Zealand pastoral sector is likely to be very small.

Possible methods of post-border management and surveillance:

Surveillance: No records about surveillance methods for *X. axonopodis* pv. *alfalfae* were found. However, CPC (2012) states that the presence of this pathogen is often detectable through visual inspection of lucerne for symptoms.

Post-border management: Control of *X. axonopodis* pv. *alfalfae* is attempted with the use of tolerant cultivars and sensible cultural practices. Resistant cultivars offer superior forage quality, including lower concentrations of ferulic acid and p-hydroxybenzaldehyde, when compared with the leaves of a susceptible lucerne variety. Resistance varies among plants. Highly resistant germplasm such as KS76 has been developed but resistant cultivars are not currently available (CPC 2012). Crop rotation is described as a management option for another *X. axonopodis* pathovar and may be effective for *X. axonopodis* pv. *alfalfae* (Karavina *et al*. 2011).

References:

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *X. axonopodis pv. alfalfae*
http://www.cabi.org/cpc/?compid=1&dsid=56906&loadmodule=datasheet&page=868&site=161 Accessed 16 August 2012.

Karavina, C; Mandumbu, R; Parwada, C; Tibugari, H (2011) A review of the occurrence, biology and management of common bacterial blight. Abstract only seen.

6.10 Fungi

Alternaria cichorii (Leaf spot of endive)

Scientific Name: *Alternaria cichorii* Nattras (Ascomycota: Dothideomycetes: Pleosporaceae)
Synonyms: *Alternaria porri f. sp. cichorii* (Nattr.) Schmidt
Common Name: Leaf spot of endive

Brief description:
Alternaria cichorii is primarily a pathogen of endive and chicory vegetables and causes necrotic spots on the leaves. Studies in Brazil where it has recently naturalised have shown that it is seed transmitted (Barreto *et al.* 2008). There is also wind dispersal of airborne conidia (David 1995).

Indicative host range:
Priority Pasture Species: Chicory *(Cichorium intybus)* main host (CPC 2012)
Other plants: *Cichorium endiva, Acroptilon repens, Carthamus tinctorius, Lactuca sativa.* A wide range of wild hosts within the Asteraceae (Barreto *et al*. 2008)

Current geographic distribution:
Asia: India, Pakistan
Africa: Egypt
Americas: Canada, USA, Argentina, Brazil
Europe: Austria, Cyprus, Denmark, Greece, Italy, former Yugoslavia
Oceania: Papua New Guinea (CAB International 1996).

Potential pathways of entry into New Zealand (Commodity Association):
The most likely entry pathway is seed for sowing. It is thought to have entered Brazil on infected seed (Barreto *et al.* 2008). Passengers (plant material in luggage) are a possible pathway. *A. cichorii* has not been intercepted at the New Zealand border, but other *Alternaria* species have been and imported seeds / grain is the most common pathway for these interceptions (MPI 2012).

Potential to establish and spread in NZ: Moderate
Little information is available on the biology of *A.cichorii.* It occurs in some countries that have a more Mediterranean, tropical or continental climate than New Zealand, but its distribution in these countries is not known. It is assumed on the basis of its current distribution that it has the potential to establish in at least some parts of New Zealand. It is probable that contaminated cichory, endive and escarole seeds served as a vehicle for introduction of this fungus in Brazil and that the fungus has then become naturalized in many vegetable growing areas and is now surviving on other native and introduced Asteraceae in the absence of cultivated hosts (Barreto *et al.* 2008). It is assumed that the same pattern could be followed in New Zealand. Once established it could spread naturally through air-borne conidia or through human assisted movement of infected seeds.

Potential Impact in NZ: Low
A. cichorii can infect wild hosts such as sow thistle which can act as a reservoir for the pathogen but reports of significant symptoms have only been found for chicory grown commercially as a vegetable and endive. It is not known what effect it would have on the pasture type of chicory. It is assumed that they would be lower than those on intensively grown vegetable chicory.

Possible methods of post-border management and surveillance:
Surveillance: No records about surveillance for *A. cichorii* were found, but *Alternaria* species can be monitored using air sampling methods (Shaonli Das & Gupta-Bhattacharya 2012)

Post-border management: No records were found about management of *A. chicorii* in pastural settings. Roumainille (2009) reports some reduction of symptoms of *A. cichorii* on vegetables with a new fungicide containing tebuconazole and trifloxystrobine. It was discussed as an alternative to other commonly used fungicides.

References:
Barreto, RW; Santin, AM; Vieira, BS (2008) *Alternaria cichorii* in Brazil on *Cichorium* spp. Seeds and cultivated and weedy hosts. *Journal of Phytopathology*. 156: 425-430.

CAB International (1996) Distribution Maps of Plant Diseases; *Alternaria cichorii*.
CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Alternaria cichorii*
http://www.cabi.org/cpc/?compid=1&dsid=4488&loadmodule=datasheet&page=868&site=161 Accessed 15 August 2012.

David JC (1995) IMI Descriptions of Fungi and Bacteria: *Alternaria cichorii*. CAB International.

MPI (2012) Interceptions database. Accessed August 2012.

Roumanille, S; France, I B (2009) PHF0707: a new versatile fungicide for vegetable crops. Anonymous *Association Francaise de Protection des Plantes, 9eme conference international sur les maladies des plantes, Tours, France, 8 et 9 Decembre 2009.* Association Francaise de Protection des Plantes (AFPP); Alfortville; pp 816-824. Abstract only seen.

Shaonli Das; GuptaBhattacharya, S (2012) Monitoring and assessment of airborne fungi in Kolkata, India, by viable and non-viable air sampling methods. *Environmental Monitoring and Assessment* 184: 8, 4671-4684. Abstract only seen

Drechslera catenaria (Leaf spot of grasses)

Scientific Name:	*Drechslera catenaria* (Drechsler) Ito 1930 (Ascomycetes: Pleosporaceae)
Synonyms:	*Bipolaris catenaria* (Drechsler) Somal 1975 *Helminthosporium catenarium* Drechsler 1923
Common Name:	Leaf spot of grasses

Brief description:
Drechslera catenaria causes leaf necrosis and crown rot of forage grasses, and is also found on the seed.

Indicative host range:
Priority Pasture Species: Rye grass*(Lolium perenne),* Common bent (*Agrostis tenuis),* Tall Fescue *(Festuca arundinacea)* (Spilker & Larson, 1985) *Lolium multiflorum,* Cocksfoot (*Dactylis glomerata*), Timothy (*Phleum pratense)* (Farr & Rossman)
Other plants: Fescues (*Festuca pratensis, Festuca rubra), Beckmannia syzigachn*e, *Phalaris arundinacea, Agrostis palustris, Poa pratensis* (Spilker & Lason 1985) *Agrostis capillaris, Sorghum sp., Alopecurus pratensis, Calamagrostis canadensis*, *Hordeum vulgare, Triticum aestivum, Cinna arundinacea* (Farr & Rossman)

Current geographic distribution:
Asia: India, Japan
Europe: Denmark, Finland, Netherlands, Poland
Americas: Canada, USA (CPC 2012; Farr & Rossman)

Potential pathways of entry into New Zealand (Commodity Association):
Drechslera catenaria is seed-borne. Seed for sowing is therefore the most likely pathway of entry. Imported wheat or barley may also be a pathway although the importance of these hosts is not known. Passengers (plant material in luggage) are a possible pathway.
Other species of *Drechslera* have been intercepted at the New Zealand border on imported fresh produce, stored products, grain and nursery stock (MPI 2012).

Potential to establish and spread in NZ: High
The current distribution of *Drechslera catenaria* suggests that climate would not be a barrier to establishment in New Zealand and hosts are widespread. It could spread rapidly through the use of infected seed.

Potential Impact in NZ: Moderate
Drechslera catenaria is reported to cause severe damage to *Agrostis palustris* cultivars but little or no damage to Fescues (*Festuca)* and rye grasses *(Lolium perenne)*. Moderate disease severity was found following experimental inoculation of Common bent (*Agrostis tenuis)* (Spilker & Larson 1985). It appears to adversely affect golf courses in Japan (National Grassland Research Institute 2001) but no reports have been found of productivity losses in pasture situations. There is uncertainty about its potential impact in New Zealand, but since it affects multiple pasture species, is likely to establish across New Zealand and have major impacts (crown rot) on affected plants its' potential impact is considered to be moderate.

Possible methods of post-border management and surveillance:
Surveillance: *Drechslera* species can be monitored using air sampling methods (Shaonli Das & Gupta-Bhattacharya 2012; Kasprzyk *et al.* 2004).

Post-border management: Effective control of *D. catenaria* is reported with application of iprodione, but this was in golf putting greens (Larsen *et al.*1981), and the result may not be applicable to agricultural settings. Use of plant varieties with resistance to *D. catenaria* has potential (Anon. 1972).

References:

Anonymous (1972) Ryegrass. Welsh Plant Breeding Station: Report for 1971. Abstract only seen.

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Drechslera catenaria* *http://www.cabi.org/cpc/?compid=1&dsid=19820&loadmodule=datasheet&page=868&site=161* Accessed 3 August 2012.

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 15/8/12.

Kasprzyk, I; Rzepowska, B; Wasylow, M (2004) Fungal spores in the atmosphere of Rzeszow (South-East Poland). *Annals of Agricultural and Environmental Medicine* .11: 2, 285-289. Abstract only seen.

Larsen, P O; Hagan, A K; Joyner, B G; Spilker, D A (1981) Leaf blight and crown rot on creeping bentgrass, a new disease caused by Drechslera catenaria. *Plant Disease* 65: 1, 79-81. Abstract only seen.

MPI (2012) Interceptions database. Accessed August 2012.

National Grassland Research Institute (2001) Illustrated encyclopaedia of forage crop diseases. http://www.naro.affrc.go.jp/org/nilgs/diseases/detitle.html Accessed 15/8/12.

Shaonli Das; GuptaBhattacharya, S (2012) Monitoring and assessment of airborne fungi in Kolkata, India, by viable and non-viable air sampling methods. *Environmental Monitoring and Assessment* 184: 8, 4671-4684. Abstract only seen.

Spilker, D A; Larsen, P O (1985) Characterization and host range of *Drechslera catenaria*, the pathogen of leaf blight and crown rot of creeping bentgrass. *Plant Disease* 69(4): 331-333.

Didymella festucae (Stem eyespot)

Scientific Name: *Didymella festucae* (Wegelin) Holm 1953 (anamorph Phloeospora idahoensis Sprague 1948) (Ascomycetes: Dothideales)
Synonyms: *Didymosphaeria festucae* Wegelin 1896
Common Name: Stem eyespot

Brief description:
Didymella festucae eyespot is the cause of a destructive stem disease in seed crops of red fescue, in Canada (Smith & Shoemaker 1974). It attacks the stem, cutting off the flow of nutrients to the fescue seed head.

Indicative host range:
D. festucae is mainly a pest of Fescues (*Festuca* spp.), but has been found on weeds such as *Agropyron* sp., *Bromus inermis* and Timothy (*Phleum pratense)* growing within heavily infected red fescue crops (Smith & Shoemaker 1974).
<u>Priority Pasture Species:</u> Fescues (*Festuca* spp.) (Farr & Rossman), Tall Fescue (*Festuca arundinacea),* Timothy (*Phleum pratense)* (Smith & Shoemaker 1974)

Current geographic distribution:
<u>Europe</u>: Sweden
<u>Americas:</u> Canada, USA (Oregon, Alaska) (Farr & Rossman)

Potential pathways of entry into New Zealand (Commodity Association):
D. festucae is transported by wind-borne ascospores and conidia and is also thought to be seed borne (Smith & Shoemaker 1974). Seed for sowing is therefore the most likely pathway of entry, but there is uncertainty about this. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: Low
D. festucae is only established in northern hemisphere areas with very cold winters. Establishment is likely to be inhibited in many areas of New Zealand due to the lack of very cold winters. It may however, be able to establish in the 'high country' of the South Island of New Zealand.

Potential Impact in NZ: Low
Stem eyespot of fescue does not affect the leaves or the forage value of Fescues (*Festuca* spp.) (Smith & Shoemaker 1974). Should it become established in New Zealand it may affect yields of fescue seed crops and may also have some effect on the regeneration ability of established pastures due to a reduction in available seed. However, any impacts will be limited by the likely restricted distribution in New Zealand.

Possible methods of post-border management and surveillance:
<u>Surveillance:</u> Ascospores are airborne (Sivanesan 1990) so spore traps could be an option for surveillance of *D. festucae.* Surveys of pastures for the incidence of pathogens may be an option (Cromey & Mace 1995).

<u>Post-border management:</u> no records were found that described management or control of *D. festucae*. The incidence of another *Didymella* species, *D. exitialis*, in New Zealand was reduced but not elimated by the foliar application of fungicides (terbuconazole and chlorothalonil) in field trials (Cromey & Mace 1995).

References:

Cromey, M G; Mace, M A (1995) Development, yield effects, and control of Didymella exitialis on wheat in Canterbury in 1994/95. In Popay, A J (ed) *Proceedings of the Forty Eighth New Zealand Plant Protection Conference, Angus Inn, Hastings, New Zealand, August 8-10, 1995.* New Zealand Plant Protection Society; Rotorua; pp 161-164. Abstract only seen.

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 15/8/12.

Smith, J D; Shoemaker, R A (1974) *Didymella festucae* and its imperfect state, *Phleospora idahoensis*, on *Festuca* species in western North America. *Canadian Journal of Botany* 52(9): 2061-2074.

Sivanesan, A; UK, C I (1990) Didymella festucae. *IMI Descriptions of Fungi and Bacteria; 1990.99, Sheet 981.* Abstract only seen.

Epichloë typhina (Choke disease)

Scientific Name: *Epichloë typhina* (Pers.) Tul. & Tul. 1865 (anamorph *Neotyphodium typhinum* (Morgan-Jones & Gams) Glenn, Bacon & Hanlin 1996) (Ascomycetes: Clavicipitaceae)
Synonyms: *Acremonium typhinum* Morgan-Jones & Gams 1982
Dothidea typhina (Pers.) Fries 1823
Hypocrea typhina (Pers.) Berk. 1860
Sphaeria typhina Pers. 1798
Common Name: Choke disease

Brief description:
Epichloë typhina has previously been recorded from New Zealand in error (NZ Fungi 2012). It infects primarily by ascospores, which are formed on stroma on leaf sheaths or around the developing floral tissue, and are spread by air to neighbouring plants. Maturation of host inflorescences is suppressed, however, if seeds are formed these carry the infection to the next generation (Pfender & Alderman 1999).

Indicative host range:
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*), Rye grass*(Lolium perenne),* Timothy (*Phleum pratense),* Common bent (*Agrostis tenuis)*
Other plants: Grass species, wheat (Farr & Rossman)

Current geographic distribution:
Asia: China, Pakistan, Japan
Europe: Bulgaria, France, Germany, Greece, Poland, Portugal, Russia, Spain, Sweden, Switzerland, United Kingdom
Americas: Canada, USA (Farr & Rossman).

Potential pathways of entry into New Zealand (Commodity Association):
E. typhina infects all above-ground parts of the plant. Seeds are normally prevented from forming, but they can carry the infection. Since fresh host material is not imported into New Zealand, seed for sowing is the most likely entry pathway, although there is considerable uncertainty about this pathway. Passengers (plant material in luggage) are a possible pathway. Imported wheat could be a pathway, but it is not known how often this species is infected.

