Slowing Pest Spread

Domestic Pathways of Human Mediated Pest Spread and Opportunities for their Management

MAF Biosecurity New Zealand Technical Paper No: 2010/22

Prepared for MAF Biosecurity New Zealand, Post Border Directorate
by Biodiverse Limited (includes edits by MAF Biosecurity
New Zealand following stakeholder consultation)

ISBN 978-0-478-37505-3 (online)
ISSN 1179-5840 (online)

October 2010

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

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Executive Overview

Our modern society is highly mobile, at both global and local scales. New biological invasions continue to occur at an accelerating rate in many places, a powerful driver of change in both natural and productive ecosystems.

Movements of people and goods from overseas are managed as a first line of defence. While this slows the rate of invasions, new species continue to arrive. Given the right conditions these new species may become naturalised, and spread.

The ways in which people facilitate the naturalisation and spread of pests within New Zealand is the focus of this paper. Of the multitude of exotic species already here, most are not naturalised. Meanwhile many which are naturalised have barely begun to spread into all their potential range.

We can therefore expect significant change in New Zealand's pest profile in the foreseeable future, most of which will be driven by species which are already here. Human actions which accelerate this process of pest spread are a form of bio-pollution.

As New Zealanders go about their affairs every day, the combinations of ways in which organisms can be moved to different places are practically endless. Within this complexity we can nonetheless classify dominant pathways, aligned to the various categories of human activity which bring those pathways into being.

Having selected and classified the known pathways of pest spread, we consider their relative risk. While we recognise that we are on an undesirable trajectory of increasing pest impacts, forecasting the contribution of known pathways to this reality with any precision is a challenge. While delivering a robust risk assessment is beyond the scope of this document, we do identify a number of high risk pathways based on consensus opinion and literature sources. It is encouraging that a high level of agreement appears to exist regarding high risk pathways.

Pathway management recognises the pre-eminence of prevention. It seeks to slow the rate at which organisms are delivered to new places, and therefore precedes all other pest management options, including surveillance. Preventative action is cost effective in principle.

Domestic pathway management must differ from that of international pathways. Firstly, the number of international ports of origin and arrival are limited, which is not true for domestic movements. The limited number of international ports of origin and arrival provide convenient "bottlenecks" where strong, coercive regulatory intervention can be applied. Secondly, comprehensive risk assessments in the form of import health standards are in place for international movements of goods and people. Their domestic equivalents in contrast, are rare.

Non-regulatory management tools are therefore an important component of domestic pathway management.

We conclude that a range of opportunities exist to slow pest spread. Strategies which inform participants of the potential consequences of their actions, and arm them with practical means for reducing that risk, are likely to be particularly beneficial.

Construction

This document relies heavily upon the contributions of expert interviewees across a range of sectors. The authors have synthesised their views in good faith and trust that their interpretation fairly reflects the intent of the contributors. While some statements are specifically referenced in this document, those which are not can be taken to reflect the collective view.

Further, reliance is placed in a number of case studies selected to reflect the breadth and scope of known pathways and their current management. Readers may prefer to begin by familiarising themselves with these practical examples (Part 5) before engaging with the more technical aspects addressed in Parts 1–4.

1 Domestic Pathways of Pest Spread

1.1 PURPOSE

The Biosecurity Strategy 2003 identifies that a more proactive approach is needed in assessing emerging threats, including identification and management of pathways to prevent the entry establishment and spread of potential pests. Specifically, there is an expectation in relation to domestic pest management that there are transparent and effective performance measures to monitor and forecast the establishment of pests via pathways[1].

The purpose of this technical paper is to examine what achieving that expectation might entail in relation to human mediated pathways of pest spread. As such this document reflects the current state of the pest spread issue, and forms a basis for discussion. Specifically we address the issue in terms of the following questions:

1. What are the domestic pathways of pest spread?
2. Which of those are likely to pose highest risk?
3. What tools are available to reduce pest spread via those pathways?
4. What opportunities exist to guide the future direction of pathway management?[2]

The document is intended to assist a range of agencies and stakeholders with an interest or responsibility for managing biosecurity risk.

The scope of the document is limited to a consideration of human mediated pathways in terrestrial, freshwater and marine environments. Specifically excluded are:

- Natural modes of pest spread.
- Domestic air travel and transport.
- Separate consideration of high value sites or resources.

1.2 WHAT ARE DOMESTIC PATHWAYS OF PEST SPREAD?

The Future of Pest Management National Plan of Action has use the following definition of "Pest" – an organism that has characteristics that are regarded by people as injurious or unwanted. In the context of this review, pests include all harmful organisms including weeds, plant pathogenic fungi and viruses.

Whilst here are natural processes by which the spread of pest organisms is increased and also extreme events (e.g. large scale flooding) can accelerate the process, this document focuses on human facilitated spread. The meaning of a domestic pathway of pest spread we adopt is:

"Any human activity, intentional or not, which moves pest organisms from one place to another place, anywhere within New Zealand[3]."

All such pathways share some common elements:

1. People
2. Two or more places (source and receiving environment)
3. Potential pest organisms

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1 Page 61, point 55. *Tiakina Aotearoa – Protect New Zealand – The Biosecurity Strategy for New Zealand*. August 2003.
2 Note: this document does not set policy direction but rather offers a basis to guide that process.
3 New Zealand includes the marine environment to the 12 mile territorial limit.

4. Mode of transfer of the live pest organisms or of viable parts of live pest organisms (e.g. seeds, fruit, etc.)

1.3 PATHWAY MANAGEMENT AND THE INVASION PROCESS

Pathway management is any action which aims to limit the movement of pest organisms by people. In this sense, pathway management is a precautionary approach.

The advantage of a precautionary approach is clear when we consider the legacy of pest problems we face in New Zealand today. The costly consequences of freely moving pest organisms to new places are often not recognised before the fact[4].

Pathway management aligns with the initial three stages of the bio-invasion process (figure 1).

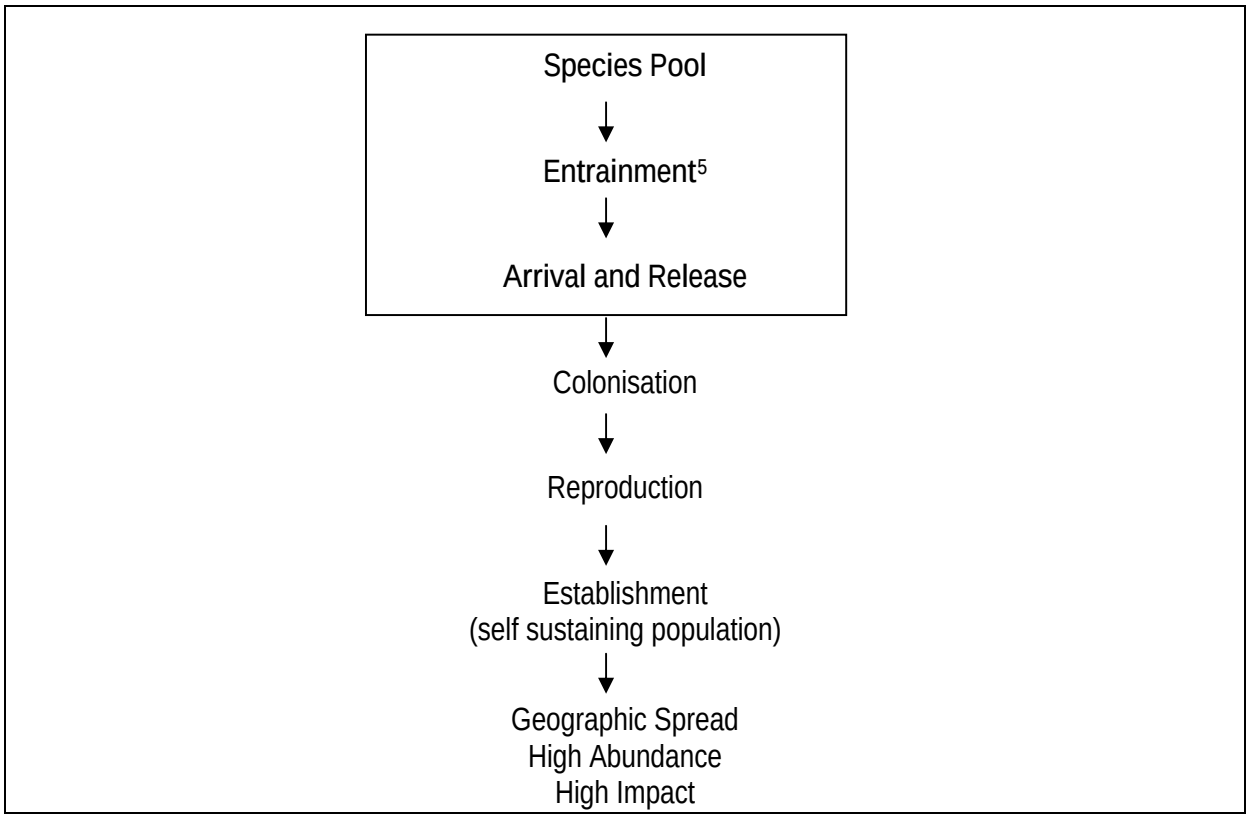

Figure 1 – The invasion process[6]

Focusing pest management effort to the earlier stages of the invasion process is warranted for a number of reasons:

The emerging pest problem New species continue to naturalise every year[7]. Most naturalised species currently have limited distribution which is expected to increase over time. Often, there is a long lag phase between species becoming naturalised and their recognition as pests

[4] *Modern trade and transport has allowed us to become more 'connected' globally than at any other time in history. Unfortunately pests have also been able to take advantage of this, relocating to another country or region in a matter of hours. Protecting our environment from the effects of these pests is becoming more and more important as we recognise economic and social costs of not managing the risk.* (Paul Bradbury, SPS Biosecurity).

[5] **Entrainment** Incorporate and sweep along in its flow. Strictly this relates to water flows, but we adopt a wider meaning. For example earth moving machinery "entrains" soil and seed material which can be later released in a new location.

[6] After Carlton 1985 and Richardson 2000.

[7] For every 10 plant species which become naturalised, about 2 are expected to become weedy. K Briden, DOC, pers.com.

("sleeper pests"). While this reality is widely acknowledged among pest managers, the emerging pest problem we face as a nation is not well understood by many non-experts. This disjunction is not helped by a lack of systematic forecasting and accounting of potential future pest impacts for all pest classes, and for all environments, which might constructively inform debate.

For these reasons we conclude that increased pest impacts will be experienced over time, driven mostly by species which are already here.

Champion et al. (2002) state the risk for aquatic environments:

> *The spread of already naturalised [aquatic] weed species represents the most immediate threat to the ecological values and biodiversity of the remaining non-impacted or minimally impacted habitats.*

There are likely to be additional drivers of change which may accelerate the emerging pest problem. Some examples include:

- Ongoing new arrivals via our international borders.
- Climate change.
- Changing land uses (e.g. biofuel cropping).

Pre-eminence of Prevention It makes good economic sense to prevent a pest problem rather than suffer the consequences later[8]. This has been quantified in a recent Australian study[9] (figure 2). Preventative pathway management tools are applied mainly at phase "1" shown in the figure.

This point has also been demonstrated for newly naturalised plants in New Zealand. Harris and Timmins (2009)[10] show that late control is on average 40 times more expensive than early control, and the removal of newly naturalised species on a precautionary basis is cost effective even where the potential weediness of the new plant is unknown.

[8] Maxim. *Prevention is better than cure.*

[9] Morf and Weiss. 2008. Optimising government investment at different stages of the weed invasion process. Department of Primary Industries. *[note: "reduction" and "containment" terms used in the graphic are not consistent with terminology used in New Zealand]*. Graphic reproduced with thanks.

[10] Harris, S.; Timmins, S.M. 2009: Estimating the benefit of early control of all newly naturalised plants. Science for Conservation 292. Department of Conservation, Wellington. 25 p.

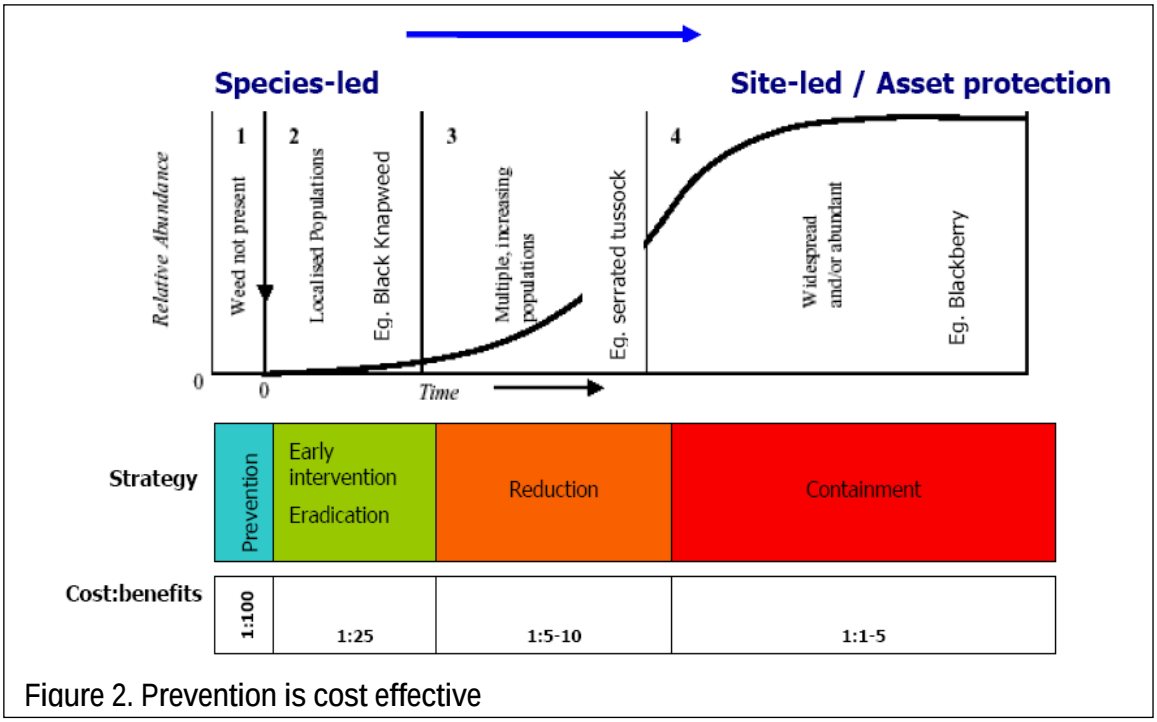

Figure 2. Prevention is cost effective

Not necessarily reliant on detailed knowledge Consistent with the precautionary nature of pathway management, effective actions can be implemented with little or no information. In fact, we do not necessarily even need to know which species are being moved.

History shows that human mediated movements of organisms, either intentional or accidental, have resulted in establishment of most present pest populations. Pathway management can therefore proceed on the premise that allowing movements of organisms to continue unabated will result in the establishment of new populations of pests.

> *"The present level of uncertainty surrounding transfers – including the species composition, likelihood of establishment, and potential impacts argues strongly for a precautionary approach……. A precautionary approach to limit unwanted invasions is conceptually simple. It requires the fewest assumptions about which species will become established, and which will have unwanted ecological or economic effects. It assumes all species are "guilty until proven innocent".*[11]

Societal resistance to the pest management toolbox The tools deployed to manage established pests include reliance on chemical and physical destruction methods. These methods are meeting increasing resistance in today's society[12]. Successful early intervention reduces (but will not entirely eliminate) subsequent reliance on such methods.

Pathway management complements other pest management Surveillance, with a view to early detection and rapid response, is a widely applied pest management tool. However, while synergies exist between surveillance and pathway management, the two are distinct. Pathway management precedes surveillance in that it aims to prevent the arrival of pest organisms at a new place. Since both are early intervention tools it is useful to consider them as distinct but complementary elements of the pest management toolbox.

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11 Ruiz G. M. and Carlton J. T (editors) 2003. *Invasive species – Vectors and Management Strategies*. Island Press. ISBN 1-55963-903-2. 518pp. (quote at page 471)

12 Hellstrom J., Moore D., Black M. 2008. *Think piece on the future of pest management in New Zealand – Main report*. Report to MAF Biosecurity New Zealand from LEGC.

For example, social marketing might be applied to reduce pest spread by targeting contributory behaviours. Leveraging off our society's strong sense of stewardship, this is likely to be a good value for money strategy. And doubly effective:

- Improved awareness leads to reduced movements of pest organisms, and,
- Improved awareness engages large sectors of society to voluntarily and competently assist with early detection of new invasions (surveillance).

1.4 CLASSIFYING PATHWAYS OF PEST SPREAD

Many pathways of pest spread exist, and may be interdependent. That is, one pathway can give rise to the next and so on, so some structured grouping is desirable.

The four common elements of pathways are people, places, organisms and a mode of transfer. While any of those four elements could be used as a basis for classification of pathways, we adopt the people element:

- All domestic pathways of pest spread exist because people choose to undertake activities to achieve some purpose.
- Reducing pathway risk therefore requires behavioural change. Pathway management is more about engaging with people, and less about engaging with pests directly.
- Many existing examples of pathway management engage groups of people who share a common purpose and activities. A classification which reflects that is most likely to be useful.

We create separate classifications for each of the three main receiving environments, marine, freshwater and terrestrial. This is practical, while recognising that many organisms do transition between these environments. And for each of these environments pathways are classified by:

1. Purpose
2. Activity
3. Pathway

1.5 PATHWAY CLASSIFICATIONS

The following pages (figures 4, 5 and 6) present the pathways identified for each receiving environment. Whilst there are possibilities for interactions to occur between the three environments, each diagram focuses solely on pathways occurring within the receiving environment.

The structure of the diagrams distinguishes which pathways are generic at the purpose level, versus activity specific pathways (figure 3). For example, many people use the terrestrial environment for the purpose of recreation. Common to most is the use of footwear and vehicles, these being "generic" pathways. At the activity level we may then add further "specific" pathways, such as the release of target species as associated with hunting.

The pathways identified are largely self explanatory. The compact format of their presentation is chosen to provide a holistic overview of known pathways by environment, and to facilitate identification of any pathways which may have been missed.

Further discussion of the pathways identified is presented in appendices 1-3. Examples of most pathways are reflected in the case studies (Part 5).

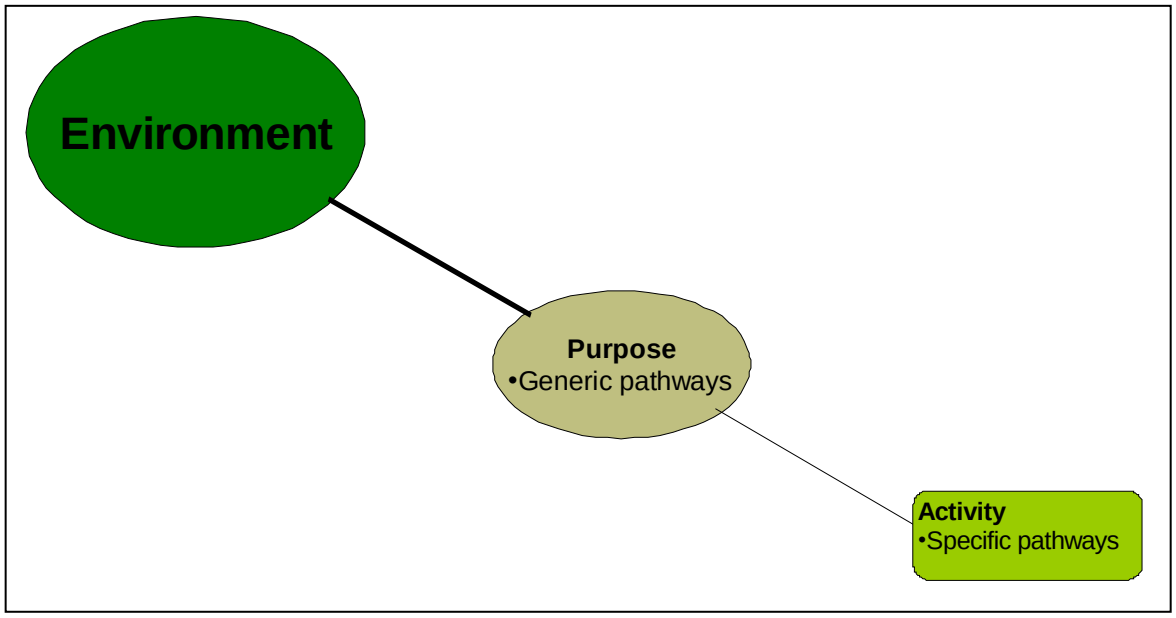

Figure 3. Key to pathways as applied in figures 4-6.

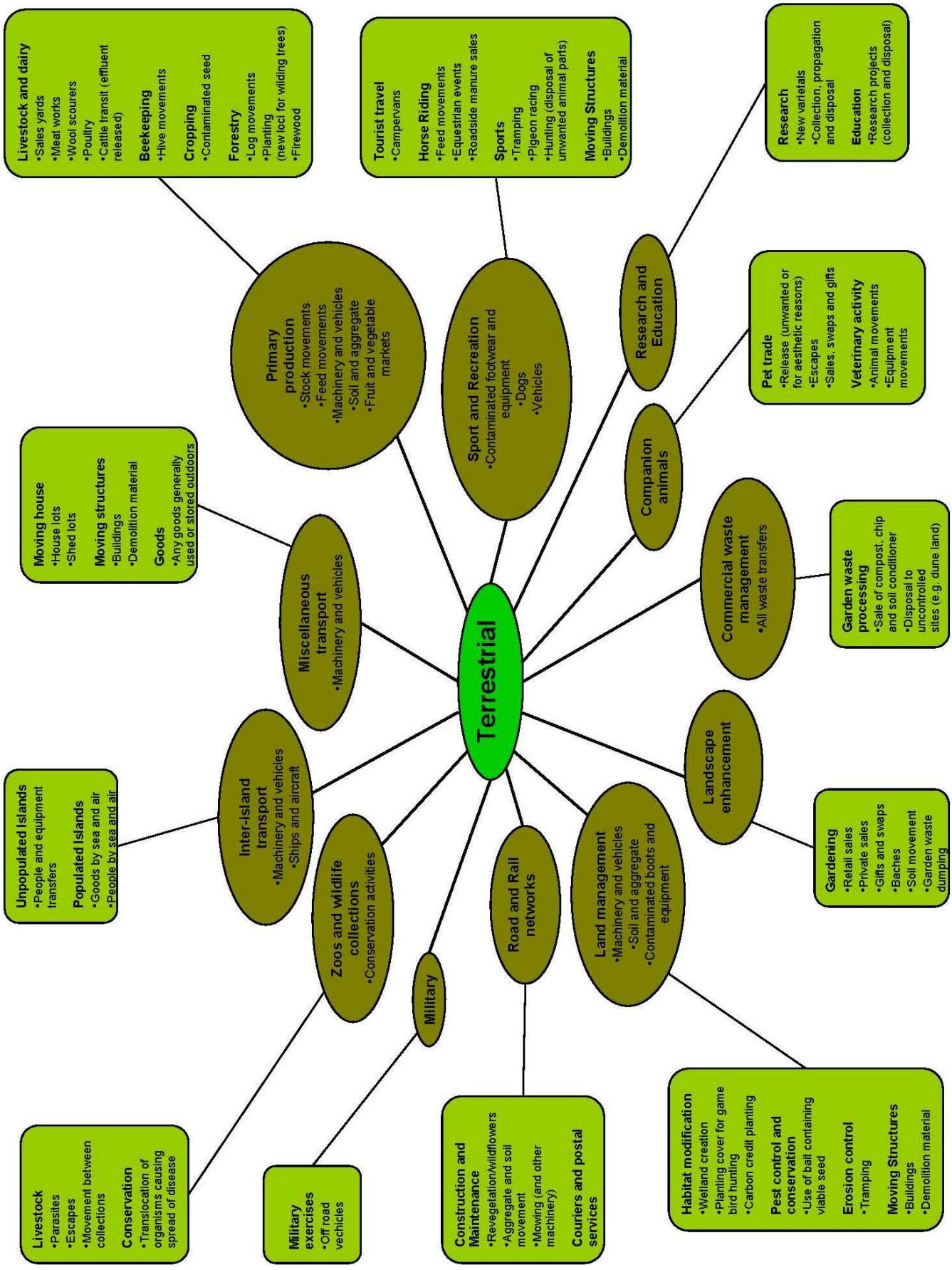

Figure 4 Terrestrial Pathways

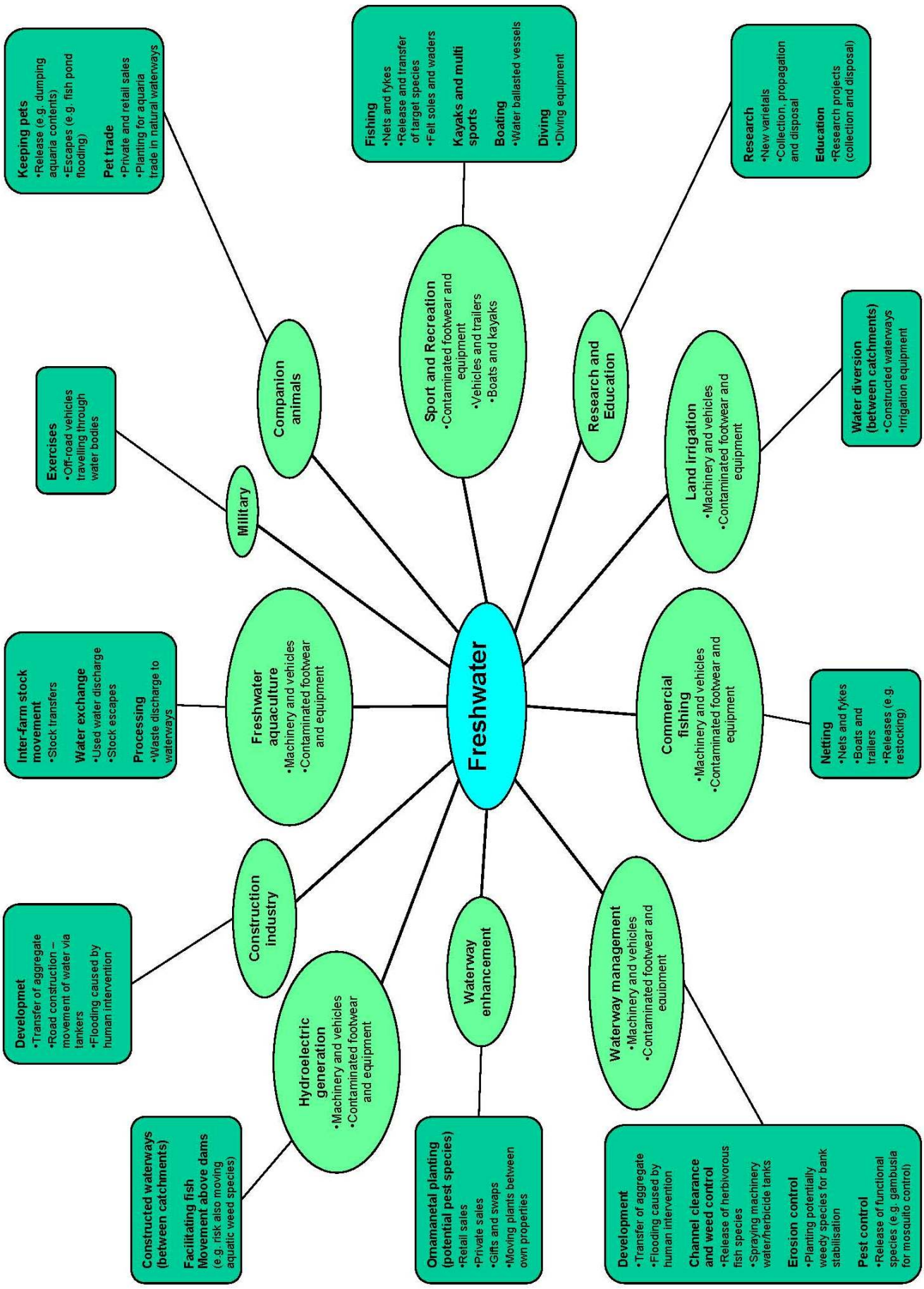

Figure 5 Freshwater Pathways

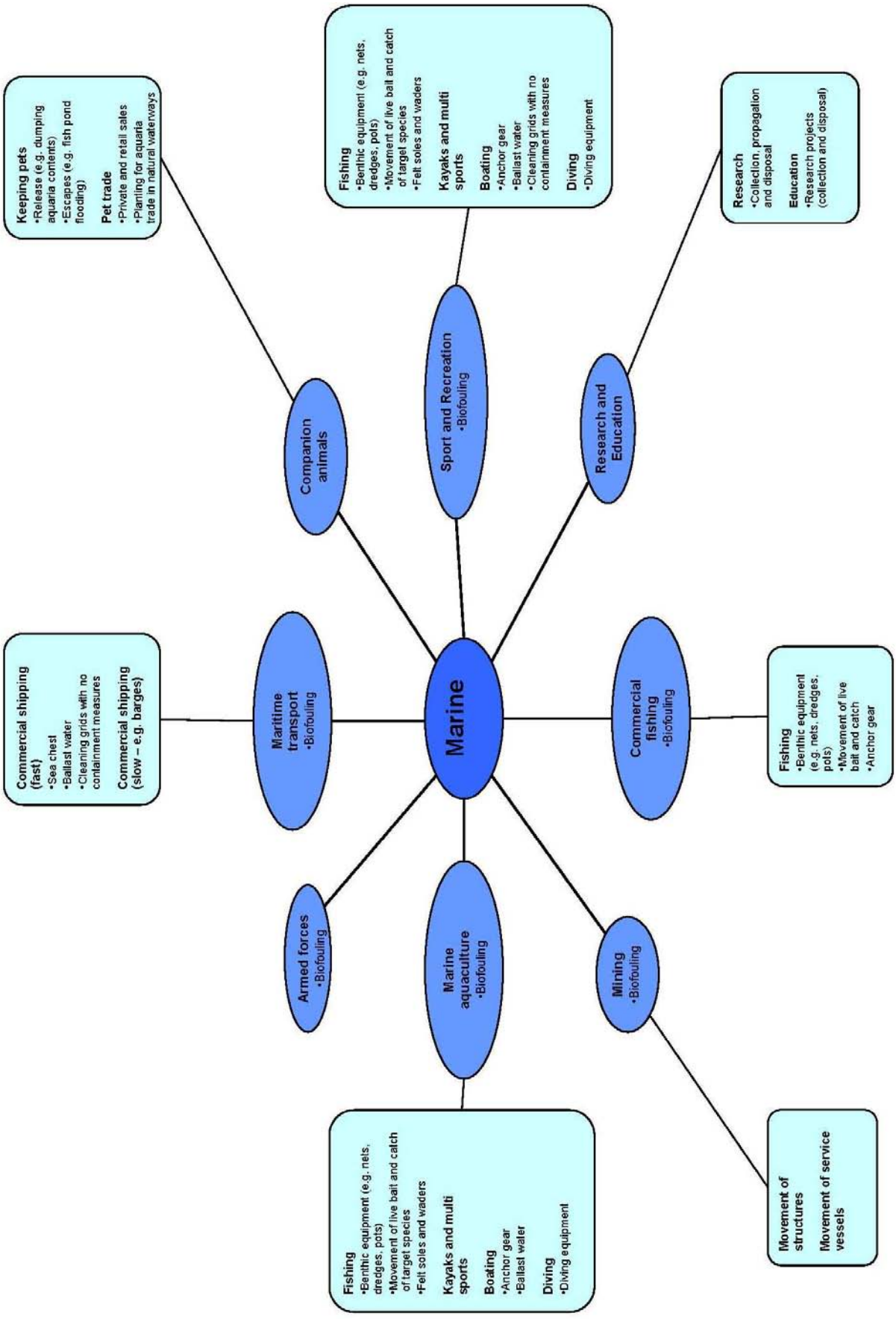

Figure 6 Marine Pathways

2 Risk Assessment

2.1 PURPOSE OF RISK ASSESSMENT

Having identified known pathways, a consideration of the relative risks of those pathways follows. Risk assessment aims to inform policy makers, and ought to contribute to the identification of feasible and cost effective opportunities for prioritising and managing risk pathways.

Ideally, risk assessment will identify which pathways are likely to be the most potent agents of change, that is those most likely to transform and impact New Zealand's natural and productive ecosystems over time. Such assessment, relevant at all space and time scales, might be reviewed regularly to capture changes in supply characteristics of known pathways. Consideration of the actual risk of incursion following the spread of a pest through a pathway should also be an important component of risk analysis.

Delivering such comprehensive risk assessment is challenging. In a considered and authoritative view, Ruiz and Carlton[13] conclude;

> *"Such a vector meta-analysis, which integrates across vectors [pathways] and temporal scales, is not available – even within taxonomic groups or ecosystem types (i.e., terrestrial, freshwater, or marine). …our ability to compare spatial or temporal differences in propagule [organism] supply is limited to qualitative estimates at best…"*

This view is reinforced for the New Zealand marine situation by Dodgshun[14] et. al.;

> *…..it should be acknowledged that even for well-known transfer mechanisms, activity can be unpredictable and variable in space and time, making it difficult to generalise about the pathways and their associated risks.*
> *To date, such [quantitative] approaches have been undertaken only in relation to particular pathways, such as ballast water introductions to Australia (e.g. Hayes & Hewitt 1998), or for multiple pathways to spatially defined regions, such as the Tasman-Golden Bay area in the Nelson region (Acosta et al. 2006).*

These conclusions are arrived at for a number of reasons, including the tremendous variation inherent to supply characteristics of pathways, and a lack of consistent and robust data on which quantitative comparisons of pathway risk might proceed. Less obviously, there is the fundamental problem that qualitative or even semi-quantitative risk assessments for individual species cannot be readily combined to provide an overall measure of pathway risk[15]. Another difficulty is that pathways and their associated risks can change over time. Therefore, it is important to remember that any prediction made of pathway risk will always have a level of uncertainty.

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[13] Ruiz G. M. and Carlton J. T (editors) 2003. Invasive species – Vectors and Management Strategies. Island Press. ISBN 1-55963-903-2. 518pp. (quote at page 475) This is an authoritative text on pathway risk assessment and management. Despite its primary focus on global pathways of pest spread, this text is recommended reading for those desiring a more comprehensive treatment of bioinvasion risk assessment.

[14] Dodgshun, T. J., Taylor, M. D., Forrest, B.M. 2007. Human-mediated pathways of spread for non-indigenous marine species in New Zealand. DOC Research & Development Series 266.

[15] Hayes K. R. 2003. Biosecurity and the role of Risk Assessment – in Ruiz G. M. and Carlton J. T (editors) 2003. Invasive species – Vectors and Management Strategies. Island Press. ISBN 1-55963-903-2. 518pp.

Despite such uncertainty, the risk manager will nonetheless need some rationale for allocating limited resources to mitigate pathway risk. Resources ought to be allocated where risk reduction is feasible, and benefits are likely to be greatest.

For our purposes here we consider risk from two perspectives. Firstly, the following section lists a range of generic risk factors relevant within individual pathways or transfer events. Secondly we identify for each receiving environment which pathways are likely to pose highest risk.

2.2 RISK FACTORS WITHIN PATHWAYS

Risk is the likelihood that an adverse event will occur, and the likely magnitude of that event's consequences[16]. For pathways, that is the likelihood that organisms are transferred to a new location, and the scale of any subsequent adverse impacts.

We can distinguish generic risk factors operating at the individual pathway or transfer level. All else being equal, risk tends to increase where:

- Species associated with significant adverse pest impacts are being transferred.
- Typical transfer distances are large, which increases the chance that organisms will be moved beyond their present range.
- Typical transfer times are short, which increases the chance that organisms will survive the transfer.
- Frequency of transfer events is high.
- Volume of risk goods moved per typical transfer is high.
- Typical time that risk goods or equipment are in the source environment is high, which increases the chance that hitchhiker organisms become entrained (e.g. old buildings or demolition material)
- An entire ecosystem is being transferred (e.g. soil, biofouled hull)
- Similarity between source and receiving environments is high, which increases the chance of successful survival and establishment.
- Small organisms are typically transferred, which makes detection more difficult.
- Organisms are reliant on human mediated transfer, having limited capacity for range expansion via natural modes of spread.
- Established pest populations exist at numerous source environments, which increases the rate at which those organisms are able to utilise transfer pathways.
- People are motivated to deliberately transfer organisms.

2.3 HIGH RISK PATHWAYS BY ENVIRONMENT

2.3.1 Rationale to distinguish high risk pathways

We now consider known pathways with a view to distinguishing those which pose the greatest risk. That will require an understanding as to which characteristics might distinguish the higher risk pathways generally.