Potential to establish and spread in NZ: High
The current distribution of *E. typhina* suggests that climate would not be a barrier to establishment in New Zealand and hosts are widespread.

Potential Impact in NZ: Low
Choke disease is not economically significant to the use of Cocksfoot as forage, but has a severe effect on seed production (Pfender & Alderman 1999). It is assumed that impacts would be similar for other grass species. Impacts are likely to be on commercial seed production, and possibly regeneration ability of established pastures and grasslands. The major impact from the related *E. festucae,* which is present in New Zealand, is poisoning of stock due to the production of toxins. *E. typhina*, however, is not known to produce toxins.

Possible methods of post-border management and surveillance:
Surveillance: As *E. typhina* ascospores are released into the atmosphere (Welch & Bultman 1993), spore traps could be used to monitor spores in various regions, and subsequent microscopic and/or molecular diagnosis would be required to identify *E. typhina*. Surveillance could also include the observance and reporting of choked stems.

Post-border management: Tajimi *et al.* (2004) report that chemical treatments[57] in autumn free choked and dwarfed plants of *E. typhina*. However, a fungicide application in field tests, using propiconazole and azoxystrobin, had no impact against *E. typhina* (Pfender & Alderman (2003). Cutting stems during dry and sunny conditions can reduce sporulation of *E. typhina* from the cut stems, but if there is sufficient humidity, sporulation is not reduced (Raynal 1991).

References:

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 9/9/12.

NZ Fungi (2012) Database. Avaiable online at: http://nzfungi.landcareresearch.co.nz/html/mycology.asp?ID= accessed 9/9/12.

Pfender, W S; Alderman, S C (1999) Geographical distribution and incidence of orchardgrass choke, caused by *Epichloë typhina*, in Oregon. *Plant Disease* 83(8): 754-758.

Pfender, W F; Alderman, S C (2003) Evaluation of postharvest burning and fungicides to reduce the polyetic rate of increase of choke disease in orchardgrass seed production. *Plant Disease* 87: 4, 375-379. Abstract only seen.

Raynal, G (1991) The release of ascospores of Epichloe typhina, the agent of choke disease of cocksfoot. Consequences for epidemiology and control. *Fourrages* 127, 345-358. Abstract only seen.

Tajimi, A; Yanagida, N; Nishikawa, M; Nakanishi, K; Takeda, R; Kasai, E; Teramoto, C (2004) Successive changes of the choke disease incidence in clonal lines of Agropyron ciliare var. minus (=Elymus racemifer, Aokamojigusa). *Grassland Science* 50: 2, 187-193. Abstract only seen.

Welch, A M; Bultman, T L (1993) Natural release of Epichloe typhina ascospores and its temporal relationship to fly parasitism. *Mycologia* 85: 5, 756-763. Abstract only seen.

[57] Article was in Japanese, so can not determine what the chemicals were without a translation.

Erysiphe pisi var. *pisi* (Powdery mildew of peas)

Scientific Name:	*Erysiphe pisi* var. *pisi* (Drechsler) Ito 1930 (Leotiomycetes: Erysiphaceae)
Synonyms:	*Alphitomorpha pisi* (DC.) Wallr. *Erysiphe communis* auct. p.p. *Erysiphe communis f. hosackiae* Jacz. *Erysiphe communis f. phaseoli* Jacz. *Erysiphe communis f. pisi* (H.A. Dietr.) Jacz. *Erysiphe communis f.sp. medicaginis-lupulinae* Hammarl. *Erysiphe macropus* Mart. *Erysiphe martii* auct. p.p. *Erysiphe pisi f.sp. medicaginis-sativae* Boerema & Verh. *Erysiphe pisi f.sp. pisi* Boerema & Verh. *Erysiphe pisi f.sp. viciae-sativae* Boerema & Verh. *Erysiphe polygoni* auct. p.p. *Ischnochaeta pisi* (DC.) Sawada
Common Name:	Powdery mildew of peas

Brief description:
Like all powdery mildews, *E. pisi* var. *pisi* produces a characteristic whitish, epigenous mycelium over the leaves, stems and fruits which is visible to the naked eye. Striking symptoms are rare although there may be some disfiguration of leaves, stems and fruits. There may also be some necrosis, diminution of growth or premature leaf fall (CPC 2012). *Erysiphe pisi* is present in New Zealand but it is not clear which variety(ies) occur here. *Erysiphe pisi* var. *pisi* has not been recorded from New Zealand (NZ Fungi 2012).

Indicative host range:
Erysiphe pisi var. *pisi* occurs on numerous species of many host genera of Fabaceae.
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host), *Trifolium* spp. (other hosts)
Other plants: peanut, sweet milk vetch, lentil, lupin, medicks, yellow alfalfa, beans, pea, vetches, *Sophora* sp. (CPC 2012)

Current geographic distribution:
Erysiphe pisi var. *pisi* is reported to be widespread throughout Asia, Africa and Europe (CPC 2012, Farr & Rossman).

Potential pathways of entry into New Zealand (Commodity Association):
Infection is by germination of ascospores or conidia on the surface of the host plant (including seeds), originating from overwintered mycelium in dormant buds or from persistent ordinary mycelium (CPC 2012). Seed for sowing and grains (dried beans) are the most likely entry pathways since fresh host material is not imported into New Zealand. Passengers (plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
The current distribution of *Erysiphe pisi* var. *pisi* suggests that climate would not be a barrier to establishment in New Zealand and hosts are widespread.

Potential Impact in NZ: Low
Erysiphe pisi var. *pisi* causes diminished growth and reduced yield and distorted growth and premature leaf fall. Losses are often in the range of 20-30% and infections can occasionally reach epidemic proportions (CPC 2012) although the host species involved are not reported. However, *Erysiphe pisi* which is already present in New Zealand affects a similar host range,

including lucerne (Farr & Rossman) and it is assumed that additional impacts over and above those relating to *E. pisi* are likely to be small.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance would require observance and reporting of the characteristic whitish epigenous mycelium (CPC 2012) and subsequent diagnosis of this particular variety of *E. pisi* by either microscopic observation or by molecular diagnostic techniques.

Post-border management: Breeding for host resistance has been attempted in the UK and USA. Sulfur and synthetic fungicides have activity against powdery mildews. Biological control has also been attempted (CPC 2012).

References:
CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report *Erysiphe pisi var. pisi* *http://www.cabi.org/cpc/?compid=1&dsid=22084&loadmodule=datasheet&page=868&site=161* Accessed 9 September 2012.

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 9/9/12.

NZ Fungi (2012) Database. Avaiable online at: http://nzfungi.landcareresearch.co.nz/html/mycology.asp?ID= accessed 9/9/12.

Phymatotrichopsis omnivora (Cotton root rot)

Scientific Name:	*Phymatotrichopsis omnivora* (Duggar) Hennebert [anamorph] (Ascomycetes: Rhizinaceae)
Synonyms:	*Hydnum omnivorum Shear [*teleomorph] *Ozonium auricomum Pammel* [anamorph] *Ozonium omnivorum Shear* [anamorph] *Phymatotrichum omnivorum Duggar* [anamorph]
Common Name:	Cotton root rot

Brief description:
Phymatotrichopsis omnivora is a soil-borne pathogen that causes leaves to become flaccid, wilt and usually die. In field crops and vegetables, the entire root system rapidly decays within a few days of wilting, while in fruit trees, death may be sudden or occur over a couple of growing seasons (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host), Red clover (*Trifolium pratense),* White clover (*Trifolium repens)*
Other plants: *P. omnivora* has one of the broadest host ranges of any known soil-borne pathogen, attacking over 2000 species of plants. Main hosts include cotton, beans, pip fruit, stone fruit and grapes (CPC 2012; Farr & Rossman).

Current geographic distribution:
Africa: Libya, Malawi,
Americas: USA, Mexico, Venezuela (CPC 2012; Farr & Rossman)

Potential pathways of entry into New Zealand (Commodity Association):
Sclerotia are the primary inoculum source for the initiation of disease. They also serve as over-seasoning propagules that enable the pathogen to persist in soil for many years. The root rot can spread between plants via hyphae. Inanimate objects such as used agricultural machinery contaminated with soil, infected nursery stock and root vegetables such as carrots are possible entry pathways. Infected growing media and passengers (footwear, plant material in luggage) are possible pathways.

Potential to establish and spread in NZ: Low
The root rot currently has a fairly limited distribution and many of the American records are from Texas (Farr & Rossman) which has a much more tropical climate than New Zealand. There are no records from any of the more northerly states of America. The climate in New Zealand is unlikely to be suitable for establishment except perhaps in a few very limited areas in the far north.

Potential Impact in NZ: Low
Given the very wide host range and the high likelihood that infection will result in death of the host plant, potential impacts if the root rot were to establish in New Zealand could be locally high. However, since it is only likely to establish in very limited parts of New Zealand, if at all, the overall impact is likely to be low.

Possible methods of post-border management and surveillance:
Surveillance: The appearance of yellowish-brown to dark-brown mycelial strands (smaller in diameter than rhizomorphs produced by other root pathogens such as *Armillaria mellea*) growing ectotrophically on roots is the characteristic sign of this pathogen. The appearance of buff to light-brown, irregularly shaped spore mats during warm, rainy periods of the growing season would be a clear indication that areas are infested with the fungus (CPC 2012).

Post-border management: For most crops and soil types there are no control measures that are both effective and economically justified. Soil fumigants such as 1,3 dichloropropene have been shown to provide control of the pathogen, and the application of a systemic triazole fungicide deep in the soil near the root appears to offer the potential for disease reduction. Other control methods (e.g. resistant varieties, biological, cultural) have not yielded adequate or sufficiently consistent reduction in plant mortality to be useful (CPC 2012).

References:

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report - *Phymatotrichopsis omnivora* *http://www.cabi.org/cpc/?compid=1&dsid=40311&loadmodule=datasheet&page=868&site=161* Accessed 16 August 2012.

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 15/8/12.

Tilletia controversa (Dwarf bunt)

Scientific Name:	*Tilletia controversa* Kühn 1874 (Basidiomycota: Ustilaginomycetes: Ustilaginales: Tilletiaceae)
Synonyms:	*Tilletia brevifaciens* Fisch. 1952
Common Name:	Dwarf bunt of wheat

Brief description:
Dwarf bunt is a serious fungal disease, particularly of winter wheat at relatively high altitudes. It primarily affects the seed heads. It is reported to occasionally attack grass species, but there is little effect on the foliage.

Indicative host range:
Priority Pasture Species: Cocksfoot (*Dactylis glomerata*), Annual (Italian) Rye grass (*Lolium multiflorum),* Rye grass*(Lolium perenne)* (Hardison *et al.* 1959). None of these are main hosts (CPC 2012)
Other plants: wheat (principle host), barley, rye (CPC 2012)

Current geographic distribution:
Asia: Afghanistan, Armenia, Azerbaijan, Republic of Georgia, Iran, Iraq, Japan, Kazakhstan, Kirgizstan, Syria, Tajikistan, Turkey, Turkmenistan, Uzbekistan
Africa: Algeria, Libya, Morocco, Tunisia
Americas: Argentina, Canada, Uruguay, USA
Europe: Albania, Austria, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Moldova, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine.
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Since the main mode of dispersal is by seeds, imported grain or seed for sowing is the most likely pathway. Teliospores are capable of surviving adverse environmental conditions and are likely to survive transit to New Zealand. Passengers (plant material in luggage) are a possible pathway.

Tilletia bromi has been intercepted on imported Fescue (*Festuca*)seeds (MPI 2012). This species is already present in New Zealand and is not considered a hazard. However the interception provides supporting evidence that seed for sowing is a potential entry pathway.

Potential to establish and spread in NZ: Low
Despite being widespread in northern Europe, analysis of geospatial climate data indicates that the climate in New Zealand's wheat growing areas, and lowland pastoral areas, is unsuitable for establishment of dwarf bunt because of mild winter temperatures and a lack of persistent snow cover (Kim & Berresford 2009). The climate in the relatively high in mountain areas in the South Island is more suitable but there is relatively little intensive pastoral cropping in these areas.

Potential Impact in NZ: Low
There are few records of *Tilletia controversa* affecting grass species, and in wheat, which is the principle host its main impact is on the seed heads. Furthermore its potential distribution in New Zealand is limited.

Possible methods of post-border management and surveillance:
Surveillance: No reports were found about field surveillance for *T. controversa*. There is a lot of literature about monitoring seeds for presence of *T. controversa*.

Post-border management: Dwarf bunt disease is difficult to control because of the resistant resting spores which remain viable in the soil for a number of years (CPC 2012). The use of resitant plant varieties is the primary method of management (CPC 2012). Systemic fungicides have been used, e.g. etaconazole, to provide good control after disease establishment (CPC 2012).

References:

CPC (2012) last modified 19 June 2012, Crop Protection Compendium Report - *Tilletia controversa* *http://www.cabi.org/cpc/?compid=1&dsid=53924&loadmodule=datasheet&page=868&site=161* , Accessed 3 August 2012.

Hardison, JR; Meiners, JP; Hoffmann, JA; Waldher, JT (1959) Susceptibility of Graminae to *Tilletia contraversa*. *Mycologica* 51:656-664.

Kim, KS; Berresford, RM (2009) Satellite data for assessing climatic risk of establishment of plant pathogens. *New Zealand Plant Protection* 62: 109-113.

Ministry for Primary Industries (2012) Interceptions database. Accessed August 2012.

Urocystis occulta (Stripe smut of rye)

Scientific Name: *Urocystis occulta* Rabenh. 1870 (Ustilaginomycetes: Tilletiaceae)
Synonyms: *Erysibe occulta Wallr. 1833*
Polycystis occulta (Wallr.) Schlecht. 1852
Tuburcinia occulta (Wallr.) Liro 1922
Uredo parallela Berk. 1836
Polycystis parallela (Berk.) Fries 1849
Common Name: Stripe smut of rye

Brief description:
Urocystis occulta is a leaf smut that principally infects rye. It causes stunted growth and reduced seed production. It is primarily seed transmitted and spores can survive in the soil for a few months. Rye grass *(Lolium perenne)* and other grasses have been reported as occasional hosts (Mordue 1984). However, no reports have been found of it adversely impacting production of any of the priority pasture pests in New Zealand. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Rye grass*(Lolium perenne)*
Other plants: rye (principle host), barley, wheat, grasses (Farr & Rossman)

Current geographic distribution:
Asia: China, Japan
Africa: Kenya, South Africa
Americas: USA, Canada, Argentina, Brazil
Europe: Bulgaria, Germany, Italy, Greece, Austria, Czechoslovakia, Hungary, Spain, Netherlands, Denmark, Finland, Norway, Sweden, Switzerland, Poland, former USSR, Turkey, UK, former Yugoslavia
Oceania: Australia (Farr & Rossman).

References:

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 15/8/12.

Mordue, J EM (1984) *Urocystis occulta*. Descriptions of Fungi and Bacteria. *IMI Descriptions of Pathogenic Fungi and Bacteria* 81: Sheet 808. Abstract only accessed

Ustilago lolii (Smut)

Scientific Name: *Ustilago lolii* Magnus (Basidiomycota: Ustilaginomycetes: Ustilaginales: Ustilaginaceae)
Synonyms:
Common Name: smut

Brief description:
Ustilago lolii is a very rare smut which destroys the seeds of grasses. There is little available information on its biology (MAFBNZ 2007).