Typically bio-invasion risk assessment for individual species includes a stepwise approach, or a "chain of events" model. The model is useful as it accurately reflects the reality that an invasion event relies on a sequence of steps such as transfer, survival and establishment, and

[16] BIOSECURITY NEW ZEALAND. 2006. RISK ANALYSIS PROCEDURES

each step is dependant on the success of the previous step. The risk manager may thereby identify weak links in the chain where management action can be effectively applied.

As acknowledged previously, such species-based risk assessments cannot be readily combined to quantify overall pathway risk. Instead, we proceed with the notion that invasion risk associated with pathways is systematic[17]. That is to say, while individual invasion events may be accidental, as a group, invasions occur regularly. So in relation to pathways, it is not a question of "if", but rather "how many" new bio-invasions we might expect over time. Having considered that, the likely consequences of those invasions then need to be judged.

Therefore, higher risk pathways will have the following characteristics:

- Pathways associated with a high rate of bio-invasions, where at least some of those invasions are likely to impose significant adverse impacts, or,
- Pathways associated with lower rates of bio-invasion, but which nonetheless are likely to include invasion of species of significant adverse consequence.

Or, to frame the question from the perspective of any given receiving environment;

Which pathways are expected to supply most high impact pests in future?

It is important to also consider which environments are most susceptible. Notwithstanding any assessment of relative pathway risks, the risk manager ought to maintain vigilance in relation to all potential pathways. This caution is warranted for a number of reasons[18]:

- Not all pathways may have been identified.
- Supply characteristics are only a surrogate measure of pathway risk (i.e. pathways which deliver few species may nonetheless deliver high risk pests).
- Risk assessment is characterised by uncertainty, and classifying any pathway as lower risk may confer a false sense of security.
- Consideration of overall pathway risk at a national scale may be less relevant at localised scales.
- Unexpected or unusual events can have significant consequences.
- Pathway risk may change over time.

In the following sections we consider high risk pathways for each environment. These are determined qualitatively based on consensus of opinion, as reflected in relevant literature and by expert interviewees. Despite the subjective and untestable nature of this approach, it is encouraging that a good level of agreement appears to exist. That said, a more comprehensive assessment of risk than provided below is desirable.

2.3.2 High Risk Pathways – Terrestrial

Most new naturalisations of plants are associated with deliberate cultivation[19] [20] [21] [22]. Plant pathogens, such as *Phytophthora* are similarly spread primarily via cultivation associated

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17 Andow D. A. 2003. Pathways based risk assessment of exotic species invasions (at p. 441). – in Ruiz G. M. and Carlton J. T (editors) 2003. *Invasive species – Vectors and Management Strategies*. Island Press. ISBN 1-55963-903-2. 518pp.

18 Variously in; Dodgshun, T. J., Taylor, M. D., Forrest, B.M. 2007. *Human-mediated pathways of spread for non-indigenous marine species in New Zealand*. DOC Research & Development Series 266.; Ruiz G. M. and Carlton J. T (editors) 2003. Invasive species – *Vectors and Management Strategies*. Island Press. ISBN 1-55963-903-2. 518pp.; and based on views expressed by expert interviewees.

19 Dehnen-Schmutz K, Touza J, Perrings C, Williamson M. 2007. The Horticultural Trade and Ornamental Plant Invasions in Britain. *Conservation Biology* Volume 21, No. 1, 224–231.

20 Sullivan, J. J., Timmins, S. M., and Williams, P. 2005. Movement of exotic plants into coastal native forests from gardens in northern New Zealand. New Zealand *Journal of Ecology* 29:1 10.

21 Gravuer, K., Sullivan, J. J., Williams P., Duncan R. 2008. Strong human association with plant invasion success for *Trifolium* introductions to New Zealand. *PNAS* vol. 105. no. 17 pp. 6344-6349.

22 Sullivan, J. J., Williams, P., Cameron, E., Timmins, S. M. 2004. People and Time Explain the Distribution of Naturalized Plants in New Zealand. *Weed Technology* 18(sp1):1330-1333.

activities[23]. Cultivation activities for whatever purpose are therefore high risk pathways[24], including forestry, agriculture, biofuel cropping, land management and gardening[25].

Associated with gardening in particular is the issue of waste disposal, with dumping of garden waste to unauthorised or uncontrolled sites also being a high risk pathway.

Primary production related activities are further implicated in high risk transfers particularly of plant pests and pathogens, including:

- Movements of stock.
- Movements of stock feed.

High risk pathways which are prone to transfer animal pests (particularly invertebrates) in addition to plants and pathogens include:

- Any activity which moves soil, organic material and or aggregate.
- Any movement of machinery used to work soil, aggregate or vegetation (e.g. earthmoving and agricultural machinery, roadside mowers).
- Inter-island transport of people and goods.
- Activities associated with sport and recreation which result in movement of contaminated footwear and equipment, companion animals, or vehicles.
- Moving of structures (e.g. used or imported railway sleepers or bridge bearers) or demolition material.

High risk pathways with respect to transfers of larger animals and their pathogens include:

- Deliberate release for hunting or aesthetic purposes.
- Escape of companion animals.
- Release of unwanted companion animals.

2.3.3 High Risk Pathways – Freshwater

Natural modes of pest spread are limited between catchments for many freshwater species[26]. Human mediated pathways which facilitate transfers between catchments therefore pose high risk[27].

Any machinery and equipment movements between catchments for whatever purpose are high risk pathways. These pathways can transfer a wide range of both plant and animal species and their pathogens. High risk pathways in this category include movements of:

- Aggregate extraction machinery.
- Drainage machinery.
- Spraying equipment.
- Irrigation equipment.

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[23] Brasier, C. M. 2008. The biosecurity threat to the UK and global environment from international trade in plants. Plant Pathology 2008, letter to the editor.

[24] *"What we get is what we plant"* Dr Peter Williams, Landcare Research. Pers. com.

[25] *"Most new weed sources are associated with garden escapes and agriculture"*. Dr Rachel McFadyen, NETS 2008 conference presentation.

[26] Champion P, Clayton J, Rowe D. 2002. Lake Manager's Handbook – Alien Invaders. Prepared for the Ministry for the Environment by National Institute of Water and Atmospheric Research Ltd.

[27] Champion P, Sutherland D, Kelly G. 2006. Canterbury lakes aquatic plants survey and recommendations to manage the risk of pest plant invasion. Prepared for Environment Canterbury, NIWA report HAM 2006-002.

Similarly any movements of vessels and trailers, vehicles and equipment are high risk pathways, including movements of:

- Recreational boats and kayaks, trailers, vehicles, and associated equipment such as nets and waders.
- Commercial fishing vessels, trailers and vehicles, and associated equipment such as nets.

High risk pathways facilitating transfers of vertebrate species in particular, and also plant species, are associated with fishing and the keeping of ornamentals (both animals and plants). Of the most recent six naturalisations of fish species in New Zealand, three were ornamental species[28], and experts interviewed consistently identified releases of game species as an ongoing problem. High risk activities include:

- Releases for recreational or commercial fishing, or aesthetic purposes.
- Release of unwanted ornamental companion species.
- Planting of ornamentals for commercial or aesthetic purposes.

2.3.4 High Risk Pathways – Marine

Vessel movements are high risk pathways with hull fouling (including sea chests) and ballast water being the primary modes of transfer[29]. Due to its relevance to all vessels, hull fouling is an important pathway at inter-regional scales. Movements of slow vessels such as barges or mining structures, are more likely to be associated with high biofouling loads than faster vessels.

Aquaculture activities predominantly occur at an intra-regional scale where movements of vessels, stock and equipment comprise high risk pathways. Though less common, inter-regional movements of vessels, stock, and equipment also pose high risk. Transfers of wild harvested juvenile shellfish and associated equipment are particularly significant at this inter-regional scale.

Looking at international pathway risk can provide useful indicators for domestic pathway risk. MAF Biosecuirty New Zealand commissioned a multi-year research programme to sample biofouling on international vessels arriving in New Zealand and examine potential relationships with vessel characteristics (build, maintenance, movements). From this work, some high-level biofouling risk factors were identified, and opportunities to apply these within border management/profiling are being considered. So identifying further risk factors may call for primary research (e.g., the vessel biofouling programme) or meta-analyses (collation and review of the current body of knowledge).

[28] Dr N Grainger pers com.

[29] This consideration of high risk marine pathways reflects consistent opinion expressed by expert interviewees, and also relies on literature sources as summarised for the New Zealand situation by; Dodgshun, T. J., Taylor, M. D., Forrest, B.M. 2007. *Human-mediated pathways of spread for non-indigenous marine species in New Zealand*. DOC Research & Development Series 266.;

3 Management of Domestic Pathways

3.1 A PATHWAY MANAGEMENT MODEL

For any identified risk pathway, a comprehensive consideration of possible management options is worthwhile. The hazard management model is built around the responses ***eliminate, isolate, minimise.*** These principles are widely recognised and easily understood. As potential invasion events can be considered an accident waiting to happen, we propose that this model is also suited to pathway management.

We can consider response classes for each of the four defining elements of a pathway as depicted in the below (figure 7). The matrix presents some generic questions which might be asked, and in itself comprises a pathway management tool. It should be noted that for the final column, the level to which we minimise will vary depending on activity, purpose, risk etc.

The following section explores available tools in more detail, with further insight provided by the case studies.

	Eliminate	Isolate	Minimise
Activity (people)	Is the activity necessary? Is replacement with alternative zero risk activities an option? Can activities be eliminated?	Can we permit activities in some places but eliminate them elsewhere?	Are alternative activities an option? Can activities be modified to reduce risk?
Places	Can activities be replaced or eliminated at specific places? If so, at the source, or the receiving environment, or both?	Should restrictions be applied to specific places? If so, at the source, or the receiving place, or both?	Should restrictions be applied to specific places? If so, at the source, or the receiving place, or both?
Pest Organisms	Can we eradicate existing populations of pests before they can be moved elsewhere?	Can we contain existing populations of pests so they are not moved elsewhere?	Can we reduce existing populations of pests to reduce probability of transfer?
Mode of Transfer	Can risk modes of transfer be eliminated? Are alternative zero risk modes of transport available?	Can the pest organisms be temporarily contained (e.g. on vessel or vehicle) so that they are not able to be released?	Can the risk modes of transfer be better managed? Are alternative lower risk modes of transport available?

Figure 7 Pathway risk management matrix

3.2 OVERVIEW OF THE PATHWAY MANAGEMENT TOOL BOX

3.2.1 Regulatory Tools

Regulatory tools may become relevant especially where voluntary measures alone are unlikely to achieve the desired outcomes. Even then regulatory intervention will often be used only in last resort. This concept is well recognised, described in one form as the enforcement pyramid. The pyramid depicts progressively increasing force, applied to progressively decreasing numbers of participants as persuasion fails to have effect (figure 8[30]).

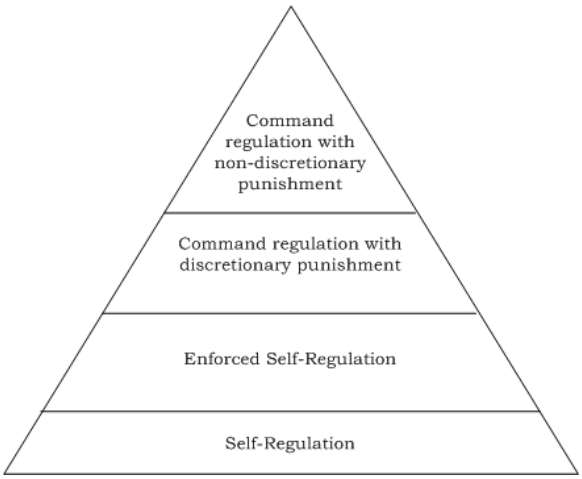

Figure 8 Enforcement pyramid

There is perceived in the realm of biosecurity to be some degree of discord between various pieces of legislation, and overlap between responsibilities of various agencies[31]. Many elements of the regulatory framework are however useful. Some of the main ones include:

The **Biosecurity Act 1993** is fundamentally species based and pathway management is not specifically its object. However, while it is unsuitable for multi-species pathway management, it can be used to manage pathway risks in relation to specific unwanted organisms or pests. Sections 52 and 53 prohibit human mediated spread of unwanted organisms and pests. Other provisions of the Biosecurity Act relevant to pathway management provide variously for declaration of controlled or restricted areas, powers to act on default, power to give directions, power of inspection, small scale eradication and power to vaccinate (case studies 5.1.1, 5.1.5, 5.2.4, 5.2.5, 5.3.4).

The **Animal Welfare Act 1999** prohibits the abandonment of domestic animals.

The **Resource Management Act 1991**, via the consent process, provides for necessary restrictions to be applied. For instance to the movement of aggregate and soil.

The **Conservation Act 1987**[32] provides for restriction on freshwater fishing, and makes all movements of freshwater aquatic organisms subject to permit. Movements of aquatic species already present in aquaculture facilities are excluded under the Conservation Act, and covered

[30] Braithwaite, John (2000) "Convergence in Models of Regulatory Strategy *Regulation, Crime, Freedom: Collected Essays in Law* Ashgate, Dartmouth 99-105.

[31] That subject has been addressed in recent "thinkpieces" prepared for MAF BIOSECURITY NEW ZEALAND, and is not further considered here:
- Hellstrom J., Moore D., Black M. 2008. *Think piece on the future of pest management in New Zealand – Main report*. Report to MAF Biosecurity New Zealand from LEGC.
- Willis G. 2008. *The Future of Pest Management in New Zealand: A Think Piece*. Report to Local Government New Zealand from EnFocus Ltd.

[32] Sections 26ZL and 26ZM.

instead by the Freshwater Fish Regulations. Movements of game species by Fish and Game, and transfers of ornamental species are also excluded.

Other restrictions can be imposed in addition to movement control. Restriction of fishing has been used to deter illegal introductions of freshwater game fish into new areas. The Orakai, Tutira and Waikopiro Refuge Order 1973 prohibits motorised boats and commercial eeling in the named lakes.

The **Wild Animal Control Act 1977** prohibits movement and release of wild animals, and also provides (section 12A(3)) for conditions to be imposed where animals such as deer are farmed (case study 5.2.1).

Restrictions and conditions may be placed on concessionaire uses of public land, such as multi-sport events and commercial tourist activities (case study 5.4.2).

A range of non-statutory tools are also available, which are nonetheless of a regulatory nature:
- Industry certification.
- Industry levies.

Industry levies enable risk to be managed at a sector level. The kiwifruit industry charges a levy to recover industry contribution to wilding kiwifruit control (case study 5.1.4).

The **Proposed National Plan of Action for Pest Management in New Zealand** addresses a need to strengthen the system under which pest management operates in New Zealand. MAF has been working alongside key stakeholders to put together a Proposed National Plan of Action to cover future pest management in New Zealand. The main aims are to solve problems around lack of clarity of roles in pest management, improve legislation and management tools, align the crown obligations as a 'good neighbour' landowner with those of other parties and to improve collective action and participation.

Pathway management has been considered within the Proposed National Plan of Action and reduced spread through pathways has been included as a proposed outcome in the *Pest Management Proposed National Plan of Action 2010 – 2035* document. The document also outlines the roles and responsibilities of MAF as being the overall leader for the pest management system and this includes overseeing national pathway management programmes to protect the public interest. Regulations for pathway management and internal borders have been highlighted as requirements for improving and simplifying processes involved around future pest management.

3.2.2 Public Awareness and Behaviour Change

There is a widely held perception among specialists interviewed that effective pathway management is largely a social exercise. Working constructively with stakeholders to "know and do the right thing".

This perspective is also apparent among those who are not biosecurity specialists. Kingsley Field, noted journalist, author and keen outdoorsman, captured this point succinctly in asking biosecurity specialists to: "*Give the rest of us the lead that we need*"[33].

[33] In closing the New Zealand Biosecurity Institute National Education and Training Seminar 2008 Biosecurity Conference (NETS 2008).

Such a philosophy is arguably fundamental to pathway management:

- Pathway management lends itself to facilitating behavioural change since people's activities are being managed, not necessarily the pest itself.
- Many New Zealander's recognise their duty of care in matters of our common environmental and economic welfare. They can by and large be expected to do the right thing if they are well informed. In commercial situations profits may be affected by potential pest impacts which further motivates constructive action.
- Given that all activities which create risk pathways are motivated by some purpose, it is important that people are aware of the potential costs and consequences of their actions. Only with that knowledge can they make an informed judgment of benefit versus cost. Together with practical guidance as to how their activities might be modified, risk reduction is achievable. Inclusion of pathways information in primary and secondary education could help to address this.
- Of the numerous examples of domestic invasions cited, many are attributed to actions taken by people unaware of the risks of their actions. Case studies presented demonstrate that active communication strategies can make a difference.
- While there is scope for regulatory management of some domestic pathways, voluntary measures are the only realistic option for many other pathways. Such measures rely on having participants on side and well informed.

Two well known national communications initiatives are "Weedbusters" (case study 5.1.3), and the didymo "Check, Clean, Dry" campaign (case study 5.4.1).

3.2.3 Science and Technology

In many cases managing pathway risk may rely on improved technical knowledge and processes.

Research outcomes may include simple solutions, such as the finding that immersing mussel spat lines briefly in freshwater kills *Didemnum*[34]. In other cases the research and development may be a substantial undertaking, such as the Scion research programme into alternative and productive uses of reject kiwifruit (case study 5.1.4).

Partnerships with tertiary institutions are a possibility where biosecurity fits the curriculum. This can involve participation with surveys, or facilitating thesis work on topical biosecurity risks (case study 5.4.2).

3.2.4 Voluntary Measures

Voluntary measures include:

- Codes of Practice (COPs).
- Agreements.
- Amnesties.

In some cases voluntary measures may interface with regulatory tools. Giving the force of regulation to industry developed COPs, and the National Pest Plant Accord (case study 5.1.2) are examples.

Codes of Practice are relevant where ineffective hygiene practices risk pest spread. They are likely to be most effective where the sector concerned stands to suffer the consequences of high risk practices. Some examples of activities which lend themselves to COPs include machinery hygiene in the agricultural and earthmoving sectors (case study 5.1.7), aggregate

[34] Courtesy of Cawthron Institute.

extraction and transfer, movements of aquaculture stock and equipment (case study 5.3.2) and containing the entrainment vector (containment on cleaning grid reduces the risk of onward spread of marine pests).

Certification of goods and services informs the consumer of associated risk, and provides them the option to minimise that risk. This might include certified clean seed or compost products, or ecotourism services.

Agreements are a formal option, similar to partnerships, but distinguished perhaps by their nature as a binding contract. The National Pest Plant Accord is a significant voluntary agreement with national effect[35], prohibiting the sale of a range of pest plants (case study 5.1.2).

At a local scale, a meat processing facility in Canterbury has entered into a Memorandum of Understanding with Environment Canterbury in relation to managing new incursions of nassella tussock onto the site.

Where pests or unwanted organisms were historically kept as companion animals or ornamental species, amnesty programmes may be useful.

3.2.5 Partnerships

Some biosecurity risks involve a diverse group of participants, with numerous agencies and groups having some form of jurisdiction, responsibility or interest in managing the risk. Where this is true, partnerships may facilitate efficient action (case study 5.2.2).

The "Top of the South" initiative is such a partnership mandated to manage marine biosecurity risks in the top of the South Island (case study 5.3.1). A regional partnership considered to be working effectively for the Rotorua Lakes is APTAG (Aquatic Pests Technical Advisory Group), (case study 5.4.2).

3.2.6 Pest Management

Some forms of traditional pest management, while not generally considered as pathway management, contribute to reducing the risk of pest spread.

Localised eradication of pest species removes a source population from which the pest might otherwise spread further. Containment initiatives similarly limit the number of locations from which further spread of the pest could occur. Most Regional Pest Management Strategies include eradication and or containment initiatives.

3.2.7 Replacement

Replacing or substituting some element of a risk activity may be possible (case study 5.1.4).

Risk associated with revegetation of roadsides might be reduced by selecting certified weed free seed sources. The "Weedbusters" regional publications "Plant me Instead" (case study 5.1.3) facilitates replacement to reduce spread of weedy species.

3.2.8 Hygiene

Observing high standards of hygiene is good housekeeping. It applies to all sectors and all activities. Acknowledging that the inadvertent transfer of "hitchhiker" organisms is a form of

[35] All species on the NPPA list are also declared unwanted organisms under the Biosecurity Act 1993. Therefore while it is discretionary whether any party chooses to participate in the agreement, the regulatory consequence thereof applies to all.

bio-pollution, poor hygiene standards are contributory to new bioinvasions (case studies 5.1.3, 5.1.6, 5.1.7, 5.2.2, 5.2.3, 5.2.6, 5.3.1, 5.3.2, 5.3.3, 5.3.5, 5.4.1, 5.4.2, 5.4.3).

3.2.9 Benchmark Species

Nominating a "benchmark risk organism" is a useful concept when considering options for managing pathways.

A nominated benchmark species will typically be a cryptic and high risk organism readily able to be transferred via identified pathways. If pathways can be managed to reduce the spread of these most challenging species, then spread of other potential pest organisms will also be reduced.

Auckland Regional Council has proposed Argentine ant as the "benchmark risk organism" within the Hauraki Gulf Controlled Area (HGCA). By ensuring that Argentine ants are prevented from being transported within the HGCA, other risk organisms (e.g. rodents) should also be prevented (case study 5.3.4).

4 Opportunities Identified

Opportunities identified below reflect ideas and suggestions of interviewees. They do not generally reflect the views of any agency which might choose to implement those ideas. Nor do they represent any obligation, commitment or policy stance on the part of any agency or individual, including MAF Biosecurity New Zealand.

4.1 LEADERSHIP OPPORTUNITIES FOR MAF BIOSECURITY NEW ZEALAND

National Leadership in pathway management – Strategic Direction MAF Biosecurity New Zealand is mandated with national leadership and oversight in the biosecurity sector. Promoting the application of domestic pathway management principles comprises a part of that mandate. A Strategic Directions report may be necessary to identify appropriate roles for MAF Biosecurity New Zealand, as well as other stakeholders. Among other topics, such a report might consider the role of pathway management in relation to the present "Pest Management Proposed National Plan of Action for in New Zealand" initiative, as well as the leadership role of MAF Biosecurity New Zealand in coordination and facilitation of pathway management efforts.

Further considerations for such a report might include some of the items listed in the following section. The importance of hygiene is a recurring theme.

Proposed National Plan of Action for Pest Management in New Zealand has outlined the leaders for different areas of pest management, and has specifically highlighted those that should be responsible for marine pathway management.

4.2 OPPORTUNITIES FOR OTHER CENTRAL AND LOCAL GOVERNMENT AGENCIES[36]

Establishment of an emerging risks advisory team Part one identifies that the emerging pest problem we face as a nation is not well understood. We also lack a systematic forecasting and accounting of potential future pest impacts which might constructively inform the issue and associated policy. Lacking a clear picture of the transformational change likely to be experienced over time also constrains risk assessment. An important component of risk assessment is an understanding of consequences, which we cannot comprehensively address without clearly expressing a range of possible future scenarios in the first instance.

Ruiz and Carlton[37] [38] propose a "Vector Early Warning System" (VEWS), and while this concept has a view to global invasion pathways, it can be applied to domestic pathways [vectors] also. Scenarios are developed by an interdisciplinary team combining expert knowledge looking both backwards and forwards in time. Estimations would be made on a regular basis, and for a range of predetermined time horizons.

[36] Includes quasi governmental agencies without limitation (e.g. Transit NZ)
[37] Ruiz G. M. and Carlton J. T (editors) 2003. Invasive species – Vectors and Management Strategies. Island Press. ISBN 1-55963-903-2. 518pp
[38] Carlton JT, Ruiz GM (2005) Vector science and integrated vector management in bioinvasion ecology: conceptual frameworks. In: Mooney HA, Mack RN, McNeely JA, Neville LE, Schei PJ, Waage JK (eds) Invasive alien species. Island Press, Washington, pp 36–58.

Nationally consistent communication Develop consistent communication material where messaging will be targeted throughout New Zealand. Examples include:

- Weedbusters awareness campaign, including completion of the "Plant me Instead" series.
- Regional Council communication needs for widely distributed pests.
- Role of pathway management (prevention of pest spread) as an important part of the pest management toolbox.

Nationally consistent regulatory tools Develop nationally consistent material to support regulatory tools, such as s52, s53 and restricted place notices under the Biosecurity Act, and also variously under other relevant Acts such as Wild Animal Control Act, Resource Management Act etc.

Further to this, good technological transfer between all organisations involved in pathway management would aid national consistency and development.

Facilitate Codes of Practice Facilitation of development and implementation of Industry Codes of Practice, with a particular focus on transport and hygiene protocols.

Facilitate Certification Facilitate development of nationally consistent standards and certification (including improved uptake of existing certification as applicable), examples include:

- Certification of compost.
- Certification of aggregate.
- Certification of seed.
- Certification of topsoil.
- Certification for bird cages.
- White list for ornamental plants.

Support pathway relevant research towards improved understanding of pathways risk, and management tools.

Some specific opportunities

- Amnesty programmes for pests of national significance such as water hyacinth and salvinia (MAF Biosecurity New Zealand specific opportunity).
- Improve consistency in implementation of the National Pest Plant Accord (NPPA) programme (some agencies for example inspect quarries and topsoil providers, others do not).
- Investigate financial and regulatory options with a view to reducing or eliminating the costs to occupiers of garden waste dumping.
- A strong opportunity to raise awareness is through education. Schools and educational facilities could be advised on how to incorporate information on pathways and pest spread into their curriculums. This could help better the public's understanding from an early age.
- Spatial depiction and data-basing of high risk pathways of pest spread and associated high risk nodes (point sources).
- Facilitate the availability of a surveillance hotline receptive to all potential pests, unwanted organisms, pests of limited regional significance, and unidentified organisms. This may be efficiently delivered in a stepwise process, beginning with local points of contact, and progressing to more centralised capacity according to some predefined rules (c.f. conduit approach, Australia).
- leaning stations in suitable areas (e.g. national parks, aquaculture areas).

It should be noted that some of the opportunities identified in this section are already underway or under consideration.

4.3 OPPORTUNITIES FOR INDUSTRY

- Consideration of pathway management principles when incorporating Biosecurity measures into industry practices.
- Further development of voluntary codes of practice focused around hygiene and transport.
- Further development of certification of products.
- Facilitate awareness among participants of pathway risk.
- Co-ordination of pathway management efforts with other agencies.
- Registration of the nursery and garden industry growers (i.e. compulsory registration of all growers and garden centres).

4.4 OPPORTUNITIES FOR NON-PROFIT ORGANISATIONS AND INDIVIDUALS

- Consider the role of pathway management towards achieving pest management goals.
- Co-ordination of pathway management efforts with other agencies.
- Consideration of how to add public incentive (e.g. if properties were given a pest rating which affected re-sale value, the owners might be more motivated to deal with pests.)
- Minimise transfers of organisms and risk goods.
- Keep it clean.

5 Case Studies

5.1 TERRESTRIAL PATHWAYS – PEST PLANTS

This case study is presented in three parts, focusing primarily on significant pathways of terrestrial plants.

The first page, "How weedy are plants recently naturalised in New Zealand" (Williams and Randall) describes the history and ongoing effects of moving plants around. This one page summary identifies the key pathways, from which its author succinctly concludes in relation to new pest plant populations "*What you get is what you plant*" (P. Williams pers. com.).

Next the National Pest Plant Accord (NPPA) is presented and discussed.

Thirdly, the "Weedbusters" initiative provides insight into gains made in recent years in raising public awareness and encouraging responsible behaviours.

Terrestrial pest plants are a significant biosecurity issue for New Zealand. Unfortunately the rate of new naturalisations of exotic plants shows no signs of slowing down as demonstrated in the figure below.

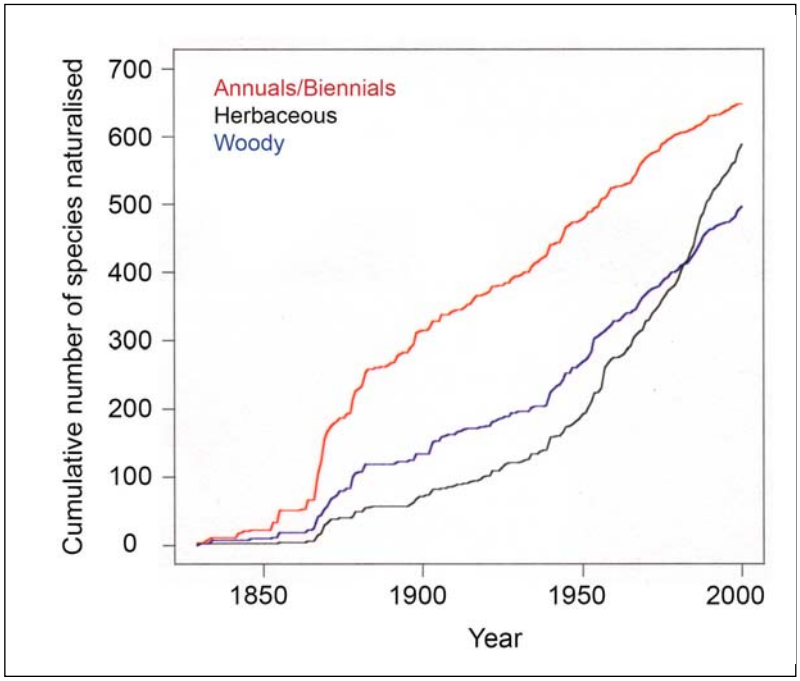

Figure 9. The rate of new naturalisations in NZ continues unabated.[39]

[39] Taken from a powerpoint presentation of J Mather, EBOP. Original source unknown.

5.1.1 New Plant Naturalisations

How weedy are plants recently naturalized in New Zealand?

Peter A. Williams[1] and Rod Randall[2]
CRC for Weed Management
[1]Landcare Research, Private Bag 6, Nelson, New Zealand
Email:williamsp@landcareresearch.co.nz
[2]Department of Agriculture, Locked bag 4, Bently DC 6983, Western Australia
Email:RPRandall@agric.wa.gov.au

The problem

The current costs of weeds to New Zealand is _ $40m in preventative expenditure and _ $60m in lost prodution per year alone[1]. The number of new species that potentially require control under the Biosecurity Act (1993) continues to increase. For example, 120 plant pests are listed in the 2002 Proposed Auckland Regional Pest Management Strategy[2].

Pueraria lobata in the USA

Naturalization is a critical step towards a plant species becoming a weed, and about 14 species do so every year in New Zealand. Casual naturalizations are those that have not yet formed self-sustaining populations or persist in the wild, whereas full naturalizations form self-

Data sources

Since 1988 there have been _ 187 casual naturalizations and _ 79 full naturalizations recorded among the dicotyledons, gymnosperms, and pteridophytes (all higher plants except grasses and their relatives)[3,4,5,6]. As a guide to their potential weediness in New Zealand we determined the number of overseas lists on which they appeared, from a Global Compendium of Weeds[10]. This lists _ 20 000 species from _ 300 referenced sources covering 11 continental regions and 46 countries. Species naturalized in New Zealand come from most of these regions. The global list distinguishes merely "naturalized" species, and those listed as "weeds".
For those naturalizations originating from cultivation, we determined the number of wholesale and retail nurseries outlets (n=200)[11].

Towards the answers

Weediness of new naturalizations

- Many species (36.2%) do not occur in other countries as either naturalized species or weeds. History can tell us little about their future in New Zealand unless we know their history of cultivation overseas.
- The majority are also naturalized elsewhere (63.8%).
- A few (11.4%) are naturalized elsewhere and have not been reported as weeds.
- Half (52.0%) of the new naturalizations are listed as weeds overseas.

Conclusions

- Most newly naturalized plant species are from horticulture and 60% are distributed via the nursery trade.
- Many newly naturalized species threaten New Zealand's biodiversity and productive systems based on their history of weediness overseas.
- The flow of new species into the environment will not be slowed unless nurseries no longer distribute them.
- Horticultural species that have progressed from "newly naturalized" to "pest" are generally too widely distributed to completely eradicate.

The questions

- Which newly naturalized species are likely to become weeds in New Zealand? As a history of weediness in another country indicates a plant's potential weediness in a new country[7], we determined whether these newly naturalized species are weeds overseas.
- For what purpose, if any, were these species brought to New Zealand? And since invasion success is correlated with planting frequency[6] and proximity of propagule sources in gardens[9], are the newly naturalized species readily obtainable for distribution around the country?

Species	Pathway	No. nurseries	No. weed lists overseas	Origin
Asclepias curassavica	Hort	2	21	Tropical America
Campanula rapunculus	Hort	3	21	Eurasia
Capsicum annum	Agri	nd	11	Tropical America
Carum carvii	Hort	2	15	Eurasia
Cucumis myriocarpus	Hort	0	24	Tropics
Cuscuta planiflora	Acci	0	14	Eurasia
Gleditsia triacanthos	Hort	19	18	North America
Gymnocorononis spilanthoides	Hort	0	19	Europe
Impatiens walleriana	Hort	0	12	Africa
Jacaranda mimosaefolia	Hort	15	13	Tropical America
Leonotis nepetifolia	Hort	1	16	Tropical
Melia azedarach	Hort	20	37	Tropical Asia
Mesembryanthemum crystallinum	Hort	0	18	Africa
Ocimum basilicum	Hort	4	15	Tropical Asia
Pueraria lobata	Hort	0	24	Temperate Asia
Ranunculus ficaria spp. calthifolius	Hort	5	18	Europe
Schinus terebinthifolius	Hort	1	42	South America
Sisymbrium irio	Acci	0	32	Eurasia
Solanum torvum	Hort	0	25	Tropical America
Thunbergia alata	Hort	1	19	Southern Africa

Plant species reported as naturalized in New Zealand since 1988 appearing on more than 10 weed lists overseas.

Pathways of new naturalizations

- Horticulture, primarily for urban gardens, provides most species (95.8%).
- Accidental introductions account for a few (2.5%) and the remainder came via agriculture or indeterminate means. These occur on an average of 11 weed lists.
- Most recent naturalizations (60.0%) are now available through nurseries with an average of 6 outlets nationwide.

Recommendation

- Biosecurity legislation and action should place greater emphasis on the important role of horticulture in general, and nurseries in particular, in the naturalization of plant pests in New Zealand.
- Public education on the role of horticulture in the naturalization of potential new plant pests should be increased.

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[1]Williams, P.A., Timmins, S. Economic Impacts of Weeds in New Zealand: some examples. In: Pimentel, D. ed. Environmental and Economic Costs of Alien Plant, Animal and Microbe Invasions. CRC Press, Boca Raton, Florida.
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[3]Brownsey, P.B., Bostwick, L. Glenny, D.S., de Lange, P.J., Brownsey, P.J. 1998. Checklist of dicotyledons and pteridophytes naturalized or casual in New Zealand: additional records 1994-1996. *New Zealand Journal of Botany*. 36: 155-162.
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[7]Pheloung, P., Williams, P.A., Halloy, S. 1999. A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. *Journal of Environmental Management*. 57: 239-251.
[8]Mahoney, M. 2001. The effect of introduction pressure on the naturalization of ornamental woody plants in South-Eastern Australia. In: Groves, R.H., Panetta, J.C. Virtue, J.G. eds Weed Risk Assessment. CSIRO Plant Industry, Canberra. Pp. 186-193.
[9]Sullivan, J., Timmins, S., Williams P.A. 2001. Subdivisions bring weeds to native forests. *Forest and Bird*. November: 10.
[10]Randall, R.P. 2002. A Global Compendium of Weeds. R.G. & F.J. Richardson. Melbourne.
[11]Goddman, M.1999. Goddman's plant finder. New Zealand Plant Finder, Gisborne. 273 pp.

Figure 10. Key pest plant pathways.

5.1.2 National Pest Plant Accord (NPPA)

Widely acknowledged as a triumph of effective co-operation between industry and regulatory authorities, the NPPA has been in force since 2001. Its primary purpose is to reduce the sale of weedy species via retail nurseries pathway.

It is a voluntary initiative in that the species on the list are agreed between the stakeholders, the Nursery and Garden Industry Association, Regional Councils and government departments. However, it is also a regulatory tool in that once agreed, the species are declared "unwanted organisms" under the Biosecurity Act 1993 which prohibits the plants being sold, propagated or distributed.

The NPPA demonstrates the value of a partnership approach to achieve high levels of voluntary compliance among retailers, and improved awareness of potential weed problems among consumers. Yet there remains a widely held perception by pest managers that despite the gains made the industry is still a significant pathway for weeds.

A number of potential opportunities exist to better manage the pathway, either by refining the existing tool (NPPA), or developing additional tools.

One option is to carry out regular assessment and monitoring of the list and add new species when justifiable. Alternatively, a number of species which are already widespread in New Zealand might be removed from the list in favour of species which are emerging threats.