Indicative host range:
Priority Pasture Species: Annual (Italian) rye grass (*Lolium multiflorum*)(Vanky 1984)
Other plants: *Lolium remotum, L. temulentum*

Current geographic distribution:
Egypt, Germany, Poland, USSR (former), USA (introduced) (Farr & Rossman; Vanky 1984)

Potential pathways of entry into New Zealand (Commodity Association):
Since *U. lolli* is primarily associated with seeds, seed for sowing is the most likely pathway for entry. However, it is reported to be a very rare smut (Vanky 1984). Passengers (plant material in luggage) are a possible pathway.

Ustilago bullata has been intercepted on imported *Bromus* seeds (MPI 2012). This species is already present in New Zealand and is not considered a hazard. However the interception provides supporting evidence that seed for sowing is a potential entry pathway.

Potential to establish and spread in NZ: Moderate
Based on the limited distribution data available it appears that *U. lolli* prefers a range of climates from a warm/ dry arid environment to a cool/ moist temperate environment. Climate is unlikely to be a barrier to establishment in at least some parts of New Zealand. Since rye grass(*Lolium)* species are the only recorded hosts, the distribution of *U. lolii* is likely to be confined to the warm ryegrass-growing areas of New Zealand; predominantly the Canterbury region, South Island (MAFBNZ 2007).

Potential Impact in NZ: Low
There is little information available on the impacts of *U. lollii* on pastoral systems. It could potentially result in reduced seed production and reduced quality in rye grasspasture for livestock. However, other *Ustilago* species are already present in New Zealand and it is assumed that measures to control those species would also be effective against *U. lolii* (MAFBNZ 2007).

Possible methods of post-border management and surveillance:
Surveillance: Spore traps operating in un-infested areas is a useful technique as an early warning tool for smut fungi; this technique has been used to monitor for *Ustilago scitaminea* in Australia (Magarey et al. 2009).

Post-border management: There are no reports about management of *U. lollii* in CAB Abstracts. However, other U*stilago* species are managed using resistant plant varieties (Menzies et al. 2010; Kumar & Bhim Singh 2004), or foliar application of fungicides e.g. conazole fungicides (Jones 1999) and triadimefon (Jones 1997). Smut disease reduction on wheat was recorded with increasing rates of N and P fertilizers (Kumar & Bhim Singh 2004).

References:

Farr, DF; Rossman, AY Fungal databases Systematic Mycology & Microbiology Laboratory, ARS, USDA. http://nt.ars-grin.gov/fungaldatabases/ Accessed 15/8/12.

Jones, P (1997) Control of loose smut (Ustilago nuda and U. tritici) infections in barley and wheat plants by foliar application of triadimefon. *Plant Pathology* 46: 6, 946-951. Abstract only seen.

Jones, P (1999) Control of loose smut (Ustilago nuda and U. tritici) infections in barley and wheat by foliar applications of systemic fungicides. *European Journal of Plant Pathology; 1999.105: 7, 729-732.* Abstract only seen.

Kumar, V R; Bhim Singh (2004) Successful management of loose smut of wheat. *Journal of Phytological Research* 17: 1, 51-56. Abstract only seen.

MAFBNZ (2007) Draft Import Risk Analysis *Lolium* seed for sowing from all countries. Unpublished report.

Magarey, R C; Bade, G; Braithwaite, K S; Croft, B J; Lonie, K J (2009) Smut spore trapping studies conducted in Australian east coast production areas in late 2007-2008. In Bruce, R C (ed) *Proceedings of the 2009 Conference of the Australian Society of Sugar Cane Technologists held at Ballina, New South Wales, Australia, 5-8 May 2009.* Australian Society of Sugar Cane Technologists; Mackay; pp 158-165. Abstract only seen.

Menzies, J G; Steffenson, B J; Kleinhofs, A (2010) A resistance gene to Ustilago nuda in barley is located on chromosome 3H. *Canadian Journal of Plant Pathology* 32: 2, 247-251. Abstract only seen.

Ministry for Primary Industries (2012) Interceptions database. Accessed August 2012.

Vanky, K. (1994). *European smut fungi*. Germany: Gustav Fischer Verlag.

6.11 Nematodes

Meloidogyne arenaria (peanut root-knot nematode)

Scientific Name: *Meloidogyne arenaria* (Neal, 1889) Chitwood, 1949 (Nematoda: Meloidogynidae)

Synonyms: Anguillula arenaria Neal, 1889
Heterodera arenaria (Neal, 1889) Marcinowski, 1909
Meloidogyne arenaria arenaria (Neal, 1889) Chitwood, 1949
Meloidogyne arenaria thamesi Chitwood in Chitwood *et al.*, 1952
Meloidogyne thamesi (Chitwood *et al.*, 1952) Goodey, 1963
Tylenchus arenarius (Neal, 1889) Cobb, 1890

Common Name: Peanut root-knot nematode

Brief description: *M. arenaria* is an economically important nematode that parasitises thousands of plant species worldwide. It causes galls on roots resulting in abnormal formation and function of the root system and giant cells blocking the vascular cylinder (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*and White clover (*Trifolium repens)* (main hosts) and *Lolium multiflorum*, Tall Fescue (*Festuca arundinacea)* and Red clover (*Trifolium pratense)* (wild hosts) (CPC 2012).
Other plants: The host range of *M. arenaria* is extremely large and includes members from many plant families including monocotyledons, dicotyledons, and herbaceous and woody plants (CPC 2012).

Current geographic distribution:

Asia: Armenia, Azerbaijan, Bangladesh, China, India, Indonesia, Iran, Iraq, Japan, Jordan, Korea, Lebanon, Malaysia, Maldives, Mongolia, Nepal, Pakistan, Philippines, Saudi Arabia, Sri Lanka, Syria, Taiwan, Tajikistan, Thailand, Turkey, Turkmenestan, Uzbekistan, Vietnam
Africa: Algeria, Ivory Coast, Egypt, Gambia, Ghana, Liberia, Libya, Madagascar, Malawi, Mauritius, Morocco, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Uganda, Zimbabwe
Americas: Bermuda, USA, Mexico, Belize, Costa Rica, Cuba, El Salvador, Guadalupe, Jamaica, Martinique, Puerto Rico, Trinidad & Tobago, Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay, Venezuela
Europe: Belgium, Bulgaria, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Russia, Spain, Switzerland, Ukraine, United Kingdom, Yugoslavia (former)
Oceania: Australia, Cook Islands, Fiji, Niue, Papua New Guinea, Samoa, Solomon Islands, Tuvalu (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The life-cycle of *M. arenaria* is completed within the roots and soil surrounding the roots of host plants. Likely pathways of introduction therefore include rooted nursery stock, tubers/rhizomes e.g. potatoes, fresh produce – root vegetables, growing medium, and soil contaminating imported used machinery. Passengers (footwear, plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
M. arenaria is widespread in temperate parts of the northern hemisphere as well as more tropical areas. Based on its distribution, there are likely to be climatically suitable areas with

suitable hosts present in New Zealand. Nematodes are very small, and require a moisture phase for activity. This allows very limited active dispersal in soil but there would be few barriers to its spread by movement of infested soil or host material. The nematode reproduces by parthenogenesis and a single female can produce up to 1500 eggs. Under most growing conditions three generations are completed a season. Consequently there is potential for rapid build up of populations (CPC 2012).

Potential Impact in NZ: Low for the pastoral sector
The peanut root-knot nematode is a pest of major food crops and significantly reduces the quantity and quality of food and fibre production, although the average loss caused by root-knot nematodes is thought to be around 5% (CPC 2012). Infestations rarely kill the host plant and the stunted unthrifty growth of infected plants can be mistaken for other causes. It is reported to be less important on lucerne in the USA than *Meloidogyne hapla* (Griffin *et al.* 1996) which is already present in New Zealand.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance for nematodes requires soil surveys to be undertaken (Strausbaugh *et al*., 2004).

Post-border management:
Cultural: *Meloidogyne* species are obligate parasites and populations decline rapidly in the absence of a host. Rotation of susceptible host crop plants with those that are immune or poor hosts is a useful way to reduce the effect that *M. arenaria* has on plant growth (CPC 2012). Crop rotation is reported to be effective when certain leguminous species which exude compounds toxic to nematodes are planted (Osei *et al*. 2010). Forage sorghum is the current industry standard for use as a biofumigant against root-knot nematodes, but Brassicaceae plants (e.g. fodder radish cv. Weedcheck) also have potential to be used as biofumigation crops to manage nematode populations (Pattison *et al.* 2006).

Biocontrol: *Pasteuria penetrans* is a bacterial parasite that causes suppression of root-knot nematode in agricultural fields in Florida (Akyazi & Dickson 2011).

Chemicals: Nematicides have often been used for limiting the damage that nematodes cause on plants. Nematicides are usually used as a soil treatment before planting. However, a few nematicides can be applied after planting. These chemicals are relatively expensive and they require costly equipment and trained personnel to apply them (CPC 2012). The chemical 1,3-D (1,3-Dichloropropene) is reported to be highly reliable to control *Meloidogyne* spp. (but note this is in tomato crops and it may not be practical to use it on pastures) (Silvestro et al., 2008). Non-fumigant nematicides[58] carbofuran, fenamiphos or ethoprop also reduce root-knot nemative populations; they can be applied as a broadcast soil spray and incorporated with a disc harrow (Fortnum *et al.* 2001).

References:
Akyazi & Dickson (2011) (conference proceedings; http://www.mbao.org/2011/Proceedings/85DicksonD2.pdf)

CPC (2012) last modified 10 July 2012, Crop Protection Compendium Report – *Meloidogyne arenaria* http://www.cabi.org/cpc/?compid=1&dsid=33233&loadmodule=datasheet&page=868&site=161 Accessed 13 August 2012.

[58] Relevance to the EPA Review: carbofuran is a carbamate and fenamiphos is an organophosphate under review.

Fortnum, B. A. Johnson, A. W. Lewis, S. A. (2001) Analysis of 1,3-dichloropropene for control of *Meloidogyne* spp. in a tobacco pest management system. *Journal of Nematology;* 33: 4 Supplement, 325-331. Abstract only seen.

Griffin, GD; Bernard, EC; Pederson, GA; Windham, GL; Quesenberry, KH; Dunn, RA (1996) Nematode pathogens of American pasture/forage crops. Pasture and Forage Crop Pathology miscellaneous publication.

Osei, K. Gowen, S. R. Pembroke, B. Brandenburg, R. L. Jordan, D. L.(2010) Potential of leguminous cover crops in management of a mixed population of root-knot nematodes (*Meloidogyne* spp.). *Journal of Nematology* 42: 3, 173-178. Abstract only seen.

Pattison, A. B. Versteeg, C. Akiew, S. Kirkegaard, J. (2006) Resistance of Brassicaceae plants to root-knot nematode (*Meloidogyne* spp.) in northern Australia. *International Journal of Pest Management* 52: 1, 53-62. Abstract only seen.

Silvestro, D. di Talame, M. D'Ascenzo, D. (2008) Strategies for the control of root-knot nematodes in vegetable crops: experiments in the Abruzzo region. *Redia* 91: 85-90. Abstract only seen.

Strausbaugh, C. A. Bradley, C. A. Koehn, A. C. Forster, R. L. (2004) Survey of root diseases of wheat and barley in southeastern Idaho. *Canadian Journal of Plant Pathology* 26: 2, 167-176. Abstract only seen.

Meloidogyne chitwoodi (Colombia root-knot nematode)

Scientific Name: *Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley, 1980 (Nematoda: Meloidogynidae)
Synonyms:
Common Name: Colombia root-knot nematode

Brief description: Symptoms of *M. chitwoodi* vary according to host, population density of the nematode and environmental conditions. Above-ground symptoms are often not obvious but may consist of varying degrees of stunting, lack of vigour and a tendency to wilt under moisture stress. Root galls usually form, all leading to reduced yield. It is primarily a pest of potatoes and effects on other crops are not as marked, nor as well documented (CPC 2012).

Indicative host range:
M. chitwoodi has a wide host range among several plant families including crop plants and common weed species. Potatoes and tomatoes are good hosts, while barley, maize, oats, sugarbeet, wheat and various Poaceae will maintain the nematode. Lucerne is a good host for race 2 but not for race 1, whereas carrot is a good host for race 2, but not race 1(CPC 2012)
Priority Pasture Species: Lucerne *(Medicago sativa)* (main host) (CPC 2012); grasses (Griffin *et al.* 1996).
Other plants: Carrot, tomato, potato (main hosts) (CPC 2012).

Current geographic distribution:
- Asia: Turkey
- Africa: South Africa
- Americas: USA, Argentina
- Europe: Belgium, France, Germany, Netherlands (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The life-cycle of *M. chitwoodi* is completed within the roots and soil surrounding the roots of host plants. Likely pathways of introduction therefore include fresh produce – root vegetables, growing medium, and soil contaminating imported used machinery. Passengers (footwear, plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: High
M. chitwoodi occurs in temperate parts of the northern hemisphere. Based on its distribution, there are likely to be climatically suitable areas with suitable hosts present in New Zealand. Nematodes are very small, and require a moisture phase for activity. This allows very limited active dispersal in soil but there would be few barriers to its spread by movement of infested soil or host material. The nematode reproduces by parthenogenesis. There are several generations a season (CPC 2012). Consequently there is potential for rapid build up of populations

Potential Impact in NZ: Moderate
M. chitwoodi is primarily a pest of potatoes and although lucerne is reported to be a good host for one race of the nematode, no reports of economic damage to lucerne crops have been found. Griffin et al (1996) state that *M. chitwoodi* 'may be an important pathogen of forage grasses although its distribution in range and pasture is not well known.' However no reports of economic damage to pasture grasses have been found. While there is uncertainty about the potential impacts of *M. chitwoodi* in New Zealand, they are considered to be moderate because multiple priority pasture species could potentially be affected in several regions.

Possible methods of post-border management and surveillance:

Surveillance: Surveillance for nematodes requires soil surveys to be undertaken (Strausbaugh et al. 2004).

Post-border management: Chemical controls in use to control *M. chitwoodi* include 1,3-D (1,3-dichloropropene) (Riga 2011), and dimethyl disulphide (Charles & Heller 2010). Leaving fields fallow for two years was reported as a management strategy in cropping fields (Gamon & Lenne 2012). Some reduction in nematode population is achieved by use of green manure crops in infested fields (Hafez & Sundararaj 2010). Breeding plants for resistance to *M. chitwoodi* is a potential option for the future (Jensen & Griffin 1994; Brown *et al.* 2003; Zoon *et al.* 2002).

References:

Brown, C R; Mojtahedi, H; Santo, G S (2003) Characteristics of resistance to Columbia root-knot nematode introgressed from several Mexican and North American wild potato species. *Acta Horticulturae* 619, 117-125. Abstract only seen

Charles, P; Heller, J J (2010) Efficacy of dmds as a soil treatment against Meloidogyne chitwoodi in the Netherlands. *Acta Horticulturae* 883, 195-198. Abstract only seen

CPC (2012) last modified 5 September 2012, Crop Protection Compendium Report – *Meloidogyne chitwoodi* http://www.cabi.org/cpc/?compid=1&dsid=33235&loadmodule=datasheet&page=868&site=161 Accessed 1 September 2012.

Gamon, A; Lenne, N (2012) Meloidogyne chitwoodi and Meloidogyne fallax in France: initial management experiences. *Bulletin OEPP/EPPO Bulletin* 42: 1, 122-126.