Other opportunities exist which target the consumer. A list of "bad plants" such as the NPPA prescribes may lead people to assume that plants not on the list must instead be "good plants". Clearly this is not true. It may be preferable to give people certainty as to which plants are definitely OK.

One example is the "Wellington Regional Native Plant Guide", available as a booklet, or an interactive website[40]. Every time a gardener chooses a local native plant, it precludes a potentially weedy plant being planted[41]. However, many gardeners don't wish to restrict their activity to native plants only, and nor need they. A "white list" of plants for aquaria and ponds already exists for New Zealand[42], and regional "Plant me instead" publications are complete for some regions (refer the Weedbusters case study 5.1.3).

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[40] http://www.bethedifference.gw.govt.nz

[41] Similar initiatives are common elsewhere in the country. Environment Bay of Plenty offers land management planting subsidy to landowners on the condition that locally sourced native plants are used.

[42] http://www.niwa.cri.nz/__data/assets/pdf_file/0008/28295/aquarium_low_risk.pdf
Clayton et. al. 2008(?). Plant Identification Guide – Low-risk aquarium and pond plants – Planting these in your pond or aquarium is environmentally friendly. Published by NIWA.

5.1.3 Weedbusters – Practical Advice and Raising Awareness[43]

Weedbusters comes under the umbrella goals of the New Zealand Biodiversity Strategy. Weedbusters is a weeds awareness and education programme that aims to protect New Zealand's environment from the increasing weed problem. Pest animals and plants (weeds) are the greatest threat to New Zealand's biodiversity. People play a large part in spreading environmental weeds, often without knowing it. Weedbusters aims to educate people and raise awareness to turn this problem around.

Weedbusters means action – taking part in weed issues is essential to limit the spread and establishment of weeds. And Weedbusters recognises there is a range of actions people can take, from simple ones in their own backyard, to joining with others on bigger projects in natural areas in their communities.
The Vision for Weedbusters:
New Zealanders are aware of and taking action to reduce the impact of weeds on the environment, economy and human health.

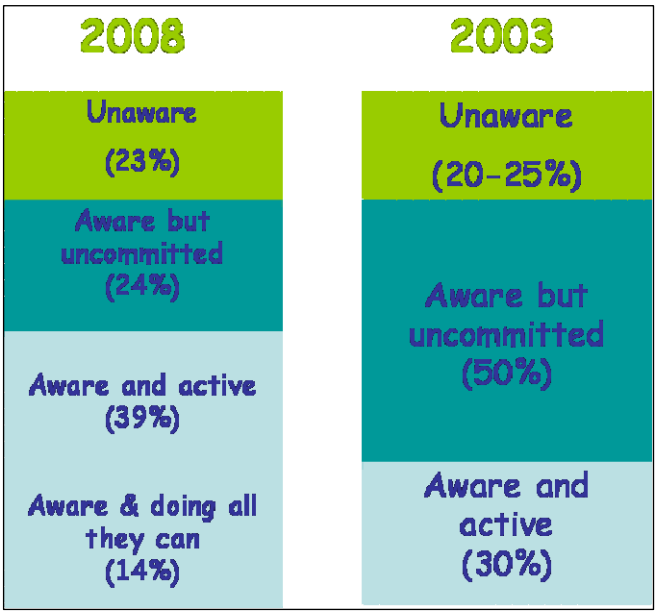

Figure 11. Practical Pathway Management Advice.

Weedbusters have engaged AC Nielsen to survey public perception of weed issues in 2003 and again in 2008. These surveys demonstrate a significant and positive shift in societal views on weed issues as demonstrated by the graphic below.

During this 5 year period the Weedbusters program was the only significant national initiative promoting weed awareness and behavioural change. Many now acknowledge that people are the main cause of weed spread, recognise their personal responsibility, and are making positive behavioural changes leading to action.

A further Weedbusters initiative directly relevant to pathway management is the development and publication of the popular “Plant me instead” regional series (not all regions completed yet).

[43] This material is taken mostly from the weed busters website http://weedbusters.co.nz and further information provided by Carolyn Lewis, National Co-ordinator.

Figure 12. Increasing awareness of weed issues.

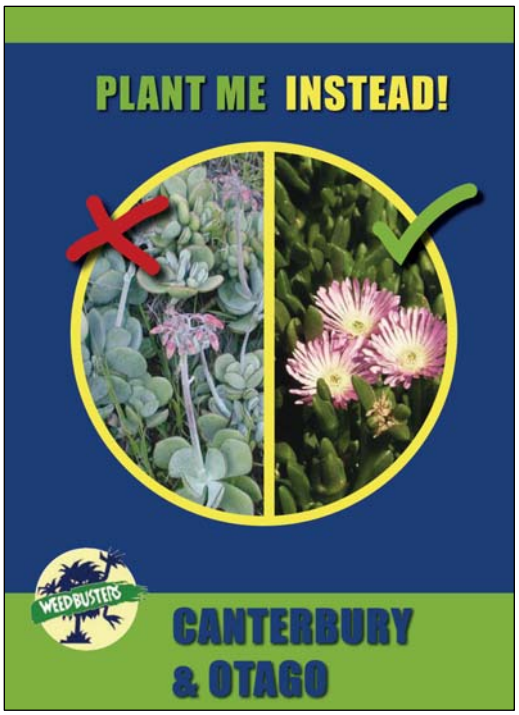

Figure 13. Example of a replacement approach.

These publications rely on local expertise to develop a list of undesirable species (irrespective of whether or not they occur in a Pest Management Strategy or the National Pest Plant Accord). For each weedy species, alternative species unlikely to be weedy are suggested, including both exotic and native species. These publications are freely available and with the visual appeal of the full colour photos have proven to be practical and popular.

5.1.4 The Wilding Kiwifruit Problem and the "Waste to Gold" Initiative

Kiwifruit *Actinidia deliciosa* is a major horticultural crop with the bulk of production in the Te Puke Area of the Bay of Plenty. Wilding kiwifruit sites have become established in many places in New Zealand, but are particularly prevalent in a 50 km^2 area around Te Puke with over 500 wilding kiwifruit sites identified.

A significant pathway is the feeding of reject kiwifruit to cattle and deer. Approximately 50,000 tons of such kiwifruit waste is disposed of every year by distributing it as livestock feed.

This results in kiwifruit being transported to many farm locations, where birds are then able to transport the small seeds into adjacent native bush areas. Some attempts have been made to cover the feed piles with windbreak netting to prevent bird access, as well as on farm staggering of feeding out to prevent mass ripening of the fruit. These initiatives have proven impractical in the context of farm management and have met with limited success.

One way to manage this troublesome pathway is to find an alternative use for the reject kiwifruit. Scion Research is investigating a range of sustainable and value added uses for kiwifruit as well as other organic waste via the "Waste 2 Gold"[44] project.

"Three examples Scion is already working on are:

1. ***Bugs to bioplastics** – we can turn your waste into biodegradable polymers using novel bacteria – a renewable substitute for existing petrochemical plastics.*
2. ***Waste to composites** – by mixing your waste with other materials, such as plastics, resins and additives, we are creating a range of novel products, including controlled-release fertilisers, biodegradable plant pots, panels, and other moulded plastic products.*
3. ***Biomass to energy** – we can convert residues into biogas, liquid biofuels, or solid energy systems (e.g. wood pellets for heating systems)."*

The feasibility of establishing a biogas plant in the Bay of Plenty is being considered by Zespri, New Zealand's kiwifruit marketing body, in partnership with Scion Research.

Figure 14. Kiwifruit is a creeping vine, seen here smothering native

[44] http://www.scionresearch.com/the+waste+2+gold+project.aspx

5.1.5 Land Development in the Waikato – Combining Regulatory and Co-operative Tools

Environment Waikato is proposing a Regional Pest Management Strategy Rule which will require land developers to pay a bond and adopt an agreed weed management plan if they are working in high risk areas.

Alligator weed readily established in pasture and cropping land, and its presence qualifies a site as high risk in the Waikato Region. This species is listed on the NPPA and is therefore listed as an unwanted organism under the Biosecurity Act 1993.

Figure 15. Alligator Weed

While the NPPA might effectively preclude the spread of alligator weed via retail nurseries, a range of additional risk pathways for the weed are identified by Environment Waikato, including:

- Soil movement (e.g. subdivision).
- Silage and other stock feed movements.
- Agricultural and drainage machinery.

In one example soil potentially containing alligator weed fragments was to be removed from a land development site. Utilising statutory powers under the Biosecurity Act 1993, Environment Waikato issued a "restricted place" notice preventing any unauthorised removal of soil material. This action was then further supported via constructive engagement with the developer to establish an agreed weed management plan.

Restricted place notices have also been issued to a recycling centre and a sand quarry where alligator weed is present.

People including machinery operators, cable diggers, utilities workers and various subcontractors are often not aware of the potential that their activities have to spread weeds. Many farmers and other landowners are similarly unaware of the ways by which their land could become infested by pests such as alligator weed.

Environment Waikato staff consider that a focus on improving awareness is pivotal to any strategy to manage pathways of agricultural weed spread. This applies particularly of farmers who ought to be financially motivated to impose border control at their farm gate. Efforts to date, including media releases and educational material appear to have had a very good uptake among farmers[45].

This case study demonstrates that effective pathway management may incorporate a range of complementary strategies.

[45] P Russell and W Mead pers. com., Environment Waikato.

5.1.6 Weed Spread via Agricultural Machinery – New Zealand Experience

A trend towards fewer and larger agricultural contractors exists, and this has resulted in agricultural machinery being regularly moved from farm to farm. Such movements, particularly of cultivation equipment, create a risk of transferring pest plants. Some examples are purple nutsedge, Chilean needle grass and Johnson grass.

Although no widely accepted written code of practice exists among New Zealand contractors, some basic approaches are recognised and includes three separate elements:

- In some cases farmers retire weed infested land, returning it to grazing.
- Contractors work un-infested sites first, leaving infested properties till last.
- Machinery cleaned when moving from infested areas.

Figure 15. A partnership approach to communications.

5.1.7Weed Spread via Machinery – Australian Experience

Landcare Notes

Machinery Hygiene

Geoffrey Tyers (Mildura), Charles Grech (Attwood), Natasha Baldyga (Bacchus Marsh)

January 2004
LC0425
ISSN 1329-833X

Introduction

This Landcare Note provides practical information about machinery hygiene and clean down procedures for equipment used in agriculture and roadside management

The Issue

The movement of machinery used in agriculture and roadside management is a major factor in the spread of weeds in Victoria. Landowners may inadvertently spread weeds, through daily routines, from paddock to paddock as well as to roadsides. The potential for weed spread has also increased with the use of equipment that travels vast distances between jobs.

Each year the number of noxious and environmental weed infestations being identified in Victoria has increased. Often the only plausible explanation for their presence is the movement of contaminated machinery and equipment.

Figure 1. Roadside slashing – large amounts of seed can be carried on top of the slashing deck.

Legislation

The relevant State legislation related to machinery hygiene is the Catchment and Land Protection (Amendment) Act 2003 *(CaLP Act)* under Section 70A. This section refers to "Removing particular vehicles or other things onto a road" which may be contaminated with plant material capable of growth. The legislation also enables the searching of a vehicle travelling on a road believed to be carrying weed contaminants.

Contaminants Causing Spread

The most common contaminants on machinery are weed seeds and other plant debris. Weed seeds and fruits, such as the spiny burr of caltrop; can adhere to tyres of machinery or implements. Other weed seeds, such as Chilean needle grass, can enter equipment cavities. Fine seeds can prove difficult to remove as they can penetrate deep into machinery such as harvesters.

Figure 2. Underside of contaminated mower.

Minimise Initial Contamination

Machinery, equipment and vehicle users should aim to limit the initial contamination to help reduce clean-down procedures.

Some useful practices include:

- Time and coordinate works prior to weed seeds maturing
- Ensure machinery operators are familiar with hygiene protocols and weed identification
- Map and monitor weed infestations
- Strategically designate clean down sites to minimise weed spread
- Work from non infested areas into infested areas
- Use the most appropriate machinery for the job to minimise soil disturbance and physical contact with seeds eg. offset mowers
- Avoid work during inclement weather

Victoria
The Place To Be

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A further detailed machinery hygiene guideline (43 pages) is available at http://www.weeds.org.au/WoNS/Chileanneedlegrass/docs/Machinery_Hygiene_Guidelines_for_Roadside_Managers.pdf

Agriculture Notes

Chilean Needle Grass: Slasher Cover for Reducing Chilean Needle Grass Spread

November 2007
AG1312
ISSN 1329-8062

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Introduction

This information note provides practical information about the design and use of slasher covers to reduce Chilean needle grass (*Nassella neesiana*, *CNG) spread along linear reserves.

The issue

Slashing of CNG is a common occurrence along roadsides and within agricultural areas for purposes of fuel reduction and pasture management.

The movement of tractors and slashers in agriculture and roadside management is a major factor in the spread of CNG. Machinery operators are inadvertently spreading CNG into clean linear reserves and paddocks through daily slashing routines. The potential for weed spread has also increased with the use of vehicles and equipment that travel long distances between jobs.

Slashing has also been known to encourage the formation of dense flat CNG swards as upright plants are eliminated.

Figure 1 - Assessing CNG seed contamination to a slasher at Sunbury

Legislation

The relevant State legislation related to machinery hygiene is Section 70A of the *Catchment and Land Protection Act 1994.* This section prohibits the movement of prescribed vehicles, machinery, equipment, hay, grain, fodder or livestock onto or off land without taking reasonable precautions to ensure they are free from noxious weed contamination. CNG is a proclaimed noxious weed throughout Victoria and Australia.

Trial setup and treatments

A RMIT Mechanical Engineering Masters project sponsored by the Commonwealth Weeds of National Significance program investigated slasher modifications to reduce weed spread. A model was developed using Computational Fluid Dynamics (CFD) to assess the best possible shape for a slasher cover to reduce CNG spread.

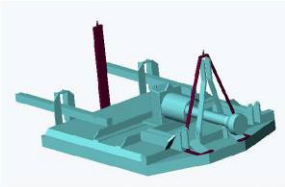


Figure 2 - Design changes (brown) to slasher deck (blue) for attachment of slasher cover

The design changes are simple to build and make no changes to the original slasher (fig 2.) A linear reserve site severely infested with CNG was selected at Sunbury to investigate slashing CNG (Fig 1). Three 200 meters transect lines of CNG were chosen to assess slasher CNG seed hygiene performance with and without the slasher modifications. The number and density of CNG plants and number of panicle seeds per plant was assessed before

slashing. The trial occurred during peak seeding in summer. This enabled an estimation of the total potential number of CNG seeds in the areas being slashed.

Figure 3 - Slasher with fitted cover being trialed at Sunbury

Results

- A "proof of concept" slasher cover has been developed to reduce slasher CNG seed contamination and spread (Figures 2 and 3).
- Within each 200 meter transect being slashed at Sunbury were approximately 1.5-2.0 million CNG panicle seeds.
- Without a cover, more than 16,000 CNG seeds were recovered from the slasher deck (Figure 4, Table 1).
- Adding a cover to the slasher resulted in a 99% reduction in CNG contamination with only 122 CNG seeds being recovered from the slasher deck (Table 1).

Table 1- Number of CNG panicle seeds recovered from slasher deck after slashing 200 meters of dense seeding CNG

Slasher modification	Number of recovered CNG seeds from slasher	% CNG seed reduction.
None	16,212	0
Cover	122	99

Management implications

- When CNG is slashed at seeding, slashers can become major vectors for CNG seed dispersal.
- A slasher cover and other modifications can reduce CNG seed collection on the slasher deck by more than 99%.
- Land managers and slasher contractors are encouraged to fit covers to their slashers to reduce weed spread.
- Slasher operators/contractors should be trained in CNG/weed identification and machinery hygiene.
- Slasher operators/contractors should have workplans to lsash "CNG/weed" areas last and to protect 'clean' areas and avoid working in weather when seeds will stick to machinery.
- Slasher operators/contractors should have appropriately located and monitored brushdown points where contaminated machinery is cleaned.

Figure 4 - CNG panicle seeds on slasher after slashing without cover

Further reading:

- Baldyga, N. & Grech, C. (2006) 'Machinery hygiene guidelines for roadside managers – Minimising the spread of Chilean need grass.' DPI Victoria. ISBN 74146 610 5.
- Grech C., McLaren D.A., Chapman D.F. & Sindel B.M. (2005) Chilean needle grass (*Nassella neesiana*) - Integrated grazing for success. In 'Tussock Terminators Research Forum', Albury, pp. 11-14.
- Grech C. (2007) Chilean needle grass: Managing seed production by slashing. AgNote AG1308. Department of Primary Industries, Victoria.
- Tyers, G., Grech, C. & Baldyga, N. (2004) 'Machinery Hygiene,' Department of Primary Industries, Victoria, *Landcare Note* LC0425.

Acknowledgments

The Weeds of National Significance program through the Natural Heritage Trust for funding the project. The Hume City Council for use of their slasher and trial site management. The CRC for Australian Weed Management.

Photos: David McLaren.

The advice provided in this publication is intended as a source of information only. Always read the label before using any of the products mentioned. The State of Victoria and its employees do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

The preceding two pages are example pages of documents available at http://www.dpi.vic.gov.au/dpi/nreninf.nsf/Home+Page/DPI+InfoSeries~Home+Page?open and enter the search term LC0425.

The Agricultural Contractors of Tasmania have developed a written Code of Practice in 2003 with assistance from the Department of Primary Industries, Water and Environment, Tasmania. This code remains current and is focused exclusively to weed hygiene. The purpose of the code is variously stated;

"It stresses the enduring value of a job well done and of working in a manner that demonstrates fairness, honesty, accountability and a duty of care to the natural environment…..
At this time, the code of practice addresses a single issue – weed hygiene. The spread of weeds by vehicles, machinery and equipment used by agricultural contractors has many unwanted consequences. …. Ultimately, the viability of any agricultural contracting business is reduced if a reputation for poor weed hygiene is allowed to develop. Thus, there are many good reasons for establishing a standard for best practice in relation to limiting weed spread by agricultural contractors."

A number of further written codes and best practice documents exist in Australia in relation to weed spread, as summarised below and for further information.