Griffin, GD; Bernard, EC; Pederson, GA; Windham, GL; Quesenberry, KH; Dunn, RA (1996) Nematode pathogens of American pasture/forage crops. Pasture and Forage Crop Pathology miscellaneous publication.

Hafez, S L; Sundararaj, P (2010) Chemical and nonchemical strategies for the management of Meloidogyne chitwoodi on potato in Idaho, USA. *International Journal of Nematology; 20:* 1, 85-90. Abstract only seen

Jensen, K B; Griffin, G D (1994) Resistance of diploid Triticeae species and accessions to the Columbia root-knot nematode, Meloidogyne. *Journal of Nematology* 26: 4 Supp.*, 635-639.* Abstract only seen

Riga, E (2011) The effects of Brassica green manures on plant parasitic and free living nematodes used in combination with reduced rates of synthetic nematicides. *Journal of Nematology; 2011.43: 2, 119-121.* Abstract only seen

Strausbaugh, C. A. Bradley, C. A. Koehn, A. C. Forster, R. L. (2004) Survey of root diseases of wheat and barley in southeastern Idaho. *Canadian Journal of Plant Pathology* 26: 2, 167-176. Abstract only seen.

Zoon, F C; Golinowski, W; Janssen, R; Mugniery, D; Phillips, M S; Schlathoelter, M; Smant, G; Kruijssen, L v; Beek, J G (2002) Durable resistance against Meloidogyne chitwoodi and M. fallax. *Plant Protection Science* 38: Special 2, 711-713.

Meloidogyne graminicola (Rice root-knot nematode)

Scientific Name: *Meloidogyne graminicola* Golden & Birchfield 1965 (Nematoda: Meloidogynidae)
Synonyms:
Common Name: Rice root-knot nematode

Brief description: *M. graminicola* is a root nematode that is of primary importance on rice. It causes galls on roots resulting in abnormal formation and function of the root system and giant cells blocking the vascular cylinder (CPC 2012). There is evidence (Windham & Pederson 1992) that it also impact a range of clover species in the USA.

Indicative host range:
Priority Pasture Species: Poaceae (main hosts) (CPC 2012), White clover (*Trifolium repens),* Red clover (*Trifolium pratense),* Subterranean clover (*Trifolium subterraneum)* (Windham & Pederson 1992).
Other plants: Rice (main host), onion, brassicas, soyabean, maize, wheat (other hosts) (CPC 2012).

Current geographic distribution:
Asia: Bangladesh, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Singapore, Thailand, Vietnam
Africa: South Africa
Americas: USA, Brazil (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
The life-cycle of *M. graminicola* is completed within the roots and soil surrounding the roots of host plants. Likely pathways of introduction therefore include fresh produce e.g onions, growing medium, and soil contaminating imported used machinery. Passengers (footwear, plant material in luggage) are a possible pathway.

Potential to establish and spread in NZ: Low
M. graminicola occurs in countries with warmer climates than New Zealand, although it is reported occurring in 'upland' areas. In the USA it only occurs in the southern states of Georgia, Louisiana and Mississippi (CP 2012). It is likely that few if any parts of New Zealand would climatically suitable for establishment.

Potential Impact in NZ: Low
M. graminicola is primarily a pest of rice which is not grown commercially in New Zealand. Windham & Pederson (1992) report that it can develop on several clover species and that it can significantly suppress growth of white clover in particular. They also refer to it being associated with pasture grasses but no indication of damage to grasses was found. While the impacts on clovers could be significant, the very restricted potential distribution in New Zealand would limit any impacts to the pastoral sector.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance for nematodes requires soil surveys to be undertaken (Strausbaugh et al. 2004).

Post-border management: Increasing soil fertility can compensate for some damage by M. graminicola. Resistant cultivars hold out the most promise for effective and economic control, and some resistance to the different species has been found. Chemical control on the field scale is generally uneconomic (CPC 2012). Breeding plants for resistance to *M. graminicola* is possible; Pederson & Windham (1995) report *M. graminicola* resistance in white clover.

The potential for biological control of *M. graminicola* is reported; example biocontrol organisms include: a fungus, *Arthrobotrys oligospora* (Singh *et al.* 2012), a terrestrial cyanobacterium, *Synechococcus nidulans* (Gaur & Dhar 2012), and a bacterium, *Pseudomonas fluorescens* (Seenivasan *et al.* 2012). *M. graminicola* is sensitive to the *Allium* sulphur compound DMDS (dimethyl disulfide) (Arnault *et al.* 2008). Chemical control options may include carbofuran[59] (Mohammed 1988; Panigrahi & Mishra 1995).

References:

Arnault, I; Vey, F; Fleurance, C; Nabil, H; Auger, J (2008) Soil fumigation with Allium sulfur volatiles and Allium by-products. In Neuhoff, D; Halberg, N; Alfoldi, T; Lockeretz, W; Thommen, A; Rasmussen, I A; Hermansen, J; Vaarst, M; Lueck, L, et al (ed) *Cultivating the future based on science. Volume 1: Organic Crop Production. Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held at the 16th IFOAM Organic World Conference in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Consorzio ModenaBio in Modena, Italy, 18-20 June, 2008.* International Society of Organic Agricultural Research (ISOFAR); Bonn; Abstract only seen.

CPC (2012) last modified 8 June 2011, Crop Protection Compendium Report – *Meloidogyne graminicola* http://www.cabi.org/cpc/?compid=1&dsid=33243&loadmodule=datasheet&page=868&site=161 Accessed 11 Spetember 2012.

Mohammad, H Y (1988) The relationship between the biology of Meloidogyne graminicola and Heterodera sacchari and nematocide treatments. *Index to Theses Accepted for Higher Degrees in the Universities of Great Britain and Ireland* 37: 3, 1236 Abstract only seen.

Panigrahi, D; Mishra, C (1995) Effect of some pesticides on rice root-knot nematode, Meloidogyne graminicola. *Annals of Plant Protection Sciences* 3: 1, 74-75. Abstract only seen.

Pederson, G A; Windham, G L (1995) Registration of MSNR4 root-knot nematode resistant white clover germplasm. *Crop Science*.35: 4, 1234-1235. Abstract only seen.

Prasanna Holajjer; Anju Kamra; Gaur, H S; Dhar, D W (2012) In vitro nematicidal activity of a terrestrial cyanobacterium, Synechococcus nidulans, towards plant-parasitic nematodes. *Nematology* 14: 1, 85-92 Abstract only seen.

Seenivasan, N; David, P M M; Vivekanandan, P; Samiyappan, R (2012) Biological control of rice root-knot nematode, Meloidogyne graminicola through mixture of Pseudomonas fluorescens strains. *Biocontrol Science and Technology* 22: 6, 611-632. Abstract only seen.

Singh, U B; Asha Sahu; Singh, R K; Singh, D P; Meena, K K; Srivastava, J S; Renu; Manna, M C (2012) Evaluation of biocontrol potential of Arthrobotrys oligospora against Meloidogyne graminicola and Rhizoctonia solani in rice (Oryza sativa L.). *Biological Control* 60: 3, 262-270 Abstract only seen.

Strausbaugh, C. A. Bradley, C. A. Koehn, A. C. Forster, R. L. (2004) Survey of root diseases of wheat and barley in southeastern Idaho. *Canadian Journal of Plant Pathology* 26: 2, 167-176. Abstract only seen

Windham, GL; Pederson, GA (1992) Comparison of Reproduction by *Meloidogyne graminicola* and *M. incognita* on *Trifolium* Species. *Journal of Nematology* 24(2):257-261.

[59] Relevance to the EPA Review: carofuran is a carbomate under review.

Tylenchorhynchus acutus (stylet stunt nematode)

Scientific Name: *Tylenchorhynchus acutus* Allen, 1955 (Nematoda: Dolichodoridae)
Synonyms: *Quinisulcius acutus* (Allen, 1955) Siddiqui, 1971
Common Name: Stylet stunt nematode

Brief description: *T. acutus* is a migratory polyphagous ectoparasite associated in the rhizosphere of plants. It generally forms only part of a general complex of plant nematodes in the soil, and its exact role in plant disease is difficult to assess. The root systems of plants infected with *T. acutus* are usually poorly developed with very few feeder roots. This poor root development is often associated with non-specific above-ground symptoms such as stunted, unthrifty plants with chlorotic foliage (CPC 2012).

Indicative host range:
<u>Priority Pasture Species:</u> Lucerne *(Medicago sativa)* (main host) (CPC 2012).
<u>Other plants:</u> Few studies have been carried on the host range of *T. acutus*. It has been reported from shelterbelt trees as well as soybean, haricot bean, tomatoes and rangeland grasses (CPC 2012).

Current geographic distribution:
The known distribution of *T. acutus* is restricted either due to a paucity of surveys or because in most instances the genus has not been identified to species level. Therefore, the possibility of its presence in several other countries, and infesting many other plant species hitherto unreported, cannot be ruled out.

<u>Asia:</u> Pakistan
<u>Americas:</u> Canada, USA (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
All stages of *T. acutus* are mobile root-feeders. They remain in the soil near the root zone and use their well-developed stylets to feed on host tissues. Likely pathways of introduction are therefore restricted to those associated with soil such as growing medium, and soil contaminating imported used machinery or footwear.

Potential to establish and spread in NZ: Low
Relatively little is known about the biology of *T. acutus.* It does not thrive in soils with excessive moisture but this may be due to the toxic effects of bacteria. It occurs in Canada and parts of the USA such as Colorado and Dakota (CPC 20112) which have a more continental climate than much of New Zealand. It is therefore unlikely to be able to establish except in limited parts of New Zealand. Nematodes are very small, and require a moisture phase for activity. This allows very limited active dispersal in soil but there would be few barriers to its spread by movement of infested soil or host material.

Potential Impact in NZ: Low
Although *T. acutus* has been associated with unthrifty stunted growth of many plants, few investigations have been carried out to establish damage threshold levels or the extent of yield losses caused by this pest. In one greenhouse study, plant shoot and root growth of range grasses was reduced by densities of 1 or 2 cm^{-3} soil, but the level of reduction is not reported (Griffin *et al.* 1996). In most instances *T. acutus* occurs alongside other major plant-parasitic nematodes which complicates the assessment of damage (CPC 2012). There are many natural enemies of nematodes in the soil including fungi and bacteria which could bring about suppression of nematode numbers under favourable conditions. It is not known the extent to which they might ameliorate any impacts from *T. acutus* in New Zealand. The impacts of *T. acutus* establishing in New Zealand are uncertain but likely to be low.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance for nematodes requires soil surveys to be undertaken (Strausbaugh *et al.* 2004).

Post-border management: There are few scientific records about *T. acutus*, and fewer about control. Hollis & fielding (1958) reported that soil fumigation using Dowfume MC-2 was effective against *T. acutus*. Given that breeding for plant resistance and use biological controls are management options for other nematodes, these are likely to be options for *T. acutus* also.

References:
CPC (2012) last modified 19 June 2012, Crop Protection Compendium Report – *Tylenchorhynchus acutus*
http://www.cabi.org/cpc/?compid=1&dsid=55411&loadmodule=datasheet&page=868&site=161 Accessed 13 August 2012.

Griffin, GD; Bernard, EC; Pederson, GA; Windham, GL; Quesenberry, KH; Dunn, RA (1996) Nematode pathogens of American pasture/forage crops. Pasture and Forage Crop Pathology miscellaneous publication.

Hollis, J P; Fielding, M J (1958) Population behaviour of plant parasitic nematodes in soil fumigation experiments. *Bulletin.Louisiana Agricultural Experiment Station* 515: 30 *pp* Abstract only seen

Strausbaugh, C. A. Bradley, C. A. Koehn, A. C. Forster, R. L. (2004) Survey of root diseases of wheat and barley in southeastern Idaho. *Canadian Journal of Plant Pathology* 26: 2, 167-176. Abstract only seen

Tylenchorhynchus claytoni (stunt nematode)

Scientific Name: *Tylenchorhynchus claytoni* (Nematoda: Dolichodoridae)
Synonyms: *Tessellus claytoni* Jairajpuri & Hunt, 1984
Common Name: stunt nematode

Brief description: *T. claytoni* is a nematode. It is ectoparasitic on roots and inhabits rhizospheres. It may produce brownish lesions at the feeding site, and can cause severe stunting and chlorosis. Symptoms are most severe when the plant is under stress (CPC 2012).

Indicative host range:
Priority Pasture Species: Lucerne *(Medicago sativa)*, Rye grass *(Lolium perenne)*. *Trifolium* spp. (main hosts), Tall Fescue (*Festuca arundinacea)* (wild host) (CPC 2012).
Other plants: *T. claytoni* has a wide host range. In addition to azaleas, sugarcane, pine, peach, maize, tobacco, pea and grasses are important hosts (CPC 2012).

Current geographic distribution:
Asia: Bangladesh, China, India, Japan, Republic of Korea, Turkey
Africa: South Africa
Americas: Canada, USA, Honduras
Europe: Belgium, Bulgaria, Cyprus, Denmark, Germany, Netherlands, Switzerland, UK
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
All stages of *T. claytoni* are mobile root-feeders. They remain in the soil near the root zone. Likely pathways of introduction are therefore restricted to those associated with soil such as growing medium, soil contaminating imported used machinery and footwear.

Potential to establish and spread in NZ: Moderate
Relatively little is known about the biology of *T. claytoni.* Limited experimental evidence suggests that it is more suited to warmer conditions than are widespread in New Zealand. However, it occurs in countries with temperate climates such as the UK and it is assumed that it has the potential to establish at least in parts of New Zealand. The nematode can move only short distances in the soil, and has no natural means of long-range movement. The main means of dispersal is with infested soil carried by wind, in rain or irrigation water, attached to boots or machinery, or transported by animals. Seedlings grown in infested soil, for example in nurseries, may carry the nematodes in soil attached to roots (CPC 2012).

Potential Impact in NZ: Moderate
T. claytoni can cause severe damage to ornamentals such as Azaleas. It is also a pest of sugarcane, rice, maize and tobacco, of which maize is an important crop in New Zealand. There is a report of 30% loss in rye grassproduction in South Africa in 1961 (CPC 2012) and Griffin et al (1996) report it causing unspecified reductions in root and shoot biomass and tiller production in forage grasses in experiments in the USA. *T. claytoni* is often recorded as a contributor to general nematode damage caused by a complex of nematode species. It may also pre-dispose hosts to fungal diseases (CPC 2012). While the impacts of *T. claytoni* establishing in New Zealand are uncertain they are likely to be moderate.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance for nematodes requires soil surveys to be undertaken (Strausbaugh *et al.* 2004).

Post-border management: The use of chemicals[60] to control *T. claytoni* is reported. The most effective treatments were the fenamiphos 10G single (22.4 kg a.i./ha) or split applications (Peackock & Dunn 1986). Foliar application of carbofuran reduced nematode populations in maize or potato crops (DiSanzo 1982). Dunn (1980) reports the results of nematicide treatment of field crops and turf, and indexes host, nematode and nematicide. Organic and inorganic nitrogen amendments are reported to reduce soil populations of *T. claytoni* (Rodriguez-Kabana 1986).

References:

CPC (2012) last modified 26 March 2012, Crop Protection Compendium Report – *Tylenchorhynchus claytoni* http://www.cabi.org/cpc/?compid=1&dsid=55414&loadmodule=datasheet&page=868&site=161 Accessed 13 August 2012.

DiSanzo, C P (1982) Effect of foliar application of carbofuran and a related compound on plant-parasitic nematodes under microplot and field conditions. *Journal of Nematology* 14: 2, 208-212

Dunn, R. (1980) Nematicides. *Fungicide and Nematicide Tests* 35: 214-236

Griffin, GD; Bernard, EC; Pederson, GA; Windham, GL; Quesenberry, KH; Dunn, RA (1996) Nematode pathogens of American pasture/forage crops. Pasture and Forage Crop Pathology miscellaneous publication.

Peacock, CH; Dunn, RA (1986) Effects of nematicide formulations on turfgrass nematodes. *Proceedings, Soil and Crop Science Society of Florida* 45: 185-188

Rodriguez-Kabana, R (1986) Organic and inorganic nitrogen amendments to soil as nematode suppressants. *Journal of Nematology* 18: 2, 129-135.

Strausbaugh, CA; Bradley, CA; Koehn, AC; Forster, RL (2004) Survey of root diseases of wheat and barley in southeastern Idaho. *Canadian Journal of Plant Pathology* 26: 2, 167-176. Abstract only seen.

[60] Relevance to the EPA Review: fenamiphos is an organophosphate and carbofuran is a carbamate under review.

6.12 Phytoplasmas

Aster yellow phytoplasma group

Scientific Name: Aster yellow phytoplasma group (Acholeplasmatales: Acholeplasmataceae)
Synonyms: '*Candidatus* Phytoplasma asteris' (16SrI)
Common Name: Aster yellow phytoplasma group

Brief description: Aster yellows phytoplasmas affect plants by causing a general reduction in quantity and quality of yield. The most severely affected hosts are carrot, lettuce, aster, onion and spinach. Disease incidence may vary from year to year depending on the population trend of the vectors in the field. *Trifolium* species are considered to be one of the most important natural reservoirs of aster yellows phytoplasma within the Czech Republic (Valova *et al.* 2002). They are spread by leafhopper vectors or grafting (CPC 2012).

Indicative host range:
Aster yellows phytoplasmas appear to have a wide host range and are reported to be associated with more than 80 plant species (Lee *et al.* 2004). The host range of phytoplasmas is strongly dependent upon the insect vectors (Bertaccini & Duduk 2009). The wide host range of Aster yellows phytoplasma subgroup B is considered to be a result of the large number and polyphagous nature of its insect vectors, rather than the phytoplasma itself having particular host-plant specificities. For many of the plant hosts which have previously been reported to be affected on the basis of symptomatology and/or microscopic examinations, the identity of the infecting phytoplasmas has never been determined with molecular techniques.

Priority Pasture Species: White clover (*Trifolium repens)* (main host), ribwort plantain (*Plantago lanceolata*) (CPC 2012).
Other plants: onion, celery, rape, broccoli, turnip, aster, chrysanthemum, strawberry, sword lilly, carrot, lettuce, paulownia, spinach, maize, French marigold (main hosts) (CPC 2012).

Current geographic distribution:
Aster yellows phytoplasmas which have been molecularly characterized have been reported from Europe, North America, Asia, Mexico and Brazil. However, there are significant differences in the distribution of the various subgroups. This is likely to be related to the distribution and mobility of the insect vectors. The current information about distribution is likely to be just a temporary picture because very little is known about the occurrence of the phytoplasmas in the former Soviet Union, Africa, and South America.

Asia: China, India, Israel, Japan, Lebanon, Malaysia, Taiwan, Thailand
Africa: South Africa
Americas: Canada, USA, Mexico, Brazil, Peru
Europe: Belgium, Czech Republic, France, Germany, Greece, Italy, Poland, Portugal, Russian Federation, Spain, UK
Oceania: Australia (CPC 2012).

Potential pathways of entry into New Zealand (Commodity Association):
Infected nursery stock or cut flowers which are capable of rooting and are planted in New Zealand are potential entry pathways. Aster yellows are not seed tranmissable so seeds-for-sowing is not a viable entry pathway (CPC 2012). Aster yellows can be transmitted by leafhoppers so there is some potential for leafhoppers associated with fresh produce or cut flowers to be an entry pathway.

Potential to establish and spread in NZ: Moderate
Aster yellows pytoplasmas occur in countries with similar climates to New Zealand and have a wide host range. Neither climate nor availability of suitable hosts are likely to be barriers to establishment. The phytoplasmas are vectored by polyphagous leafhoppers including: *Macrosteles fascifrons, M. laevis, M. striiformis, M. quadripunctulatus, M. sexnotatus, M. viridigriseus, Euscelis plebeja, E. lineolatus, E. incisus, Euscelidius variegatus, Aphrodes bicinctus, Hishimonoides sellatiformis, Scaphytopius acutus, Dalbulus elimatus, Colladonus montanus and C. geminatus* (CPC 2012). Whilst none of these species occurs in New Zealand (Lariviere *et al.* 2010), there is a species from the vector genus *Macroteles* in New Zealand (Lariviere, 2005), and two planthopper species are known to transmit other phytoplasma species in New Zealand (Liefting *et al.* 1997). Given that one of the planthoppers, *Zeoliarus oppositus*, is a polyphagous feeder, and that some Aster yellows phytoplasmas seem to have low specificity for vectors, *Z. oppositus* is a potential vector of Aster yellows phytoplasmas in New Zealand. The distribution of the insect vector(s) will influence the potential for the phytoplasmas to spread.

Potential Impact in NZ: Low for the pastoral sector
White clover (*Trifolium repens)* is reported to be a main host of Aster yellows (CPC 2012) and clover species are considered to be one of the most important natural reservoirs of aster yellows phytoplasma within the Czech Republic (Valova *et al.* 2002). The impact on clover plants include virescense (greening) and phyllody (development of leafy structures) of flowers, and dwarfing (small leaves, proliferation of shoots, dwarf growth habit) (Staniulis *et al.* 2000). However, no reports of economic impacts on pasture species were found. It is assumed that they would cause some loss of yield if established in New Zealand. The potential distribution of Aster yellows phytoplasma would be restricted if the insect vectors are few in species and not widespread, and this would in turn limit the potential impact.

Possible methods of post-border management and surveillance:
Surveillance: Surveillance would require the observance and reporting of phytoplasma symptoms (e.g. viresence and phyllody in flowers, shoot proliferation, dwarfing, leaf yellowing) in any of the known host plants (and potentially other plant species), and subsequent molecular diagnosis of a phytoplasma agent. Surveillance could include the monitoring leaf and plant hoppers that might be potential vectors of phytoplasmas, and molecular analysis for presence of phytoplasma.

Post-border management: Phytoplasmas are difficult to manage. Insect control would need to form a key part of management of phytoplasmas. Insecticide sprays remain the most common control measures in horticultural and field crops. However, integrated pest management techniques using beneficial insects, biotechnology, and plant resistance are emerging (Olivier *et al*. 2009).

Some examples of chemicals used to control leaf-hoppers are[61]: In field trials on lettuce crops, the pyrethriod permethrin was effective in reducing the incidence of aster yellows, and was as effective as 10-20 times the concentration of carbaryl (the standard insecticide used in Ontario in the 1980s) (Stevenson & Pree 1984). In ornamental crops, control of adult leafhopper (Macrosteles laevis) with bifenthrin (Talstar 100 EC) is recorded in Poland (Soika & Kaminska 2000). Application (from a fixed-wing aircraft) of 40% metaphos [parathion-methyl] EC at 0.5 litre/ha, 50% Sumithion [fenitrothion] EC at 0.5 litre/ha, or 5% esfenvalerate EC at 0.20-0.25 litre/ha resulted in 83-98% control of cicadellids (including Macrosteles laevis) in Russia (Korobov *et al.* 1991). CAB abstracts have many other reports

[61] Relevance to the EPA Review: carbaryl is a carbamate, and fenitrothion is an organophosphate under review.

from pre-1970 of other chemicals used to control leaf-hoppers and the impact of aster yellows.

References:

Bertaccini, A; Duduk, B (2009) Phytoplasma and phytoplasma diseases: a review of recent research. *Phytopathologia Mediterranea* 48(3): 355-378.

CPC (2012) last modified 27 February 2012, Crop Protection Compendium Report – *Tylenchorhynchus claytoni* http://www.cabi.org/cpc/?compid=1&dsid=7642&loadmodule=datasheet&page=868&site=161 Accessed 12 September 2012.

Larivière, M. C. (ed). 2005 (and updates), July 2009, Checklist of New Zealand Hemiptera (excluding Sternorrhyncha). The New Zealand Hemiptera Website, NZHW 04. http://hemiptera.landcareresearch.co.nz/, 2009, 6 July

Larivière, MC; Fletcher, MJ; Larochelle, A (2010) Auchenorrhyncha (Insecta: Hemiptera): catalogue. *Fauna of New Zealand 63* : 232 p. Available online at: http://wwwold.landcareresearch.co.nz/research/biosystematics/invertebrates/faunaofnz/Extracts/FNZ63/FNZ63ind.asp Accessed 12 Septembe 2010.

Liefting, L W; Beever, R E; Winks, C J; Pearson, M N; Forster, R L S (1997) Planthopper transmission of *Phormium* yellow leaf phytoplasma. *Australasian Plant Patholog*y 26: 148-154.

Lee, I M; Gundersen-Rindal, D E; Davis, R E; Bottner, K D; Marcone, C; Seemuller, E (2004) '*Candidatus* Phytoplasma asteris', a novel phytoplasma taxon associated with aster yellows and related diseases. *International Journal of Systematic and Evolutionary Microbiolog*y 54(4): 1037-1048.

Olivier, CY; Lowery, DT; Stobbs, LW (2009) Phytoplasma diseases and their relationships with insect and plant hosts in Canadian horticultural and field crops.
Canadian Entomologist 141: 5, 425-462

Valova, P; Fialova, R; Navratil, M; Franova, J; Simkova, M; Nebesarova, J (2002) Weed hosts of phytoplasmas in the Czech Republic. *Plant Protection Science* 38: Special 2, 285-287. Abstract only accessed.

6.13 Viruses

Beet necrotic yellow vein virus

Scientific Name: *Beet necrotic yellow vein virus* (BNYVV) (Virus: unassigned family currently classified as a possible species of the Furovirus genus)
Synonyms: *Beet necrotic yellow vein furovirus*
Beet rhizomania virus
Beet yellow vein virus
Common Name: Rhizomania

Brief description:
Beet necrotic yellow vein virus is primarily a pathogen of sugarbeet and causes significantly reduced sugar yields. It infects all cultivars of sugarbeet, fodder beet, garden beet, leaf beet, spinach and several species of the Chenopodiaceae. BNYVV is transmitted by the soil-borne fungus *Polymyxa betae*. Chicory (as a weed) is described as an alternative wild host. No reports of adverse impacts on this species have been found. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Chicory (*Cichorium intybus)*wild host (CPC 2012)
Other plants: The host range of BNYVV is narrow. The virus infects all cultivars of sugarbeet and fodder beet, Swiss chard, spinach and many species of the genus *Chenopodium* (CPC 2012)

Current geographic distribution:
Rhizomania disease was first found in Italy during the 1950s and is now thought to occur in most sugarbeet producing countries in Europe. It was first detected in Japan in 196 and in China in 1978 and is now widespread in sugarbeet growing areas of both countries. It has also spread rapidly in the USA (CPC 2012).

References:
CPC (2012) last modified 10 July 2012, Crop Protection Compendium Report – Beet necrotic yellow vein virus
http://www.cabi.org/cpc/?compid=1&dsid=10257&loadmodule=datasheet&page=868&site=161 , Accessed 15 August 2012.

Chicory yellow mottle virus

Scientific Name: *Chicory yellow mottle virus* (ChYMV) (Virus: Comoviridae)
Synonyms: *Chicory yellow mottle nepovirus*
Common Name: *Chicory yellow mottle virus*

Brief description:
Chicory yellow mottle virus is reported as a pathogen of chicory. It is transmitted by mechanical inoculation, seed and possibly by nematodes. Symptoms include ringspots, line pattern and bright yellow mottling of leaves (Brunt 19922). However no reports of it causing adverse impacts on either the vegetable or pasture forms chicory have been found. In the absence of evidence for adverse impacts on priority pasture species it is not considered a hazard to the New Zealand pastoral sector and no further assessment has been undertaken.

Indicative host range:
Priority Pasture Species: Chicory (*Cichorium intybus)* main host
Other plants: Parsley (main host), celery (other host) (CPC 2012)

Current geographic distribution:
Europe: Italy

References:
Brunt, AA (1992) Plant viruses online: Chicory yellow mottle nepovirus. Accessed 15/8/12. http://www.agls.uidaho.edu/ebi/vdie/descr207.htm

CPC (2012) last modified 15 May 2008, Crop Protection Compendium Report – Chicory yellow mottle virus
http://www.cabi.org/cpc/Default.aspx?LoadModule=datasheet&site=161&page=868&CompID=1&dsID=13690 , Accessed 15 August 2012.

7 Glossary

Aestivation	Cessation or slowing of activity during summer.
biosecurity	The exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health.
bug	Plant-piercing insects in the order Hemiptera.
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.
disease	A finite abnormality of structure or function with an identifiable pathological or clinicopathological basis, and with a recognizable syndrome of clinical signs. Its cause may not be known, or may be from infection with a known organism.
direct pest	in relation to a particular plant, a pest that feeds on that plant
endemic	in ecology it means native to a region and it can be found only in that certain region.
entry	(of an organism or disease) Movement of an organism or disease into a risk analysis area.
establishment	Perpetuation, for the foreseeable future, of an organism or disease within an area after entry.
exotic	Not native to a particular country, ecosystem or eco-area.
gregarious	a pest that associates or clusters together with its peers
hazard	Any disease or organism that has the potential to produce adverse consequences.
hitchhiker	An organism that has an opportunistic association with a commodity or item with which it has no biological host relationship.
host	A plant species that an organism depends on.
indirect pest	in relation to a particular plant, a plant that is associated with, but does not feed on, that plant
interception records	Border and post-border detections of organisms in association with imported commodities or conveyances (e.g. shipping containers).
IPM	Integrated Pest Management
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.
oviposit	to lay eggs especially by means of an ovipositor.
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 plant products [FAO, 1990; revised FAO, 1995; IPPC, 1997] Note: For the purpose of this analysis “pest” includes an organism sometimes associated with the pathway, which poses a risk to human or animal or plant life or health (SPS Article 2).
Poaceae	A large family of monocotyledonous flowering plants commonly known as grasses and cereals.
polyphagous	Able to feed on many kinds of food plants.
risk analysis	The process composed of hazard identification, risk assessment, risk management and risk communication.
risk assessment	The evaluation of the likelihood, and the biological and economic consequences, of entry, establishment, or exposure of an organism or disease.
risk management	The process of identifying, selecting and implementing measures that can be applied to reduce the level of risk.
risk	The likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.
sclerotia	masses of fungal hyphae
spread	Expansion of the geographical distribution of a potential hazard within an area.
vector	An organism that carries disease-causing micro-organisms from one host to another. For example, aphids can be transmitters of plant viruses
weed	A plant considered undesirable, unattractive, or troublesome, especially one growing where it is not wanted.

8 Appendices

8.1 Appendix 1: The Pastoral sector in New Zealand

The following summary was compiled from information provided by the pastoral sector. Its purpose is to inform the assessment of potential hazards.