Movement of Contaminated Vehicles

National/ State/ Region	Outcome Sought	Mechanism/ Activity/Tool	Description
NT	Management of weeds on rail corridors – prevents weed spread	Weed Management Procedure	Procedure written for the identification and control of weeds along NT Rail corridors. The rail network is seen as an important corridor for weeds. http://www.aarc.com.au/
NT	Minimise spread by contaminated vehicles.	Management Plan	Hay Industry Weed Management Plan – For use as a guide by hay producers. Includes farm hygiene practices and purchasing of clean seed Northern Territory Agricultural Association Incorporated, PO Box 2243 Katherine NT 0851. Phone (08) 8972d 3440, Fax (08) 8972 3441.
NT	Minimise movement of seeds by vehicles and machinery	Codes of Practice	DBIRD Extractive Industry Association Code of Practice http://www.nt.gov.au/dpifm/
NT		Agreement	NT Transport Industry Association – an "in principle agreement" http://www.atant.asn.au/
NSW	Prevent parthenium entering NSW	Cross border inspections	Ensure that harvesters and other designated machinery are free of notifiable noxious weed material. http://www.biodiversity.ea.gov.au/biodiversity/invasive/publications/p-hysterophorus.html
NSW	Prevent spread of Giant Parramatta grass by vehicles etc	Protocol	Protocol for vehicles and machinery to prevent the spread of Giant Parramatta grass http://www.bookshop.nsw.gov.au/pubdetails.jsp?publication=5084
Qld	Minimise movement of seeds by vehicles and machinery	Guidelines	Guidelines prepared for vehicle/machinery cleaning, inspection and construction of wash down facilities. http://www.nrm.qld.gov.au/pests/weeds/weed_spread/washdown/index.html
Qld	Written assurance a vehicle etc is clean prior to entry	Vendor Declarations	Weed Hygiene Declaration contains a section for the transport of contaminated things, including grain. http://www.nrm.qld.gov.au/pests/weeds/weed_spread/legal/weed_hygiene_dec.html http://www.saleyards.info/svpictures/n_576.pdf
SA	Prevent spread into NSW of crop weeds	Cross border inspections	Ensure that harvesters entering SA are free of proclaimed weeds http://www.agric.nsw.gov.au/reader/1981
Tas	Minimise movement of seeds by vehicles and machinery	Code of Practice	Agricultural Contractors of Tasmania Inc. Presently only addresses weed hygiene, primarily the spread of weeds by machinery http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/OTRG-5RY3NA?open
Tas	Informing farmers on how to minimise spread by machinery	Brochure	Tasmanian Rural Industries – Farm Hygiene. Details how to minimise the spread – including spread by machinery
Tas	Ensure that employees and contractors are not spreading weed seeds	Environmental Management System – Work Instruction	Aurora Work instructions have been developed to assist company employees and contractors to comply with legislations and Weed Plans. Emphasis on vehicle and equipment hygiene http://www.auroraenergy.com.au/
Vict	Informing the general public on what to do to minimise spread	Brochure	Landcare Notes – How weeds spread Details how weeds are spread and how to minimise the spread. – including spread by machinery http://www.dpi.vic.gov.au/dpi/nreninf.nsf/childdocs/-9B2A7AB4FD562D03CA256BC800058E91-CFDA3D3A34BB72EDCA256BC8000629A6-809521AFF6EC9A7B4A256DEA00294A9B-47FD30E0F8A2446FCA256BCF000AD36A?open
Vict	Minimise spread by slashers	Product Development	Research has lead to new slasher designs to minimise the spread of weeds caused by the lodgement of seeds during slashing and their later release. http://www.weeds.org.au/WoNS/Chileanneedlegrass/CNGNews.pdf
Vict	Minimise spread by	Vendor Declaration	Weedstop Program

Movement of Contaminated Vehicles

National/ State/ Region	Outcome Sought	Mechanism/ Activity/Tool	Description
	vehicles and machinery		Log book for contractors Vendor declaration for land managers http://www.wsvic.org.au/weedscene/Weedscene%2015_4.pdf
Vict – (Surfcoast Shire)	Ensure that employees and contractors are not spreading weed seeds	Industry Standard	Earthmoving, Civil Construction & Agricultural Contractors Industry Standard for Prevention of assisted weed spread.
Vict – (Surfcoast Shire)	Ensure that contractors are not spreading weed seeds	Work Book	Environmentally Aware Contractors Operator's work book - Provides guidelines in vehicle hygiene http://www.loc-gov-focus.aus.net/editions/1999/july/green/cont.shtml
Vict – (Surfcoast Shire)	Ensure that contractors are not spreading weed seeds	Code of Practice	Code of Practice to prevent the assisted spread of noxious weeds. Developed by Environmentally Aware Contractors funded by Dept. of Nat. Res. & Environment. http://www.loc-gov-focus.aus.net/editions/1999/july/green/cont.shtml
WA	Educating farmers on how they can prevent weed seeds onto and from their property	Promoting farmers rights - includes brochure	Empowering farmers to practice 'farm biosecurity' on their property. Including the need for all machinery, vehicles, bins etc to be clean prior to entry or only come onto designated areas. http://agspsrv38.agric.wa.gov.au/pls/portal30/docs/folder/ikmp/pw/Fn071_2002.pdf

5.2 TERRESTRIAL PATHWAYS – PEST ANIMALS AND DISEASES

5.2.1 Wild Animals – Where is a regulatory approach effective?

The Department of Conservation (the Department) administers the Wild Animal Control Act 1977 (the Act). This Act prohibits the capture and release of wild animals except under written authority, and also provides for statutory regulation of deer farming by *Gazette* notice.

We can broadly contrast the effectiveness of these provisions.

The Act provides, by Gazette Notice, where the farming of different species of deer is allowed or prohibited, and sets perimeter fence standards for deer farms. The 1984 *Gazette* Notice has been reviewed and replaced with a 2008 Notice. This review process includes industry consultation. Levels of compliance are high, and this regulatory tool has proven to be quite effective.

The release of wild animals such as deer, pigs, thar etc. for hunting purposes is prohibited. However, wild animals can be caught and released surreptitiously, and this practice is believed to be widespread. It is difficult to prove who might have released wild animals into an area, and accordingly enforcement action of such activities under the Act is rare.

Prohibiting the capture and release of wild animals serves a purpose in that it dissuades those who feel bound to comply with NZ Statutes from moving animals about. But the provisions have proven somewhat ineffective where participants do not feel bound to comply.

The practical outworking of this reality is that the Department manages these hunter mediated pathways by eradication. Where wild animals are introduced to an area, and are expected to cause unacceptable future pest impacts, the Department will undertake control with a view to eradication. This applies both on Conservation lands, and on private land.

The purpose of this policy is to discourage further releases. The considerable effort required to capture and transfer wild animals is less likely to be undertaken if the participant knows the Department will kill the animals anyway.

This strategy has proven effective in the Twizel area where the Department will actively follow up eradication of any new populations of pigs, thar or wallaby. While the Department has taken a low key approach, most landowners now actively discourage releases on their land. In other cases landowners have undertaken control of new populations themselves to prevent Department involvement[46].

[46] M. Beardsley, DOC, pers. comm.

5.2.2 Slowing Spread of Kauri Dieback

Formally identified in 2008, *Phytophthora* taxon Agathis (PTA) is known to affect nationally significant Kauri trees. Collaborative management efforts include slowing the further spread of the soil pathogen by encouraging appropriate behaviours such as keeping to tracks and ensuring footwear and other equipment is clean when entering or leaving kauri forest areas.

Agencies join forces to fight kauri disease

Six government agencies have joined forces to try to stop the spread of a disease that affects kauri trees.

The newly identified disease – Kauri dieback (*Phytophthora* taxon Agathis or PTA) – has been confirmed as attacking trees in Northland, Auckland and on Great Barrier Island.

The six agencies – MAF Biosecurity New Zealand (MAFBNZ), the Department of Conservation (DOC) and four regional councils, Auckland Regional Council, Northland Regional Council, Environment Bay of Plenty and Environment Waikato – have set up a response team to identify and manage the risks to kauri.

Kauri is a nationally and regionally significant species that is a Taonga of great significance to Māori and has cultural value for many New Zealanders. Kauri are among the worlds tallest trees and once covered much of the upper North Island. They are part of New Zealand's history, and an essential part of the ecosystem as they are home to many other trees, plants and threatened wildlife.

A collaborative effort is needed to ensure the survival of kauri as a species. The six agencies working together to protect kauri, known as the Joint Agency Response team, have committed to co-ordinating a management approach across all land in affected regions.

While each agency involved has unique expertise to offer the response, all share a common mandate to protect New Zealand's environmental, social and cultural values.

PTA, or kauri dieback as it's more commonly known, is a serious threat to kauri forest and individual kauri trees in the upper North Island. Believed to be a soil-borne disease caused by a soil pathogen, PTA is specific to kauri and can kill trees and seedlings of all ages. Affected trees show yellowing leaves, canopy thinning, dead branches and lesions that bleed resin across the lower part of the trunk.

It is believed to be spread mainly through soil and soil water movement, and it is strongly suspected PTA can be transferred by people, tracked from place to place on shoes, equipment and tyres.

PTA has been found at sites in the Waitakere Ranges Regional Park and at DOC reserves at Great Barrier and Trounson Kauri Park in Northland. Symptoms of kauri dieback have also been observed in other areas within the greater Auckland region.

Formally identified in April 2008, this *Phytophthora* is new to science and there is limited information on its impacts, how it spreads and effective treatments, and there is currently no known cure. A technical advisory group (TAG) has been established to provide the Joint Agency Response team with information and advice as to the biology, ecology and potential surveillance and management tools for this *Phytophthora*. The TAG has identified areas of research that need to be undertaken so that a better understanding of the disease is obtained and appropriate measures are put in place to manage it.

"This information will allow us to develop future management plans and a co-ordinated way forward that ensures kauri ecosystems and individual trees are protected. We are aiming to have these plans finalised by the end of February," Joint Agency Response Manager Fiona Bancroft says.

The Joint Agency Response team has prioritised immediate research in three particular areas: getting good methodology in place by optimising sampling and diagnostic techniques; defining symptoms that can be linked to PTA; and developing detailed best practices, including control/hygiene methods to limit any further spread. The research will be contracted and take place over the coming months as environmental conditions make it feasible.

Canopy thinning and bleeding lesions on kauri trees as a result of kauri dieback. Photo courtesy Auckland Regional Council.

Until more is known about PTA, one of the strongest chances of containing it lies with public education. The Joint Agency Response team has been liaising with iwi, local councils and landowners in the Upper North Island, as well as members of the public using kauri areas, asking for their help in stopping the disease from spreading further.

Information sheets and track signs have been distributed encouraging simple behaviours people can adopt right now to stop further spread – namely keeping to defined tracks in parks and reserves, and cleaning footwear and tyres, or any other equipment that comes into contact with soil, before and after leaving kauri forest areas.

A specially created website – www.kauridieback.co.nz – has been set up by the Joint Agency Response team to provide more information, including details about particular regions. A free phone number – 0800 NZ KAURI – has also been set up so that the most up-to-date information is readily available 24 hours a day, seven days a week.

The Joint Agency Response team is striving to ensure the integrity of kauri ecosystems, protect high value kauri areas and iconic kauri trees.

■ Lisa Gibbison, Communications Adviser, MAFBNZ, lisa.gibbison@maf.govt.nz

5.2.3 Sudden Oak Death *Phytophthora ramorum*

Until 2000, *Phytophthora ramorum*, the causal agent of Sudden Oak Death, was undiscovered and unnamed. This fungus is the cause of much concern in North America and Europe due to three factors: (i) the high level of local destruction it causes in California, (ii) the lack of knowledge of its epidemiology (due to its recent discovery), and (iii) its high prevalence in nurseries (which increases the potential of spread to a new location and/or country). The fungus has an extensive host range, covering many plant genera and several families and including trees and shrubs and woody and herbaceous perennials. *P. ramorum* causes canker development, shoot drooping and leaf blight. Fungal spores spread to new locations mainly by the nursery trade and are spread locally by vectors: soil, water and articles associated with humans[47].

Management approaches in the United States to reduce human mediated pathways of spread include regulation of plant movement, as well as relying on public awareness and education to ensure effective sanitary procedures are observed.

[47] This information primarily sourced from www.issg.org which relies in turn on key sources Sansford, Jones and Brasier, 2003. Pest Risk Analysis: Phytopthora ramorum. And Garbelotto, 2004. Sudden Oak Death: A Tale of Two Continents.

5.2.4 Bovine Tuberculosis – Movement Control

The Animal Health Board (AHB) implements the National Pest Management Strategy (NPMS) for Bovine Tuberculosis. The primary objective of the NPMS is to reduce the number of Tb-infected cattle and deer herds in New Zealand to a 0.2 % Annual Period Prevalence rate by 2012/13. That equates to having about 50 infected herds nationally (at current national herd numbers). The strategy includes three complementary elements towards the objective:

1. Test and cull
2. Feral vector control
3. Movement control

Of these, livestock movement control is a well known example of pathway management. One of the ways bovine Tb is spread is by the uncontrolled movement of infected cattle or deer. To help manage this risk, the AHB has developed Movement Control Areas (MCAs) in which certain movement restrictions apply. Any cattle or deer over 90 days old must have a pre-movement test within 60 days prior to being moved from any property within an MCA[48].

Movement control is managed and enforced by regulation. Prior to being moved, all cattle or deer more than one month old must be correctly identified with AHB approved ear tags. And a full Animal Status Declaration Form must go with the animals.

The measures are widely recognised and accepted in the industry, including farmers themselves and stock freighters.

[48] Does not apply where stock is being sent directly for slaughter.

5.2.5 Cattle Ticks – Role of Southland's RPMS in Pathway Management

Many Regional Pest Management Strategies (RPMS) include "surveillance" pests, being species not known to be present in the region. It is prohibited to release, spread, propagate or sell any pest in an RPMS by virtue of sections 52 and 53 of the Biosecurity Act 1993.

Environment Southland includes an additional category of "exclusion" pests in its RPMS. These species are subject to surveillance activities, as well as addressing the pathways by which the species might arrive or be spread[49].

Cattle ticks are an example of an Environment Southland "exclusion" pest, with a rule specifically addressing pathway management:

Rule

Owners of livestock (sheep, cattle and deer) being transported into or within Southland must ensure these stock are free from cattle ticks.

Figure 16. Severe cattle tick infestation in the ear of a deer.

Cattle ticks were first discovered in Southland herds in the summer of 2000 and there have been two isolated cases reported in 2001 and 2002. They relish warmth and humidity and summer is the time they're most likely to appear.

When cattle ticks were first discovered in Southland in 2000, a lot of livestock was being transported south and it was widely assumed they arrived here on the backs of North Island cattle. But according to ES Biosecurity Manager Richard Bowman, cattle ticks are not at all fussy about which species they hitch a ride on and all farmers needed to exercise caution and common sense when it comes to buying or moving stock.

Once they become established, they are very difficult to get rid of and could prove a considerable and costly burden for farmers. They take blood from animals, puncture hides, reduce the animal's vigor and vitality and severe infestations can result in livestock mortality especially in young animals. When bringing animals into Southland from tick infested areas they are to be dipped with the appropriate products before transport, and quarantined and treated again when they arrive at the property.

[49] Information and image courtesy of Richard Bowman, Environment Southland.

5.2.6 Avian Diseases

Pathway management is a well recognised tool in disease management. The short lifecycle and explosive reproductive rates of most disease organisms means that prevention of spread is an important aspect.

In large commercial operations comprehensive hygiene and disease management practices must be observed to maintain bird health. At a smaller and less intensive scales birds tend to be less susceptible to disease, and many private bird owners may be less conscious of potential risks. Disease spread via non-commercial pathways would become significant if a disease such as avian influenza were to arrive on our shores.

Accordingly, some effort is being targeted to raising awareness and encouraging appropriate behaviours among private bird owners, as illustrated by the figure below.

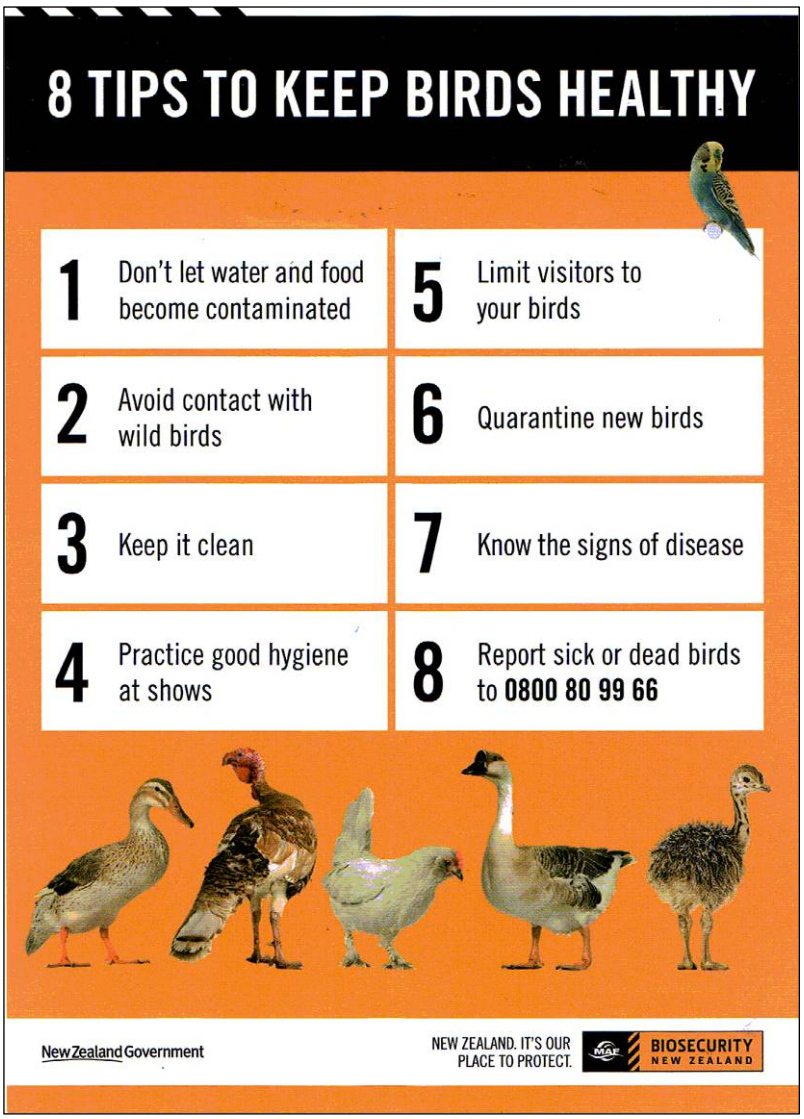


Figure 17. Communication of simple messages.

5.2.7 Hauraki Gulf Biosecurity – The "Benchmark" species concept[50]

The Hauraki Gulf Controlled Area (HGCA) was declared by public notice in 1998 and in accordance with section 131 of the Biosecurity Act 1993.

A number of islands in the Gulf are nationally important wildlife sanctuaries, such as Tiritiri Matangi, Hauturu and Great Barrier Island. Many of the islands within the Gulf do not have the same pest problems as those on the mainland, and therefore present a unique opportunity to maintain and improve the pest-free or low pest presence within the Gulf.

Because of the high and increasing visitation rates of vessels within the Hauraki Gulf, it can be assumed that the risk of pest incursions is also rising. This risk is further compounded by the number of island residents and visitors moving goods to and between islands. It can be assumed that there are risks associated with movement of vessels and goods therefore biosecurity procedures will need to be improved and consistently applied in order to minimise these risks.

The general approach taken within the HGCA Management Plan is to focus on the management of risk pathways, rather than management of specific risk organisms. However, the methods used to manage risk pathways will vary depending on the risk organisms considered to be a significant threat along that pathway. Pathways are described both in terms of risk goods and mode of transport. Risk goods include landscaping supplies, aggregate, plants, animal feed, livestock, rubbish, used vehicles and buildings. Buildings are subject to a certificate of compliance prior to movement. Modes of transport identified include commercial freight and passenger traffic, aircraft, private and fishing vessels.

Included among the various stated management initiatives is the concept of a "benchmark risk organism". Argentine ant is the proposed "benchmark risk organism" for which the implementation of new biosecurity management options aims to prevent new incursions. By ensuring that Argentine ants are prevented from being transported within the HGCA, other risk organisms (e.g. rodents) should also be prevented by default, because the number and standard of measures required to exclude Argentine ants is greater than for any other known pest species.

Nominating a "benchmark risk organism" in this way is a useful notion when considering options for managing pathways which can move multiple risk organisms.

[50] This case study sourced with thanks from Auckland Regional Council's "*Biosecurity Management Plan for the Hauraki Gulf Controlled Area – A biosecurity plan to help prevent the entry and establishment of pests into the Hauraki Gulf Controlled Area*. 12 March 2009". [The "HGCA Management Plan".]

5.3 FRESHWATER PATHWAYS

5.3.1 Didymo – Check, Clean, Dry

Didymosphenia geminata (didymo), also known as "rock snot" is a freshwater diatom (a type of alga) and was first reported in New Zealand in the Lower Waiau River in 2004. Didymo is currently found in a number of South Island Rivers. Biosecurity New Zealand has since declared the entire South Island a Controlled Area for Didymo. This means waterways remain open to angling and other recreational activities, but people are legally obliged to prevent the spreading of didymo. Didymo is a microscopic pest that can be spread by a single drop of water.

Early efforts to manage the spread of didymo relied heavily on regulatory measures under the Biosecurity Act 1993 (restricted or controlled place measures). Such measures were quickly found to be somewhat ineffective and difficult to enforce. Accordingly the focus moved to managing behaviour of users via a strong social marketing programme.

Now well known, the "Check, Clean, Dry" campaign remains the centerpiece of the MAF Biosecurity New Zealand led partnership *Didymo Long-Term Management Programme*[51]. The partnership continues to communicate consistent messages often and through many different channels. The communication campaign is widened to include the spread of aquatic pests in general, a goal to which the "Check, Clean, Dry" concept lends itself particularly well.

Figure 18. Renegade alga: New Zealand Fish and Game Officer Stu Sutherland holds gobs of "didymo" alga blooming on the Mararoa

"We need people to clean their equipment after using any river in the South Island.

If you are moving items between waterways you must:
Check: Before leaving the river, remove all obvious clumps of algae and look for hidden clumps. Leave them at the affected site. If you find any later, do not wash them down drains. Treat them with the approved cleaning methods below, dry them and put them in a rubbish bin.
Clean: Soak and scrub all items for at least one minute in either, hot (60°C) water, a two percent solution of household bleach or a five percent solution of salt, nappy cleaner, antiseptic hand cleaner or dishwashing detergent. A two percent solution is 200 ml, a five percent solution is 500 ml (two large cups), with water added to make 10 litres.
Dry: If cleaning is not practical (i.e. livestock), after the item is completely dry to touch, wait an additional 48 hours before contact or use in any other way.

Under no circumstances should water, fish, rocks, plants or other items be moved from an affected waterway to an unaffected waterway."

51 MAF Biosecurity Information Paper No: 2007/03. August 2007.

5.3.2 Rotorua Lakes – Pathway Management of Fish and Macrophytes[52]

While Rotorua Lakes and their catchments are already substantially modified, immediate risk of further introductions of pest populations (either fish or macrophytes) and further degradation exists. And these risks are primarily via human mediated pathways such as boating and fishing.

Potential source populations exist within the region, as well as neighbouring Waikato region where aquatic weeds and pest fish are more prevalent.

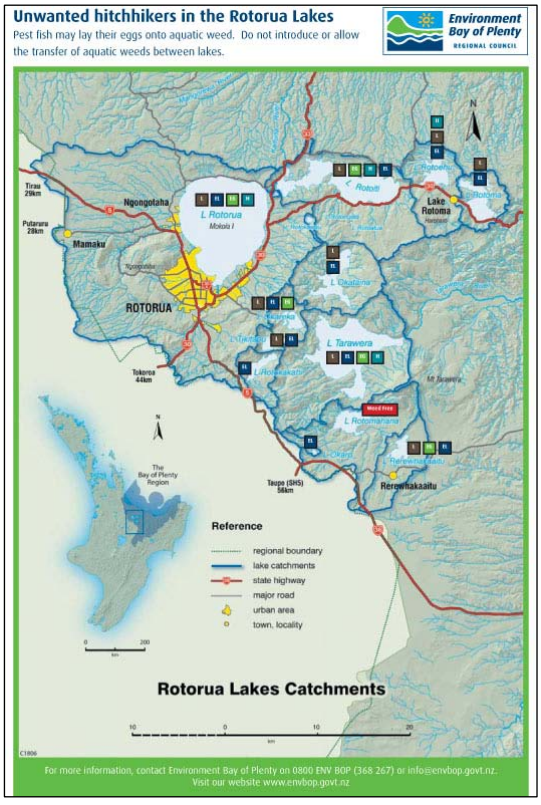
A range of management initiatives is applied to mitigate the risk of new pest populations becoming established, including;

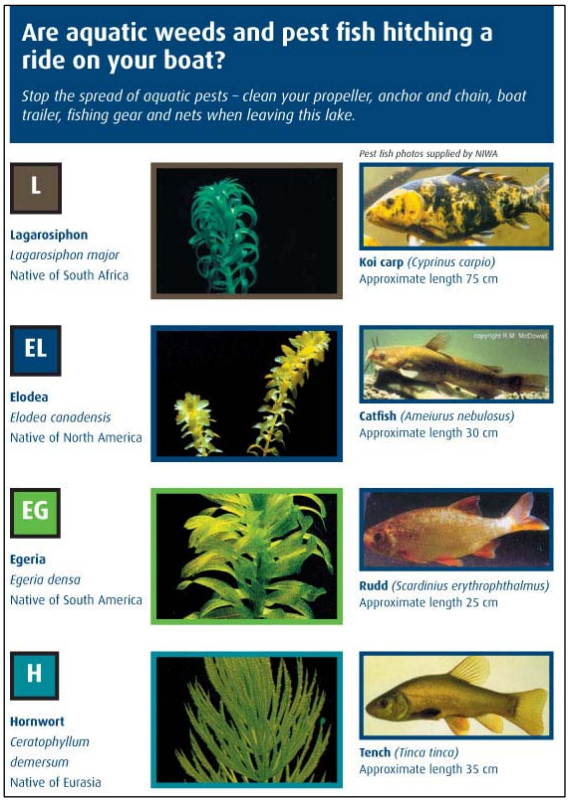
Co-ordination

As identified in recent thinkpieces for MAF Biosecurity New Zealand (Hellstrom et al. 2008, Willis 2008), responsibility and jurisdiction in the freshwater environment are somewhat unclear, and overlapping. Formation of the Aquatic Pest Technical Advisory Group (APTAG) is a constructive approach which attempts to overcome these realities, and includes representatives from Local and Regional Councils, Fish and Game, local Iwi, Department of Conservation, Land Information NZ. This group is considered to be proactive and effective.

Education and Awareness

An ongoing campaign of communication is pursued. Relatively passive means of communication include signs on road ways and at boat ramps, and promotional material such as brochures. More active communication is achieved via a summer programme which employs tertiary students to deliver the message personally at boat ramps, to fishers, and other lake users. In school visits and demonstration aquaria showing the siltation effects of koi carp further achieve active engagement. Surveys completed by Environment Bay of Plenty





[52] Information and images provided courtesy of Environment Bay of Plenty.

demonstrate a significant increase in awareness from 2004 to 2006.

A further effective communication tool is the use of electronic signs at boat ramps. These only come on to display their message when a vehicle drives over an in ground pressure plate switch e.g. “Clean your boat and trailer now”. This method of signage is highly visible and personal, and is now being further supported with the provision of boat washdown facilities at the more popular boat ramps.

Active Management

New incursions are actively controlled with a view to eradication. The commonly used tool in the case of aquatic weeds is Diquat. This action protects the site itself from a new pest population establishing, and also prevents the site from becoming a new source for potential transfer of the species to other locations.

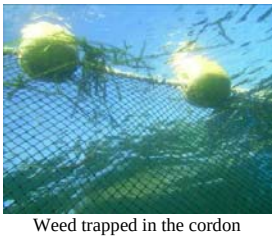
Further control of aquatic weeds is undertaken in the vicinity of boat ramps where risk weeds occur. This reduced the chance that boats will become contaminated with weeds.

Associated with lakes management, river users are also targeted. The “Moa Man” multi-sporting event, for instance, requires that all kayaks are inspected and have a sticker attached confirming they are clean prior to going into the river.

Environment Bay of Plenty takes an active interest in ensuring that macrophyte harvesting machinery originating from the Waikato is meticulously cleaned prior to deployment in the Rotorua lakes.

Weed Cordon

A final initiative still in trial stage is the use of weed cordons. These weed cordons can be used both to prevent weeds becoming established in a new place, or to assist in excluding weed from the vicinity of boat ramps in infested lakes. The first trial is in Lake Rotoma which is free of both hornwort and egeria.


Weed trapped in the cordon


Cordon deployed in Lake Rotoma


Cordon construction (chain at base)

This project is led by Environment Bay of Plenty, with support from other agencies. Notably, Sanford Fisheries supplied the trawl net material and custom built the cordon at no cost. Such community minded action evidences many New Zealander’s commitment to act in an environmentally responsible manner.

The cordon deployed at Lake Rotoma is expected to deliver the following benefits:

- Prevent the spread of weed fragments if they are inadvertently introduced at the boat ramp.


Summer student hired to spread the word

- Enable a confined area of the Lake to be regularly monitored for new weed incursions.

The holistic approach and co-operative action results in a highly visible program around the Rotorua Lakes. Lake and river users cannot help but be exposed to the issues, driving public awareness and support to high levels.

Zebra Mussels, *Dreissena polymorpha*[53]

Zebra mussels were first introduced into North America in the mid-1980s and since then have rapidly spread throughout the Great Lakes Region, the Mississippi River drainage, and many other waterways east of the Rocky Mountains. The most likely source of introduction was ballast water from an ocean-crossing commercial vessel. Their subsequent dispersal can, in large part, be attributed to boat/barge traffic within the inland water systems.

The zebra mussel, though small in size, has become the most troublesome freshwater biofouling organism in North America. Once a single mussel is in place, others settle on or around it. The colonization increases until a pipe or an opening is partially or completely blocked or equipment is fouled to the point of being unusable. Since the introduction of the species in the mid-1980s, the zebra mussel has caused an estimated expense of hundreds of millions of dollars (O'Neill 1996, 1997).

To lessen their rate of spreading, perhaps the most effective approach is to increase public awareness, education, and concern. It is simpler and far less costly to prevent a problem from arising than it is to treat it once it has become established. Recreational boaters, anglers, and commercial barges all need to take great care to avoid the transfer of zebra mussel "stowaways."

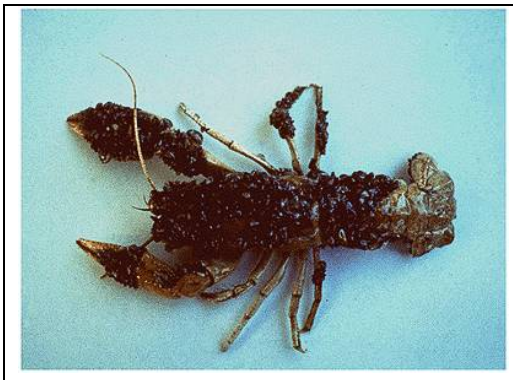


Figure 18. Mussels attached to lobster.

Figure 19. Mussels attached to weed.

Risk Management

The threat to western waters posed by zebra mussels and other nonindigenous aquatic species has fostered a cooperative effort by resource agencies called the 100th Meridian Initiative[54] to prevent or slow their movement west of this meridian (Drees 1998). Efforts include public awareness and education programmes, including recommendations for boat owners to prevent the transfer of the mussels.

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[53] The above information was taken from http://el.erdc.usace.army.mil/zebra. To slow the human mediated spread of this species US agencies rely primarily on public awareness programs, education, and cooperative compliance.
www.100thmeridian.org this site includes a .pdf file summarising both the zebra and quagga mussel problem, and a detailed boat cleaning protocol; David K. Britton, Ph.D. 2007. Western Quagga mussels – background information. U.S. Fish & Wildlife Service.
That document also asks; "*How can we prevent additional spread? Short Answer: Educate boaters.*"

5.4 MARINE PATHWAYS

5.4.1 Top of the South

The Top of the South Marine Biosecurity Partnership co-ordinated by MAF Biosecurity New Zealand is expected to release a long term strategic plan in early 2009. The draft *Top of the South Island Marine Biosecurity Strategic Plan*[55] includes in its purpose statement an intention to prevent the introduction, and minimise the spread, of damaging marine species.

The region has previously suffered an incursion of *Didemnum vexillum* via a hull fouling of a commercial barge originating from the Port of Tauranga. *Didemnum* management costs to the aquaculture industry are now estimated at about $750,000 per year. This incursion factored strongly in the establishment of the Partnership. A later example of marine biosecurity breach involved a mining structure, the "Ocean Patriot", which included the South African mussel *Perna perna* in its biofouling load. This species was not previously present in New Zealand, and the cleaning of the structure in Tasman Bay delivered a potentially viable population of the mussels onto the seabed. This population was later surveyed and dredged to remove the mussels.

Detailed pathway management actions have yet to be developed under the strategy. However the partners have a track record of positive action including:

- Voluntary codes of practice in the marine farming sector to encourage behaviours which reduce the risks posed by marine pests.
- Communications programmes to raise awareness and encourage hull cleaning (Although a lack of awareness of the consequences of hull fouling is identified as a significant issue)
- Development of control tools, e.g. pile wrapping for control of *Didemnum*

This Partnership approach to marine pathway management will be an interesting model as it develops.

5.4.2 Toxic Algae Bloom Affects Mussel Spat Supply – *Gymnodinium catenatum*

A toxic bloom developed around the coast of the North Island of New Zealand between May 2000 and February 2001. Translocation of juvenile shellfish from affected to non-affected areas was therefore banned to reduce the spread of *G. catenatum* cysts. This resulted in significant impacts on the commercial shellfish industry, as the prime locations for collecting juvenile "seed" mussels and oysters were within the affected area.

The bloom appears to have developed in the vicinity of the Manukau Harbour before spreading north up the west coast to Ninety Mile Beach, south to Wellington Harbour, and then north up the east coast to Hawke Bay (Mackenzie & Beauchamp[56]). Sampling undertaken in 2001 detected *G. catenatum* cysts in the shipping ports of Manukau Harbour, Taharoa, Port Taranaki, Wellington harbour and Port of Napier. Cells were also found in Port Taranaki, Wellington Harbour, Port of Napier and Tauranga Harbour. Ports Gore and Underwood in the Marlborough Sounds were the only South Island locations where the presence of *G. catenatum* was detected (Taylor & MacKenzie, 2001[57]).

[55] In Prep – MAF Biosecurity New Zealand, Peter Lawless 2009. Top of the South Island Marine Biosecurity Strategic Plan. In Prep.
[56] Taylor, M. D., and MacKenzie, L. A. 2001. Delimitation survey of the toxic dinoflagellate Gymnodium catenatum in New Zealand.
[57] Mackenzie, L.; Beauchamp, T. (2000) *Gymnodinium catenatum* in New Zealand: a new problem for public health and the shellfish industry. Cawthron Report No. 633

Impacts:
Economic/Livelihoods: The toxic bloom significantly affected the shellfish-growing industry that relied on spat (juvenile shellfish) from affected areas.
Pathogenic: A voluntary shellfish-gathering ban was imposed on over 1500 km of coastline due to the risk of paralytic shellfish poisoning (PSP) in humans.

Risk Management

The industry continues to closely monitor for *G. catenatum*, voluntarily prohibiting any collection of spat as necessary. These initiatives are considered an example of effective pathway management. Cawthron Institute Research has variously contributed to other management techniques, including freshwater treatment to treat collected spat[58].

Voluntary industry codes of practice have been developed[59], and while giving those regulatory status remains an option, that is considered unnecessary. This example highlights the utility of voluntary Codes of Practice particularly where the industry concerned stands to suffer the consequences of transferring pests.

[58] M. Mandeno, Aquaculture New Zealand pers. com.
[59] NEW ZEALAND MUSSEL INDUSTRY COUNCIL LTD CODE OF PRACTICE FOR TRANSFER OF MUSSEL SEED. Available from Aquaculture NZ, M. Mandeno pers com.

5.4.3 Biosecurity Initiative for the Chatham Islands

Internal borders are a form of geographical barrier restricting movement of organisms. This can include rivers or ranges, while the sea separates New Zealand's many islands. Such natural barriers provide potential opportunities to manage human mediated pathways.

The 2005-2006 Chatham Island Biosecurity and Quarantine Strategy examples a holistic approach to preventing unwanted pests reaching the islands. Despite their long history of habitation, the islands remain free of many pests.

The physical connections between the Chathams and New Zealand provide risk pathways by which pests could transfer to the islands. By targeting these connections a wide range of pest organisms can be managed.

Pathways identified for the marine environment include hull fouling, ballast water discharge and fishing gear. Pathways for the terrestrial and freshwater environments include small boat traffic, and commercial air and sea transport.