Regional variation
Table 4 indicates the relative importance of the regions for the different elements of the pastoral sector in New Zealand.

Table 4 Livestock by production region at 30 June 2010

	Sheep	**Beef**	**Dairy**	**Deer**
North / south Auckland	13%	35%	43%	15%
Taranaki / Manawatu	11%	13%	16%	6%
East Coast	25%	24%	6%	8%
Total North Island	**49%**	**72%**	**65%**	**30%**
Canterbury /Westland	22%	18%	21%	35%
Otago	15%	6%	3%	13%
Southland	14%	5%	10%	22%
Total South Island	**51%**	**28%**	**35%**	**70%**

Source: Beef + Lamb New Zealand Economic Service Statistics New Zealand

Summary of pastoral production trends

Table 5 Changes in production 2002 -2009 (MPI 2012; DINZ pers. com. 2013)

	Beef	**Sheep**	**Dairy**	**Deer***
Pasture	- 2.3% (- 45,000 ha)	- 6.2% (-240,000ha)	+6.3% (+120,000ha)	-19% (-70,000ha)
Livestock[62]	- 9%	-17%	+13%	-30%
Production[63]	- 7.5%	- 8.1%	+ 19%	+11%

*****Deer statistics provided by DINZ (DINZ pers. com. 2013)

[62] Based on number of animals.
[63] Beef and Sheep production relates to weight of meat. Dairy production relates to weight of milk solids.

Priority pasture species

Representatives of the pastoral sector in New Zealand provided a list of pasture species they consider to be of greatest importance. Table 6 indicates the relative significance of the priority pasture species for the different elements of the pastoral sector.

Table 6

Common Name	**Scientific Name**	**DEER Importance**	**DAIRY Relative importance (0 low- 10 high)**	**BEEF&SHEEP Relative importance (0 low- 10 high)**
White Clover	*Trifolium repens*	Moderately and highly developed systems	10	10
Red Clover	*Trifolium pratense*	Highly developed systems	3	6
Lucerne	*Medicago sativa*	Highly developed systems	2	6
Subterranean Clover	*Trifolium subterraneum*	Moderately developed systems		5
Cocksfoot or orchard grass	*Dactylis glomerata*	Moderately and highly developed systems	3	10
Tall Fescue	*Festuca arundinacea*		4	6
Timothy	*Phleum pratense*			5
Perennial Ryegrass	*Lolium perenne*	Highly developed systems	10	10
Hybrid Ryegrasses	*Lolium x boucheanum* Kunth syn *L. hybridum* Hausskn		10	10
Annual Rye grass (Italian Ryegrass)	*Lolium multiflorum*	Highly developed systems	10	10
Browntop or Bent grasses	*Agrostis capillaris* *Agrostis tenuis*	Moderately developed systems	2 (only for early conversions)	4
Chicory	*Cichorium intybus*	Highly developed systems	5	5
Ribwort plantain	*Plantago lanceolata*	Highly developed systems	5	5

References

MPI (2012) Pastoral input trends in New Zealand a snapshot.

8.2 Appendix 2: Potential hazards - pests which are not present in NZ <u>and</u> associated with at least one of the priority pasture species

Pest name	**Pest type**	**Priority pasture species assocations**	**assessed further**	**comment**
Burkholderia andropogonis	Bacteria	White clover *(Trifolium repens)*	no	
Rhizobium rhizogenes	Bacteria	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)*	no	
Xanthomonas axonopodis pv. alfalfae	Bacteria	Lucerne *(Medicago sativa)* *Trifolium spp.*	yes	
Xanthomonas oryzae pv. oryzae	Bacteria	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC. Primarily a rice problem
Xanthomonas translucens pv. arrhenatheri	Bacteria	Rye grasses *(Lolium spp).*	no	little information
Xanthomonas translucens pv. phlei	Bacteria	Rye grasses *(Lolium spp).*	no	little information
Xanthomonas translucens pv. poae	Bacteria	Rye grasses *(Lolium spp).*	no	little information
Alternaria cichorii	Fungus	Chicory *(Cichorium intybus)*	yes	little information
Cercospora medicaginis	Fungus	Lucerne *(Medicago sativa)*	no	little information
Cercospora plantaginis	Fungus	*Plantago lanceolata*	no	uncertain significance, little information
Clavibacter toxicus [syn] (Rathayibacter)	Fungus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC
Cochliobolus victoriae	Fungus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC; little information
Colletotrichum truncatum	Fungus	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)*	no	uncertain impact
Didymella festucae	Fungus	Tall Fescue *(Festuca arundinacea)*	yes	
Drechslera catenaria	Fungus	Tall Fescue *(Festuca arundinacea)* Annual (Italian) rye grass *Lolium multiflorum* Bent grasses *(Agrostis spp.)*	yes	
Drechslera sativa	Fungus	Rye grasses *(Lolium spp).*	no	insufficient information
Epichloë typhina	Fungus	Rye grasses *(Lolium spp).* *Tall Fescue (Festuca arundinacea)*	yes	
Erysiphe pisi var. pisi	Fungus	Lucerne *(Medicago sativa)* *Trifolium spp.*	yes	

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Fusarium moniliforme var. subglutinans	Fungus	*Plantago lanceolata*	no	uncertain significance
Helicobasidium purpureum	fungus	Chicory *(Cichorium intybus)*	no	little information
Hymenula cerealis	Fungus	Rye grasses *(Lolium spp).*	no	little information
Mycosphaerella loliacea	Fungus	Rye grasses *(Lolium spp).*	no	little information
Neophoma graminella	Fungus	Rye grasses *(Lolium spp).*	no	little information
Neotyphodium x siegelii	Fungus	Rye grasses *(Lolium spp).*	no	only recorded from L. pratense. Should not be regarded as a disease. This is an endophytic seed-transmitted fungus that has no external stage and does not sexually reproduce. Like other endophytic fungi in this genus it poses no risk to plant health.
Ovularia lolii	Fungus	Rye grasses *(Lolium spp).*	no	little information
Ovularia pusilla [syn]	Fungus	Rye grasses *(Lolium spp).*	no	uncertain NZ status
Peronospora alta	Fungus	*Plantago lanceolata*	no	uncertain significance
Phomopsis subordinaria	Fungus	*Plantago lanceolata*	no	uncertain significance
Phymatotrichopsis omnivora	Fungus	Lucerne *(Medicago sativa)*	yes	
Phytophthora medicaginis	fungus	Lucerne *(Medicago sativa)*	no	
Phytophthora tentaculata	fungus	Chicory *(Cichorium intybus)*	no	little information
Pseudomonas fuscovaginae	Fungus	Rye grasses*(Lolium spp).*	no	priority spp not main hosts in CPC. Primarily a rice problem
Pseudomonas marginalis	fungus	Chicory *(Cichorium intybus)*	no	little information
Pyricularia setariae	Fungus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC
Pythium aphanidermatum	Fungus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC
Rathayibacter tritici	Fungus	Rye grasses *(Lolium spp).*	no	little information
Sclerospora graminicola	Fungus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC
Septoria loligena	Fungus	Rye grasses *(Lolium spp).*	no	little information
Septoria lolii	Fungus	Rye grasses *(Lolium spp).*	no	little information
Sorosporium lolii	Fungus	Rye grasses *(Lolium spp).*	no	little information
Tilletia controversa	Fungus	Rye grasses *(Lolium spp).* Cocksfoot *(Dactylis glomerata)* Fescues *(Festuca spp.)*	yes	a severe pest but priority pasture species are not main hosts
Tilletia indica	Fungus	Rye grasses*(Lolium spp).*	no	little information
Tilletia lolioli	Fungus	Rye grasses *(Lolium spp).*	no	little information
Tilletia texana	Fungus	Fescues *(Festuca spp.)*	no	little information

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Urocystis occulta	Fungus	Rye grasses *(Lolium spp).* Fescues *(Festuca spp.)*	yes	
Ustilago compacta	Fungus	Rye grasses *(Lolium spp).*	no	little information
Ustilago lolii	Fungus	Rye grasses *(Lolium spp).*	yes	
Aster yellows phytoplasma group ('Candidatus Phytoplasma asteris')	Phytoplasma	White clover *(Trifolium repens)* Ribwort plantain *(Plantago lanceolata)*	yes	uncertain impact
Potato witches' broom phytoplasma	Phytoplasma	Lucerne *(Medicago sativa)* White clover *(Trifolium repens)*	no	main impact appears to be on potatoes
Anicla infecta	Virus	Rye grasses*(Lolium spp).*	no	little information
Beet necrotic yellow vein virus	Virus	Chicory *(Cichorium intybus)*	yes	wild host
chicory yellow mottle virus	Virus	Chicory *(Cichorium intybus)*	yes	little information
Cynosurus mottle virus	Virus	*grasses*	no	
Pea early-browning virus	Virus	Lucerne *(Medicago sativa)*	no	appears to impact mainly peas
Rice black streaked dwarf virus	Virus	Rye grasses *(Lolium spp).* *Cynosurus cristatus* Tall Fescue *(Festuca arundinacea)*	no	priority spp not main hosts in CPC
Rice gall dwarf virus	Virus	Rye grasses *(Lolium spp).*	no	priority spp not hosts in CPC
Rye grassalphacryptovirus	Virus	Rye grasses*(Lolium spp).*	no	little information
Sugarcane mosaic virus	Virus	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC
Wheat streak mosaic virus	Virus	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC
Aceria tosichella	Acari	Rye grasses *(Lolium spp).* Fescues *(Festuca spp.)*	no	hitchiker sp.; priority pasture species are not main hosts
Agriotes lineatus	Coleoptera	*grasses*	no	
Agriotes obscurus	Coleoptera	*grasses*	yes	
Agriotes sputator	Coleoptera	*most priority species*	yes	little information,
Chaetocnema pulicaria	Coleoptera	Cocksfoot *(Dactylis glomerata)*	no	priority spp not main hosts in CPC
Exomala orientalis	Coleoptera	Bent grasses *(Agrostis spp.)* Tall Fescue *(Festuca arundinacea)*	no	priority spp not main hosts in CPC, invasive in the USA
Gonioctena fornicata	Coleoptera	Lucerne *(Medicago sativa)*	yes	
Hypera brunneipennis	Coleoptera	Lucerne *(Medicago sativa)*	yes	
Hypera postica	Coleoptera	*Plantago lanceolata* Lucerne *(Medicago sativa)*	yes	
Hypera zoilus	Coleoptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)*	yes	

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Limonius californicus	Coleoptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)*	yes	
Naupactus xanthographus	Coleoptera	Lucerne *(Medicago sativa)*	yes	
Oulema melanopus	Coleoptera	Timothy *(Phleum pratense)* Tall Fescue *(Festuca arundinacea)*	yes	
Sitona cylindricollis	Coleoptera	Lucerne *(Medicago sativa)* White clover *(Trifolium repens)*	yes	
Sitona hispidulus	Coleoptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)*	yes	
Popillia japonica	Coleoptera	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC
Sitona humeralis	Coleoptera	Lucerne *(Medicago sativa)*	no	in NZ
Sitophilus linearis	Coleoptera	Rye grasses *(Lolium spp).*	no	little information
Sphenophorus venatus confluens	Coleoptera	*Dactylus glomerata*	yes	pest of seed crops
Tanymecus palliatus	Coleoptera	Chicory *(Cichorium intybus)*	yes	
Agromyza frontella	Fly	Lucerne *(Medicago sativa)*	yes	
Chromatomyia fuscula	Fly	*Dactylus glomerata* Timothy *(Phleum pratense)*	yes	
Contarinia medicaginis	Fly	Lucerne *(Medicago sativa)*	no	priority species is main hosts; little information
Dasineura ignorata	Fly	Lucerne *(Medicago sativa)*	no	little information
Liriomyza sativae	Fly	Lucerne *(Medicago sativa)*	yes	
Liriomyza trifoliearum	Fly	Lucerne *(Medicago sativa)*	yes	
Liriomyza trifolii	Fly	Lucerne *(Medicago sativa)* White clover *(Trifolium repens)*	yes	
Napomyza cichorii	Fly	Chicory *(Cichorium intybus)*	Yes	little information
Napomyza lateralis	Fly	Chicory *(Cichorium intybus)*	yes	
Ophiomyia pinguis	Fly	Chicory *(Cichorium intybus)*	yes	
Oscinella frit	Fly	Fescues *(Festuca spp.)* *L. multiflorum* Timothy *(Phleum pratense)*	yes	main impacts on oats
Tipula paludosa	Fly	Lucerne *(Medicago sativa)* *grasses*	yes	
Adelphocoris lineolatus	Hemiptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)*	yes	
Cicadulina bipunctata	Hemiptera	*Dactylus glomerata*	no	uncertain impacts
Collaria scenica	Hemiptera	*Dactylus glomerata*	no	little information
Dysaphis plantaginea	Hemiptera	*Plantago lanceolata*	no	secondary host

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Dysmicoccus brevipes	Hemiptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)*	no	uncertain impact
Empoasca fabae	Hemiptera	Lucerne *(Medicago sativa)*	yes	
Eurygaster integriceps	Hemiptera	Rye grasses *(Lolium spp).* Fescues *(Festuca spp.)*	no	hitchiker sp
Leptopterna dolobrata	Hemiptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	no	little information (in Russian)
Leptopterna laevigatum	Hemiptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	no	little information (in Russian)
Lygus lineolaris	Hemiptera	Lucerne *(Medicago sativa)*	yes	
Lygus pratensis	Hemiptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	no	little information (in Russian)
Lygus rubescens	Hemiptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	no	little information (in Russian)
Macrosteles quadrilineatus	Hemiptera	Lucerne *(Medicago sativa)*	no	main impact appears to as vector of diseases of cut flowers
Piezodorus guildinii	Hemiptera	Lucerne *(Medicago sativa)*	no	possibly only impacts on soybean
Piezodorus hybneri	Hemiptera	Lucerne *(Medicago sativa)*	yes	
Sitobion avenae	Aphid	Cocksfoot *(Dactylis glomerata)*	yes	
Sitobion avenae	Aphid	Cocksfoot *(Dactylis glomerata)*	no	Grasses are wild hosts impacts uncertain
Sitobion papillatum	Aphid	Rye grasses *(Lolium spp).*	no	little information
Trigonotylus ruficornis	Hemiptera	Tall Fescue *(Festuca arundinacea)*	no	little information
Pachynematus clitellatus	Hymenoptera	*Dactylus glomerata* Timothy *(Phleum pratense)* Tall Fescue *(Festuca arundinacea)*	yes	little information, uncertain impacts
Solenopsis geminata	Hymenoptera	Tall Fescue *(Festuca arundinacea)*	yes	
Agrotis exclamationis	Lepidoptera	Lucerne *(Medicago sativa)*	no	uncertain impact
Agrotis segetum	Lepidoptera	Lucerne *(Medicago sativa)*	yes	
Autographa gamma	Lepidoptera	Lucerne *(Medicago sativa)* Chicory *(Cichorium intybus)* Red clover *(Trifolium pratense)*	yes	
Chrysoteuchia culmella	Lepidoptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	yes	little information but possible emerging pest
Chrysoteuchia topiaria	Lepidoptera	*grasses*	yes	
Epichoristodes acerbella	Lepidoptera	Lucerne *(Medicago sativa)*	yes	

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Glyphipterix simpliciella	Lepidoptera	Tall Fescue *(Festuca arundinacea)* Cocksfoot *(Dactylis glomerata)*	yes	
Helicoverpa punctigera	Lepidoptera	Lucerne *(Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)* Subterranean clover *(T. subterraneum)*	Yes	
Hydraecia micacea	Lepidoptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	yes	priority pasture species are not main hosts but rapid spread
Junonia coenia	Lepidoptera	*Plantago lanceolata*	yes	
Melitaea cinxia	Lepidoptera	*Plantago lanceolata*	no	no apparent impact
Oligia strigilis	Lepidoptera	*Dactylus glomerata* Timothy *(Phleum pratense)*	no	little information (in Rumanian)
Oligia strigilis	Lepidoptera	Cocksfoot *(Dactylis glomerata)*	no	little information (in Romanian) but possible emerging pest
Papaipema nebris	Lepidoptera	*Dactylus glomerata* Tall Fescue *(Festuca arundinacea)*	yes	little information, uncertain impact
Parnara guttatus	Lepidoptera	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC
Peridroma saucia	Lepidoptera	Rye grasses *(Lolium spp).*	no	little information
Platynota stultana	Lepidoptera	Lucerne *(Medicago sativa)*	no	uncertain impact
Spilosoma congrua	Lepidoptera	*Plantago lanceolata*	no	generalist feeder on Plantago, but not a pest
Spodoptera frugiperda	Lepidoptera	Lucerne *(Medicago sativa)* Clovers *(Trifolium spp.)*	yes	
Spodoptera littoralis	Lepidoptera	Lucerne *(Medicago sativa)*	yes	
Arion hortensis	Mollusc	White clover *(Trifolium repens)*	no	present in NZ
Anguina funesta	Nematode	Rye grasses *(Lolium spp).*	no	L.rigidum is main host
Anguina tritici	Nematode	Rye grasses *(Lolium spp).*	no	priority spp not main hosts in CPC
Belonolaimus longicaudatus	Nematode	Tall Fescue *(Festuca arundinacea)*	no	priority spp not main hosts in CPC
Meloidogyne arenaria	Nematode	Lucerne *(Medicago sativa)* White clover *(Trifolium repens)*	yes	
Meloidogyne chitwoodi	Nematode	Lucerne *(Medicago sativa)*	yes	main impact appears to be on potatoes
Meloidogyne graminicola	Nematode	Clovers *(Trifolium spp.).*	yes	
Meloidogyne naasi	Nematode	Rye grasses *(Lolium spp).* Fescues *(Festuca spp.)*	no	little information, uncertain impact
Tylenchorhynchus acutus	Nematode	Lucerne *(Medicago sativa)*	yes	

Pest name	Pest type	Priority pasture species assocations	assessed further	comment
Tylenchorhynchus claytoni	Nematode	Rye grasses *(Lolium spp).* Lucerne *(Medicago sativa)*	yes	
Xiphinema americanum	Nematode	Lucerne *(Medicago sativa)* Chicory *(Cichorium intybus)* White clover *(Trifolium repens)*	no	not reported as present in NZ in CPC, but it is a species complex and several specimens have been reported from NZ (Sturham et al. 2010)
Dichroplus elongatus	Orthoptera	Lucerne *(Medicago sativa)* Clovers *(Trifolium spp.).*	yes	
Melanoplus bivittatus	Orthoptera	Lucerne *(Medicago sativa)* Chicory *(Cichorium intybus)* White clover *(Trifolium repens)*	yes	
Frankliniella intonsa	Thysanoptera	Lucerne *(Medicago sativa)*	no	Uncertain impact. Recent arrival in NZ Teulon & Nielson
Stenchaetothrips biformis	Thysanoptera	Fescues *(Festuca spp.)*	no	priority spp not main hosts in CPC
Thrips angusticeps	Thysanoptera	Lucerne *(Medicago sativa)*	yes	uncertain impact
Thrips flavus	Thysanoptera	Lucerne *(Medicago sativa)*	yes	

8.3 Appendix 2.2: Additional potential hazards identified by expert peer-review within MPI

The pests in the table below were identified as additional potential hazards, in the expert peer-review within MPI. A different methodology was used to identify these pests.

Pest name	Pest type	Priority pasture species assocations	Comment	Reference
Cernuella virgata (Mediterranean snail; common white snail)	Snail	*Medicago sativa*, (lucerne), *Trifolium* spp. (clover)	An invasive species and agricultural pest in parts of Australia. Cause severe damage and occasionally total destruction on seedling crops such as wheat, barley oil seeds, seed carrots and legume-based pastures. Lifestock refuse to feed on pasture and hay that are heavily contaminated by slime trails. Also implicated in protostrongylid transmission affecting livestock.	MPI Biosecurity http://www.biosecurity.govt.nz/pests/mediterranean-snail http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg_temp_terr_gastro.pdf
Theba pisana (White garden snail)	Snail	*Lolium perenne* (perennial ryegrass), *Festuca arundinacea* (tall fescue), *Dactylis glomerata* (Cocksfoot), *Trifolium subterraneum* (subterranean clover), *Medicago sativa* (lucerne)	An invasive species and agricultural pest in parts of Australia. Cause severe damage and occasionally total destruction on seedling crops such as wheat, barley oil seeds, seed carrots and legume-based pastures. Lifestock refuse to feed on pasture and hay that are heavily contaminated by slime trails. Also a pasture pest in South Africa. Also a pest of grape.	http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg_temp_terr_gastro.pdf Invasive Species Compendium http://www.cabi.org
Penthaleus spp. (*P. falcutus, P. tectus;* excluding *P. major* as it is already in NZ) (Blue oat mites)	Mite	*P. falcatus* occasionally attacks pasture; rarely attacks lucerne. *P. tectus* commonly attacks pasture, occasionally attacks lucerne.	Major agricultural pests in southern Australia, and other parts of world, attaching various pasture, vegetable and crops plants, including cereals.	http://www.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects/blue-oat-mite McQuillan *et al.* (2007) Tasmanian Pasture and Forage Pests: Identification, biology and control
Balaustium medicagoense	Mite	*Medicago sativa* (lucerne); Grasses (species not specified, but likely to include pasture grasses)	An emerging pest of winter crops and pasture in Australia. Reported to cause considerable damage to canola, lupins and lucerne. But they have a preference for grasses, cereals and weeds, particularly barley, wheat, oats, barley grass and capeweed. Even in pastures, they tend to prefer grasses and weeds over clovers and *Medicago* spp.	http://www.dpi.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects/ag1413-balaustium-mite Bailey (Ed) (2007) Pests of Field Crops and Pastures: Identification and Control

Pest name	Pest type	Priority pasture species assocations	Comment	Reference
Amnemus quadrituberculatus	Beetle	*Trifolium* spp. (clover)	Australian native. Moderate pest. Attack *trifolium* roots	Bailey (Ed) (2007) Pests of Field Crops and Pastures: Identification and Control
Amnemus superciliaris	Beetle	*Trifolium repens* (white clover)	Australian native. Larvae attack roots. Pest status unknown. Very little information available	Davis 1966 Australian Journal of Entomology Vol 5, Issue 1.
*Sitona lineatus (*pea leaf weevil)	Beetle	*Trifolium* spp. (clover) and *Medicago sativa* (lucerne)	Polyphagus larvae and adults.	Crop Protection Compendium (*S. lineatus*)
Helicoverpa zea (corn earworm)	Lepidoptera	*Medicago sativa* (lucerne)	A pest of lucerne in the USA (Pearson *et al* 1989)	Pearson, A. C. *et al.* (1989) Population dynamics of *Heliothis virescens* and *H. zea* (Lepidoptera: Noctuidae) in the Imperial Valley of California. *Environmental Entomology*; 1989. 18: 6, 970-979
Ocopera intricata (Tasmanian grassgrub) and *Ocopera rufobrunnea*	Lepidoptera	*Trifolium* spp. (clover), *Lolium* spp. Perennial grasses	*O. intricata*: Major pest in Tasmania, widespread in pastures (Bailey 2007) *O. rufobrunnea*: Major pest in southern NSW and wetter parts of Tasmania, widespread in pastures (Bailey 2007)	Bailey (Ed) (2007) Pests of Field Crops and Pastures: Identification and Control McQuillan *et al.* (2007) Tasmanian Pasture and Forage Pests: Identification, biology and control OGTR (2004) http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/clover-3/$FILE/biologywclover2.pdf OGTR (2008) http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/ryegrass-3/$FILE/biologyryegrass08.pdf
Psuedaletia unipuncta	Lepidoptera	*Trifolium* spp. (clover),	Has a wide global distribution; host plants include *Trifolium*; causes extensive damage to fescue/*Lolium* pastures by gregarious defoliation in the US (https://www.soils.org/publications/cs/articles/51/1/370); severe defoliation on pastures composed dominantly of *Phalaris arundinacea*, *Lolium perenne* and *Dactylis glomerata* (Peters *et al*.)	Peters et *al*.: http://cropandsoil.oregonstate.edu/seed-ext/Pub/2006/22.pdf

Pest name	Pest type	Priority pasture species assocations	Comment	Reference
Pseudaletia convecta	Lepidoptera	*Lolium* spp. (ryegrass)	In Australia. A common pest of turfgrass in Australia.	OGTR (2008) http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/content/ryegrass-3/$FILE/biologyryegrass08.pdf
Tilletia walkeri (Ryegrass bunt)	Fungus	*Loliom multiflorum* (annual ryegrass), *Lolium perenne (*perennial ryegrass),	Very similar to *Tilletia indica* (which causes karnal bunt of wheat). Previously thought to be in NZ, but NZ status disputed.	Castlebury & Carris (1999) Mycologia 91: 121-131

8.4 Appendix 2.3: Additional potential hazards identified by expert peer-reviewers from AgResearch

The pests in the table below were identified as additional potential hazards, in the expert peer-review by AgResearch scientists. A different methodology was used to identify these pests. The information in the last three columns was contributed by MPI.

Pest name	Pest type	Priority pasture species assocations	Comment	Reference
Sericesthis spp.	Beetles (Scarabaeidae family)	*Lolium perenne* (Perennial ryegrass)	Occurs in Australia. Known to cause pasture damage by root feeding. Very little information available about impacts in pasture environment. Records of severe damage to lawns and golf links.	http://bie.ala.org.au/species/Sericesthis Carne & Chinnick (1957) The Pruinose scarab (Sericesthis pruinose Dalman) and its control in turf. *Australian Journal of Agricultural Research* 8: 604-616. Ridsdill Smith & Roberts (1976) *Journal of Applied Ecology* 13: 423-?
Rhopea spp.	Beetles (Scarabaeidae family)	? No evidence was found of association with NZ priority pasture species.	Occurs in Australia. Information about this genus as a pasture pest relate to larvae of *Rhopea magnicornis* causing damage to the pasture grass Kikuyu (*Pennisetum clandestinum*) in Australia.	http://www.fao.org/ag/agp/AGPC/doc/Gbase/DATA/Pf000298.HTM
Phyllophaga spp. (White grubs)	Beetles (Scarabaeidae family)	*Festuca arundinacea* (Tall fescue) *Dactylis glomerata* (Cocksfoot) *Trifolium* spp. (Clover) *Lolium perenne* (Perennial ryegrass) *Phleum pratense* (Timothy)	A very large genus (>260 species). Many white grubs are important pests in turf and pastures in temperate areas in North America. Larvae feed on roots. Pasture species affected include bluegrass, but very little information could be found about *Phyllophaga* species affecting the priority pasture species. In Southeastern USA there are at least 91 species.	http://www.cabdirect.org/abstracts/19400701024.html?freeview=true http://www.cabdirect.org/abstracts/19911155880.html?freeview=true Kard & Hain (1988) Influence of grown covers on white grub (Coleoptera: Scarabaeidae) populations and their feeding damage to roots of Fraser fir Christmas trees in the southern Appalachians. Environmental Entomotolgy 17:63-66.
Phyllopertha horticola	Beetles (Scarabaeidae family)	*Lolium perenne* (Perennial ryegrass)	An example of a “white grub” which is an important pest in turf and pastures in temperate	http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=2606280

(garden chafer)		*Trifolium* spp. (Clover) *Agrostis* spp. (Browntop) *Festuca* spp. (Tall Fescue)	areas in the UK. Also a pest of forest trees.	http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=2581140 Malinowski, H.; (2006) Forest protection from root pests (part I) - Methods of assessment of threat to nurseries and forest plantations from insect pests of roots. [Polish] *Ochrona Roslin* 51: 11, 35-38
Hoplia philanthus (Welsh chafer)	Beetles (Scarabaeidae family)	Lolium perenne (Perennial ryegrass) *Agrostis tenuis* (Bentgrass)	Larvae are a serious pest of turfgrass. Evidence of impact in pastures is difficult to find, but there are a few older references.	Ansari, M. A. Casteels, H. Tirry, L. Moens, M. (2006). Biology of *Hoplia philanthus* (Col., Scarabaeidae, Melolonthinae): a new and severe pest in Belgian turf. *Environmental Entomology*; 35: 6, 1500-1507. http://rd.springer.com/chapter/10.1007/978-94-011-1490-5_33# http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7348.1944.tb06223.x/abstract
Sitona lineatus	Beetles (Curculionoidea superfamily) i.e. weevils	*Trifolium* spp. (Clover)	See Table 8.3	See Table 8.3
Apion spp. including *Apion fulvipes* (white clover seed weevil)	Beetles (Curculionoidea superfamily) i.e. weevils	*Trifolium* spp. (Clover) *Lolium perenne* (Perennial ryegrass)	*A. fulvipes* can cause severe reduction in white clover seed yield in Denmark.	http://www.bioforsk.no/ikbViewer/Content/48399/f_2_12_aamid.pdf#page=195
Hypera punctata (clover leaf weevil)	Beetles (Curculionoidea superfamily) i.e. weevils	*Trifolium* spp. (Clover) *Medicago sativa* (Lucerne) *Phleum pratense* (Timothy)	Larvae begin feeding on clover leaves early in the spring. Damage is most severe during late, cool, dry springs. Sporadic but potentially serious pest of lucerne. Occurs throughout most of the USA	http://entoweb.okstate.edu/ddd/insects/cloverleafweevil.htm Madsen, R. A. Hunt, T. E. Higley, L. G. (2004) Simulated clover leaf weevil injury and alfalfa yield and quality. *Agronomy Journal*; 96: 1, 224-228. http://ipm.illinois.edu/fieldcrops/insects/clover_leaf_weevil.pdf
Ischnopterapion	Beetles	*Trifolium* spp. (Clover)	*Ischnopterapion virens* is a pest of clover in the	Byers, R.A., Sanderson, M.A. Damage to

virens	(Curculionoidea superfamily) i.e. weevils		USA. Surveys in 1997-1999 showed it is present in seven states. In Pennsylvania pastures an average of 70% to 80% of the primary stolons (horizontal above-ground shoot) of white clover had feeding tunnels caused by *I. virens*.	white clover stolons caused by larvae of *Ischnopterapion virens* (herbst), a new pest of clovers in the northeast. *Northeast Regional Field Crops Insect Conference Proceedings*. 2000. p. 4-5.
Sphenophorus parvulus (bluegrass billbug)	Beetles (Curculionoidea superfamily) i.e. weevils	*Lolium perenne* (Perennial ryegrass)	*S. parvulus* is widely distributed in USA and is a known turf grass pest, attacking *Lolium perenne* among other grass hosts. *L. perenne* resistance to *S. parvulus* is associated with presence of a fungal endophyte.	http://onlinelibrary.wiley.com/doi/10.1111/j.1570-7458.1986.tb02164.x/abstract
Phaulacridium vittatum (wingless grasshopper)	Grasshopper	*Trifolium* spp. (Clover) *Medicago sativa* (Lucerne)	The economic damage of moderately high populations of wingless grasshoppers to dryland pastures is probably no greater than the effect of one sheep grazing per hectare. The wingless grasshopper is native to Australia, occurs in southern Australia (south Queensland, New South Wales, Victoria, Tasmania and southern Western Australia). Damage is caused during midsummer and autumn by adult grasshopper feeding on green summer-growing crops. Lucerne stands can be stripped, and as a consequence hay and seed production and grazing are reduced. Other susceptible plants are sunflowers, sweetcorn, potatoes, and similar summer-growing crops, new pine plantations. The insect can damage commercial vegetable plantings and household gardens, and can defoliate fruit trees and ornamentals.	http://www.sardi.sa.gov.au/__data/assets/pdf_file/0005/44951/grashopp.pdf
Heterodera spp. (cereal cyst nematodes) (e.g. *H. bifenestra, H. mani, H. pratensis, H. zeae*)	*Nematode*	*Lolium perenne* (Perennial ryegrass)	Plant parasitic nematodes. *H. bifenestra*, *H. mani*, and *H. pratensis* all belong to the *H. avenae* complex (or *H. avanae* group). NOTE: *H. avanae* is recorded as being present in New Zealand (PPIN 2013); further analysis will be required to determine which members of the *H. avanae* complex are present/absent from New Zealand.	http://naldc.nal.usda.gov/download/7674/PDF http://www.fao.org/docrep/006/y4011e/y4011e0p.htm http://www.russjnematology.com/subbotin/Reprint/Hpratensis.pdf PPIN (2013) Plant Pest Information Network. Ministry for Primary Industries

			H. zeae: a maize pest. No evidence was found that it is associated with the priority pasture species.	Database.
Meloidogyne spp. (root knot nematodes) *(e.g. M. marylandi, M. microtyla, M. minor*)	*Nematode*	*Lolium perenne* (Perennial ryegrass) *Festuca arundinacea* (Tall fescue) *Trifolium* spp (Clover)	Plant parasitic nematodes. Larvae infect plant roots, causing development of root-knot galls. Infection of mature plants cause decreased yield. *M. microtyla* infects *Lolium perenne* (perennial ryegrass). Endophytes in Tall fescue appear to provide some protection against nematode damage by *M. marylandi*. The species *M. minor* was newly described in 2004, it occurs in UK, Ireland, the Netherlands, Belgium. Natural hosts include *Trifolium* spp. (clover), *Phleum pratense* (Timothy), *Festuca* spp. (tall fescue) and potato. Experimental hosts include *Lolium* spp. (ryegrass). Most likely mode of international spread of *M. mino*r is via golf shoes & clubs.	http://www.apsnet.org/publications/PlantDisease/BackIssues/Documents/1986Abstracts/PD_70_438.htm http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2494.2000.00210.x/abstract http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_nematodes/08-14648%20PRA%20%20MELGMI.pdf http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-91-7-0908B

8.5 Appendix 3: Summary of the hazard identification process for the New Zealand pastoral sector

This appendix summarises the results of the hazard idenfication assessments (section 6). The methods used are described in section 2.4.

Hazard	**Organsim Type**	**Priority pasture species affected**	**Establishment potential**	**Impact potential**	**Hazard group**
Solenopsis geminata	Ant	Tall Fescue *(Festuca arundinacea)*	low	low	Low
Agriotes obscurus	Beetle	Poaceae			not a hazard*
Agriotes sputator	Beetle	*Cynosurus cristatus* Timothy *(Phleum pratense)* *Plantago lanceolata* Rye grass *(Lolium perenne).* Red clover *(Trifolium pratense)*	high	high	High
Gonioctena fornicata	Beetle	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)*	mod	mod	High
Hypera brunneipennis	Beetle	Lucerne (*Medicago sativa)*	mod	low	Low
Hypera postica	Beetle	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)* *Plantago lanceolata*	high	high	High
Hypera zoilus	Beetle	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)* Timothy *(Phleum pratense)*	high	mod	High
Limonius californicus	Beetle	Lucerne (*Medicago sativa)* Red clover (*Trifolium pratense)*	mod	mod	High
Naupactus xanthographus	Beetle	Lucerne (*Medicago sativa)*	mod	low	Low
Oulema melanopus	Beetle	Tall Fescue *(Festuca arundinacea)* Timothy *(Phleum pratense)*	high	mod	High

Hazard	Organsim Type	Priority pasture species affected	Establishment potential	Impact potential	Hazard group
Sitona cylindricollis	Beetle	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)*	high	mod	High
Sitona hispidulus	Beetle	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)*	high	high	High
Sphenophorus venatus confluens	Beetle	Cocksfoot *(Dactylis glomerata)*	high	high	High
Tanymecus palliatus	Beetle	Chicory *(Cichorium intybus)* Clovers (*Trifolium spp.)*			not a hazard*
Agromyza frontella	Fly	Lucerne *(Medicago sativa)*	high	low	Low
Chromatomyia fuscula	Fly	Cocksfoot *(Dactylis glomerata)* Timothy *(Phleum pratense)*	high	low	Low
Liriomyza sativae	Fly	Lucerne (*Medicago sativa)*	low	low	Low
Liriomyza trifoliearum	Fly	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)*			not a hazard*
Liriomyza trifolii	Fly	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)*	low	low	Low
Napomyza cichorii	Fly	Chicory *(Cichorium intybus)*	high	low	Low
Napomyza lateralis	Fly	None			not a hazard*
Ophiomyia pinguis	Fly	Chicory *(Cichorium intybus)*	high	low	Low
Oscinella frit	Fly	*Lolium multiflorum* Timothy *(Phleum pratense)* Cocksfoot *(Dactylis glomerata)*	high	mod	High
Tipula paludosa	Fly	Lucerne (*Medicago sativa)* Rye grass*(Lolium perenne)* White clover *(Trifolium repens)*	high	high	High
Dichroplus elongatus	Grasshopper	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.)* *Grass species* *Plantago lanceolata*	high	mod	High

Hazard	Organsim Type	Priority pasture species affected	Establishment potential	Impact potential	Hazard group
Melanoplus bivittatus	Grasshopper	Lucerne (*Medicago sativa)* Red clover *(Trifolium pratense)* Chicory *(Cichorium intybus)*	high	high	High
Agrotis segetum	Moth	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.).*	high	moderate	High
Autographa gamma	Moth	Lucerne (*Medicago sativa)* Red clover *(Trifolium pratense)* Chicory *(Cichorium intybus)*	moderate	high	high
Chrysoteuchia culmella	Moth	Cocksfoot *(Dactylis glomerata)* Timothy *(Phleum pratense)*	high	mod	High
Chrysoteuchia topiaria	Moth	Fescues (*Festuca spp.)* Bent grasses *(Agrostis spp.)*	high	mod	High
Epichoristodes acerbella	Moth	Lucerne (*Medicago sativa)*			not a hazard*
Glyphipterix simpliciella	Moth	Bent grasses *(Agrostis spp.)*	high	low	Low
Helicoverpa punctigera	Moth	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)* Subterranean clover (*Trifolium subterraneum)*	high	moderate	High
Hydraecia micacea	Moth	Cocksfoot (*Dactylis glomerata)* Timothy *(Phleum pratense)*	high	low	Low
Junonia coenia	Butterfly	*Plantago lanceolata*			not a hazard*
Papaipema nebris	Moth	Tall Fescue *(Festuca arundinacea)* Cocksfoot (*Dactylis glomerata)* Lucerne (*Medicago sativa)*	high	moderate	High
Spodoptera frugiperda	Moth	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)*	low	low	Low

Hazard	Organsim Type	Priority pasture species affected	Establishment potential	Impact potential	Hazard group
		Timothy *(Phleum pratense)*			
Spodoptera littoralis	Moth	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* *Poaceae*	negligible		not a hazard
Adelphocoris lineolatus	Plant bug	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)*	high	high	High
Empoasca fabae	Plant bug	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.)*	moderate	high	High
Lygus lineolaris	Plant bug	Lucerne (*Medicago sativa)*	high	mod	High
Piezodorus hybneri	Plant bug	Lucerne (*Medicago sativa)*	low	low	Low
Sitobion avenae	Plant bug	Cocksfoot (*Dactylis glomerata)*	high	low	Low
Thrips angusticeps	Thrips	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.)*	high	low	Low
Thrips flavus	Thrips	Lucerne (*Medicago sativa)*	high	low	Low
Pachynematus clitellatus	Wasp	*Festuca arundinacea* Timothy *(Phleum pratense)* Cocksfoot (*Dactylis glomerata)* Rye grass*(Lolium perenne)*			not a hazard*
Xanthomonas axonopodis pv. *alfalfae*	Bacteria	Lucerne (*Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)*	low	low	Low
Alternaria cichorii	Fungus	Chicory *(Cichorium intybus)*	moderate	low	Low
Didymella festucae	Fungus	*Festuca arundinacea* Timothy *(Phleum pratense)*	low	low	Low
Drechslera catenaria	Fungus	Bent grasses (*Agrostis tenuis)* Cocksfoot (*Dactylis glomerata)* Timothy *(Phleum pratense)* *Festuca spp.*	high	moderate	High

Hazard	Organsim Type	Priority pasture species affected	Establishment potential	Impact potential	Hazard group
		Rye grasses*(Lolium spp.)*			
Epichloë typhina	Fungus	Bent grasses (*Agrostis tenuis)* Cocksfoot (*Dactylis glomerata)* Timothy *(Phleum pratense)* *Festuca spp.* Rye grass*(Lolium perenne)*	high	low	Low
Erysiphe pisi var. *pisi*	Fungus	Lucerne (*Medicago sativa)* Clovers (*Trifolium spp.)*	high	low	Low
Phymatotrichopsis omnivora	Fungus	Lucerne (*Medicago sativa)* Red clover *(Trifolium pratense)* White clover *(Trifolium repens)*	low	low	Low
Tilletia controversa	Fungus	Cocksfoot (*Dactylis glomerata)* Rye grasses *(Lolium spp.)*	low	low	Low
Urocystis occulta	Fungus	Rye grass*(Lolium perenne)*			not a hazard*
Ustilago lolii	Fungus	Rye grasses *(Lolium spp.)*	moderate	low	Low
Meloidogyne arenaria	Nematode	Lucerne (*Medicago sativa)* White clover *(Trifolium repens)* Red clover *(Trifolium pratense)* Annual (Italian) rye grass *Lolium multiflorum* Tall Fescue (*Festuca arundinacea)*	high	low	Low
Meloidogyne chitwoodi	Nematode	Lucerne (*Medicago sativa)*	high	moderate	High
Meloidogyne graminicola	Nematode	Clovers (*Trifolium spp.)* grasses	low	low	Low
Tylenchorhynchus acutus	Nematode	Lucerne (*Medicago sativa)*	low	low	Low
Tylenchorhynchus claytoni	Nematode	Lucerne (*Medicago sativa)* Rye grasses *(Lolium spp.)* Clovers (*Trifolium*	mod	mod	Low

Hazard	Organsim Type	Priority pasture species affected	Establishment potential	Impact potential	Hazard group
		spp.) Tall Fescue (*Festuca arundinacea)*			
Aster yellows phytoplasma group	Phytoplasma	White clover *(Trifolium repens)*	low	low	Low
Beet necrotic yellow vein virus	Virus	Chicory *(Cichorium intybus)*			not a hazard*
Chicory yellow mottle virus	Virus	Chicory *(Cichorium intybus)*			not a hazard*

* organism not considered a hazard because of lack of evidence of any adverse impacts on any priority pasture species.

8.6 Appendix 4: New Zealand climate

New Zealand is situated in the South Pacific and ranges from 34˚ 00’ S and 166˚ 00’ E to 48˚ 00’ S and 179˚ 00’E. It has a maritime climate which varies from warm subtropical in the far north to cool temperate in the far south, with severe alpine conditions in the mountainous areas. Mountain chains extending the length of New Zealand’s South Island provide a barrier for the prevailing westerly winds, dividing the country into two separate climatic regions. The West Coast of the South Island is the wettest and the area to the east of the mountains, just over 100 km away, is the driest (NIWA 2007).

Annual rainfall in most parts of the country is between 600 and 1600 mm, with a dry period during the summer. At four locations on the west coast of the South Island (Westport, Hokitika, Mt Cook and Milford Sound) mean annual rainfall was between 2200 mm and 6800 mm for the period 1971-2000 (NIWA 2007). Rainfall is higher in winter than summer in the northern and central areas of New Zealand, whereas for much of southern New Zealand rainfall is lowest in winter. Mean annual temperatures range from 10°C in the south to 16°C in the north. The coldest month is usually July, and the warmest month usually January or February. Inland and to the east of the ranges the variation between summer and winter temperatures is up to 14°C. Temperatures also drop about 0.7°C for every 100 m of altitude (NIWA 2007).

Sunshine hours are relatively high in places sheltered from the west and most of New Zealand would have at least 2000 hours annually. Most snow falls in the mountain areas. Snow rarely falls at the coast of the North Island and west of the South Island, although the east and south coasts of the South Island may experience some snow in winter. Frosts can occur anywhere, and usually form on cold nights with clear skies and little wind (NIWA 2007).

Source: MPI

8.7 Appendix 5: Scope of external peer-review

Given the scope, objectives and limitations of the hazard identification report, the expert peer-reviewer(s) is/are asked to conduct their review with a focus on the following aspects of the report:

1. Methodology:
   - Do you consider that the methodology of the hazard identification is appropriate, in particularly for Steps 1 and 2? (refer to Section 2.3 of the report).
   - With regard to Step 1, do you consider that the sources of information were appropriate?
   - Do you consider that the methodology used to assess the potential to establish and spread in New Zealand was appropriate? (refer to Section 2.4.1).
   - Do you consider that the methodology used to assess the potential impact to pastoral sector in New Zealand was appropriate? (refer to Section 2.4.2).
   - Do you consider that the methodology used to classify hazards into 'high' or 'low' hazard categories was appropriate? (refer to Section 2.6).

2. Critical information:
   - Are you aware of any pests <u>absent</u> from the 'long-list' that are more serious than the pests that are on the 'long-list' (see Appendix 2)?
   - For any of the pest hazard assessments in Section 6, are you aware of any critical information that is missing, that would alter the hazard rating for 'Potential to establish and spread in NZ', or 'Potential Impact in NZ'?

3. Hazard ratings:
   - Given the information provided about each hazard organism in Section 6, and the hazard rating criteria defined in Section 2.4.1 and 2.4.2, do the hazard-rating criteria appear to have been applied consistently?

4. Limitations:
   - Do you agree with the limitations documented in Section 2.8.
   - Do you consider that there are any additional limitations of the hazard identification that should be added to Section 2.8?

5. Do you consider that there are any critical issues of logic and clarity that need to be addressed to enable a technical audience to understand the meaning of any part of the text in the hazard assessments (Section 6)? *Note: the scope of the peer-review excludes scrutiny of sentence structure, grammar and punctuation).*

6. Please provide responses to the few comments/queries that have been inserted into the document.