These pathways are managed via a range of initiatives, elements of which include[60]:

- Integrated pest management programmes at ports of origin, and on ships.
- Risk site surveillance on the Chathams.
- Training of cargo handlers for air and sea transport.
- Audits of commercial transport activities.
- Communications strategy.

The Chatham Islands Council website has a page dedicated to biosecurity risk associated with the movement of pests (shown below and available at http://www.cic.govt.nz/noPestsPlease.html).

[60] **A biosecurity strategy to help prevent the entry and establishment of pests on the Chatham Islands Implementation report – year ending June 2006.** Prepared for the Chatham Islands Council & Environment Canterbury by Target Pest Contracting Ltd.

You are here: Home > Environmental > No Pests Please!

No Pests Please!

The Chatham Islands are a beautiful part of the world and it is important that pests do not endanger the islands' unique flora and fauna.

A variety of pests have already arrived on the Chatham Islands and cause significant damage, both to the islands' ecology and economy.

It is also essential that pests currently on the Chatham Islands (possums, rats, hedgehog) don't spread to the Pitt Island and other outer islands. The impact on agriculture, the marine industry and the Chatham Islands environment would be disastrous.

If you have seen a pest or are unsure about what to do, please contact us.

Pests of Land and Waterways

Freshwater and land pests are most likely to arrive in vehicles, small boats, timber and machinery (especially agricultural and construction equipment), and with imported livestock, plants and general freight. Even commercial foods, fertilisers, grains and potting mix could contain pests.

The list of undesirable land and freshwater pests includes:

broom
chilean rhubarb
banana passionfruit
sycamore
cotoneaster
ginger
montbretia
potato vine
rhododendron
phoenix palm
agapanthus
waterlily
green frog
freshwater fish

What can you do?

Everyone who travels to or from the islands is responsible for ensuring that they do not bring pests with them.

You must:

- Thoroughly clean vehicles, camping gear, freight containers and machinery before arriving in the Chathams
- Make sure luggage, camping gear etc is free of stowaway pests
- Do not bring plants onto the island without checking the Chatham Islands Council whether they are pests
- Check supplies and equipment for signs of pests before travelling to the Chatham Islands
- If you suspect that pests are being moved about or have established themselves contact the Chatham Islands Council
- If possible, destroy or contain the pests immediately and then contact the Chatham Islands Council
- If you are moving within the Chatham Islands or travelling out of an area with a known pest problem, make sure vehicles, equipment and other material are clean. Even boots, socks and clothing can carry unwanted seed!

Marine Pests

Marine pests are most likely to arrive on boat hulls, in ballast water or water intake systems (eg sea chests). They can also arrive as a result of fishing and harvesting activities or with marine equipment.

Marine pests include:

Asian clam and Asian date mussel
Chinese mitten and European shore crabs
Mediterranean fan worm
North Pacific sea star
Caulerpa (a green seaweed)
Undaria/Wakame (a japanese seaweed)

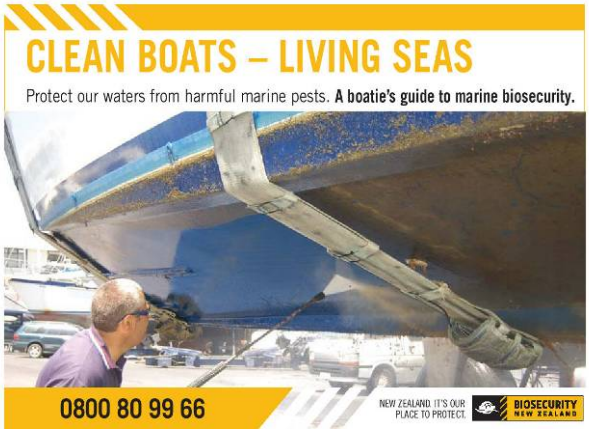
What can you do?

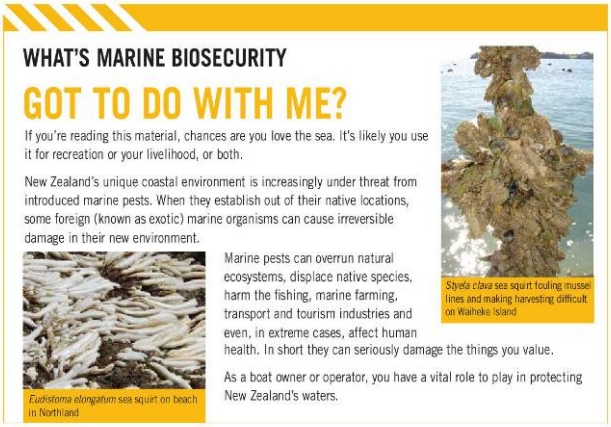
Boat owners and commercial or recreational fishermen must:

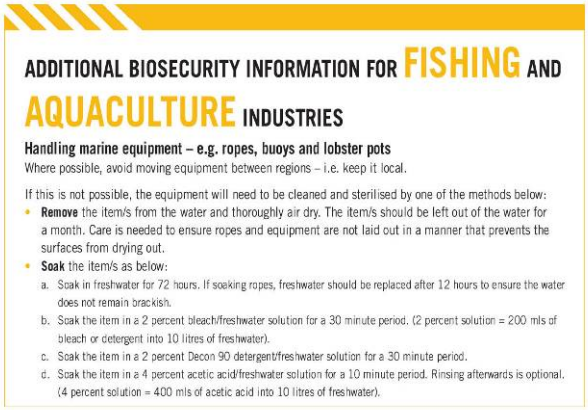
- Clean vessel hulls regularly to prevent the introduction of marine pests
- Collect and dispose of, on land, any material removed from vessel hulls
- Use and effective antifoulant to keep vessels free from fouling organisms
- Make sure fishing gear or marine equipment is clean before transporting it to the Chatham Islands
- Make sure that if a vessel moves its operational base to the Chatham Islands that it is slipped, cleaned and re-antifouled before relocating
- Make sure that if you regularly visit the Chatham Islands that your hull is free of fouling before leaving mainland New Zealand
- Avoid, where possible, discharging ballast water in the Chatham Islands that has been loaded in the coastal waters of mainland New Zealand (as long as this is consistent with the safety of the crew and the vessel).
- Exchange all ballast water loaded within the territorial waters of a country other than New Zealand in accordance with the Import Health Standard under the Biosecurity Act 1993
- Collect a sample of any marine pests mentioned above, place them in a plastic bag and freeze. Contact the Ministry of Agriculture and Forestry on 0800 809-966

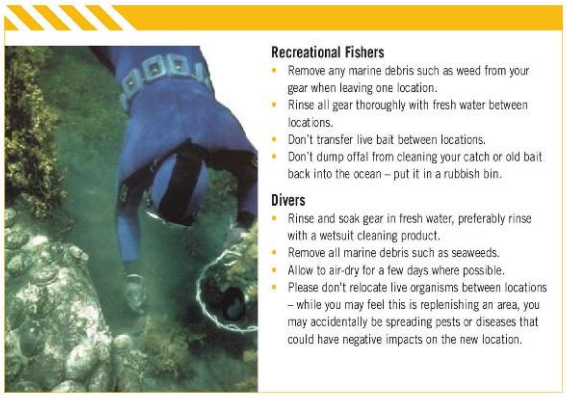
If you have seen a pest or are unsure about what to do, please contact us.

Hull fouling is believed to be the pathway by which approximately 70% of about 150 known incursions of marine species arrived in New Zealand. And marine pests can hitch a ride within New Zealand waters by the same means. MAF Biosecurity New Zealand has published a practical and comprehensive (32 page) boatie's guide addressing this and various other pathways[61]. Six pages from that document below present the issue.









Zebra mussels, *Dreissena polymorpha*[62]

[61] Can be downloaded at http://www.biosecurity.govt.nz/biosec/camp-acts/marine/cleaning

5.5 OVERSEAS EXAMPLE OF PATHWAY MANAGEMENT

5.5.1 Don't Move Firewood – USA

The spread of wood boring pest insects is a growing problem throughout large areas of the world. The USA is no exception, where species like the Asian longhorned beetle has caused significant tree damage in certain areas of the country.

The movement of firewood is thought to be a significant contributing pathway to increased rate of pest spread. Members of the public will often take firewood with them when embarking upon long distance camping outings. This can result in very rapid and expansive movement of wood boring pests throughout the country and is now considered to be posing a serious threat to large numbers of trees and native habitats.

A campaign has been launched to encourage the public to stop moving firewood throughout the states. The "Don't Move Firewood" campaign outlines the problems caused by moving firewood and stresses the importance of leaving it in its original location. On the website (www.dontmovefirewood.com) organisations are invited to become collaborators and to aid the campaign through distribution of a whole range of promotional material including videos, DVDs, bumper stickers, postcards, clothing and posters. All of these items are branded with a common and recognisable logo to help spread the message.

Appendix 1: Terrestrial Pathway Descriptions

Terrestrial environments include some geographic barriers to dispersal, such as mountain ranges and separations between islands. Many species expand their range relatively slowly in the absence of human assisted spread.

The following descriptions of pathways include examples in a general sense which have been communicated by the contributors (appendix 5), and without further reference. Further specific examples are presented in the case studies (Part five).

Primary Production

Most active use of New Zealand's terrestrial environments involves some form of primary production of animal and plant products. Potential pathways associated with such activities can be broadly characterised.

Pathogens and parasites may be associated with animals including undesirables such as Tb, avian influenza, or varroa. Larger herbivores may get weed seeds and other plant fragments caught in their hooves, hair and wool, or retained in their digestive tract. Any movement of animals off farm therefore comprises a risk pathway. Focal points which attract animals or animal products from numerous locations are of particular interest, and this includes sales yards, processing plants, and wool scourers. Waste discharge from processing activities can create further risk pathways for pathogens. In one instance potentially Tb infected cattle offal was disposed to duneland where feral animals such as ferrets had access to it.

Movements of feed are a further major category of risk pathways, with most agricultural weeds readily able to be transferred by such means. Some farmers have refused to take delivery of feed containing either nodding thistle or alligator weed. Chilean needle grass is another species of concern which can use this pathway.

Farm development and maintenance will include use of aggregate and soil movements from time to time, with associated vehicle and machinery movements. Such activities are pathways for weed spread. Soil on a bulldozer in Canterbury was found to contain seeds from at least 73 different species.

Cropping gives rise to two classes of risk pathways. Firstly the use of contaminated seed can introduce undesirable weed species, or for that matter the crop itself may possess weedy characteristics. This latter issue may become more significant with the development of the biofuel cropping industry with plants like *Miscanthus* and *Jatropha* proposed for use. Secondly, most cropping activities utilise contractor operated machinery which is able to facilitate weed transfers between farms. Alligator weed is known to have been introduced into Bay of Plenty via kumara machinery from Northland.

Forestry activities potentially able to transfer pests include machinery movements associated with forest management, log transfers and soil and aggregate movements. Also, the trees themselves may have weedy characteristics where they spread beyond their intended boundaries.

Land Management

Further to primary production, a range of other pathways associated with land management activities exist.

Activities which involve planting of trees or other vegetation for whatever purpose can result in the introduction of species possessing weedy characteristics, either directly, or via contaminated seed.

The development of carbon credit schemes may not take adequate account of the cost of planting weedy species, or the added value of re-establishing native associations of species.

Use of machinery, particularly soil moving machinery, creates risk pathways where that machinery is moved elsewhere.

Off-road vehicles are able to entrain soil, plant and seed material which can transfer pest plants and invertebrates.

Transport and Interisland Transport

The transport category includes the road, rail or sea transport of risk goods not addressed elsewhere.

Both risk goods, and associated conveyances (i.e. packing materials) may provide opportunity for hitchhiker species to be transferred. Examples of risk goods include houselots, old buildings and demolition material.

Military Exercises

Military off road vehicles are potential pathways of spread of terrestrial and aquatic weeds and invertebrates.

Road and Rail Networks

Road and rail networks comprise an artificial conduit which can facilitate the spread of pest plants and animals along them.

Their construction and maintenance involves the movement of large volumes of soil and aggregate, which may move weed species and invertebrates. This includes also removal of spoil from roadside slips.

Management of roadside vegetation provides further pathways of pest spread. Wild flowers may be sown whose seed mixes may contain potential pest plants. Embankments may be stabilised by sowing grass seed, with some uncertified grass seed sources potentially including weed species. Once pest plants become established along a road or railway, other machinery movements and activities, particularly mowers, are able to facilitate their spread elsewhere.

Waste Management

Garden waste accepted by waste management facilities may be processed and resold. The extent of processing is variable, with products including chipped woody waste, soil conditioner and compost. Unless the processing is intensive enough to ensure no viable plant fragments or seed remains, opportunity exists to redistribute weeds.

Garden waste sites themselves are generally managed such that natural weed dispersal from the site is minimised. However, some waste management practices include disposal of garden waste onto dunelands for instance, and such a practice may result in undesirable weeds becoming established there.

Landscape Enhancement

Landscape enhancement mainly comprises gardening activities. Gardening is a popular pastime, with an estimated 80% of the adult population participating in some way[63]. The present distribution of various pest plants in New Zealand can largely be explained by historic gardening practices. A study in Northland found that around 70% of the variation in number of weed species in forest remnants was explained by proximity to houses[64].

The ways in which gardening activities can move pest plants around New Zealand can be broadly grouped.

Firstly, via gardeners planting and propagating potential pest plants on their own properties. This also includes baches or holiday homes where owners may plant species taken from their primary residence. This is evident at many baches adjoining native forest at Tarawera, where a range of pest plants continue to be introduced by homeowners from places such as Auckland and Wellington.

Secondly, gardeners can come into possession of plants via the retail trade, private sales, or swaps and gifts. Species such as Madeira vine, blue passionflower and banana passionfruit remain popular even though they are listed on the NPPA. Other species which do display pest characteristics are not listed on the NPPA and continue to be sold (e.g. jasmine, agapanthus and ivy).

Thirdly, disposal of garden waste can result in transfer of pest plants to new locations. For example illegal dumping can spread a wide arrange of pest plants to reserves, roadsides and riverbeds. And there is anecdotal evidence of increased illegal dumping associated with the trend towards user pays user pays waste disposal. A walk through survey of a 2 km stretch of Akatarawa Saddle road (native forest either side) found at least 13 environmental weeds to be establishing. This is attributed primarily to garden waste dumping, and further aggravated by road maintenance as vegetatively spread species like Japanese honeysuckle and tradescantia are readily moved by mowers.

Sport and Recreation

Sporting activities can involve participants travelling significant distances, including inter-island, which means pests can be displaced far and wide.

Trampers and multi-sporters can transfer pests via their gear. Seeds can be attached to clothing and equipment, fungal spores such as *Phytophthora* may be present in soil attached to uncleaned footwear. Heath and heather were probably introduced into Mount Cook National Park by trampers from in the Central North Island.

Hunting activities introduce a further pathway where game species are illegally liberated to improve or establish populations. Associated organisms may also be transferred, and the ongoing release of feral pigs in the Auckland region may be facilitating the spread of

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63 C. Lewis pers. com. From weed awareness survey completed by AC Nielsen for Weedbusters in 2008 which showed that 82% of respondents had gardened in the preceding six months.

64 Sullivan, J. J., Timmins, S. M., and Williams, P. 2005. *Movement of exotic plants into coastal native forests from gardens in northern New Zealand*. New Zealand Journal of Ecology 29:1 10.

Phytophthora, while Tb can be moved nationwide via pig and deer releases. Dogs are commonly used by hunters, with seed material readily caught up in the hair of many breeds.

Pests and soil can become attached to vehicles used by outdoor recreationalists and tourists.

The sale of horse manure at roadsides can readily transfer weed species off farm, while the purchasing of feed can transfer weeds onto the farm. Equestrian events involve the movement of vehicles, trailers and the horses themselves. Soil and seed material attached to any of these can be spread in this way, as can seed material retained in horse bowels. With the presence of didymo in New Zealand, back country horse trekking can potentially transfer this pest across catchments via wet horses and equipment.

Companion Animals

The keeping of companion animals is common, and the range of species kept continues to become more diverse over time.

Pets may be abandoned into the wild, usually because they are no longer wanted, or less frequently species released to establishing wild populations for aesthetic reasons (e.g. rainbow lorikeets). In other instances pets simply escape, with many classes of pets such as birds, reptiles, amphibians and insects less inclined to come back to their owners than the more traditional mammalian pets.

Pets can be transferred between owners via private sales, gifts and swaps, and the retail pet trade. The retail pet trade is not subject to any agreement comparable to the National Pest Plant Accord observed by the nursery trade.

Research

Any research using potential or known pest organisms gives rise to potential pathways of pest spread by the disposal or escape of the organisms.

Research into new or improved varietals can give rise to organisms becoming established in New Zealand which display pest characteristics not observed in the parent stock. For instance, new olive varietals bred for improved frost and drought resistance have been planted in the South Island. In addition to their frost and drought characteristics improving their ability to survive as wildings, an unexpected consequence also saw a reduction in fruit and seed size. These olive seeds are now able to be consumed and dispersed by small beaked species such as blackbirds greatly increasing the potential for these varietals to become a wilding pest problem in future. Wild olives are already a serious pest in arid areas of Australia where they rank among the top twenty serious environmental weeds. Similarly new kiwifruit varietals are considered to be more invasive than the established Hayward kiwifruit variety.

Appendix 2: Freshwater Pathway Descriptions

Freshwater environments are well suited to pathway management as many freshwater organisms are unable to cross catchment boundaries by natural means.

As most freshwater organisms will die out of water, good opportunities exist for managing pathways of spread of aquatic pests. The *Didymo* "Check, Clean, Dry" campaign makes use of this simple principle.

However, management opportunities are perceived to be hampered by the number of agencies which have jurisdiction in the freshwater environment. The statutory responsibilities and regulatory tools similarly suffer from being limited and somewhat disjointed. For instance, DOC, Land Information New Zealand, landowners, iwi and regional council's may all share an interest in any given water body. As a consequence pathway management may of necessity rely on active partnership arrangements.

The following descriptions of pathways include examples in a general sense which have been communicated by the contributors (appendix 5), and without further reference. Further specific examples are presented in the case studies (Part five).

Commercial Fishing

Activities include primarily eel fishers, and also whitebait, and mullet fishers.

Nets and eel fykes can trap potential pest organisms such as plant fragments, and any fish eggs which might be attached thereto. Boats, trailers and other equipment are further pathways, with propellers, jet units and bilge water all able to retain and later release plant fragments.

Further to such unintentional transfers, fish stocks may be actively managed by releases of target species from time to time. This pathway may become more relevant as species such as koi and grass carp become more popular in the restaurant trade.

Freshwater aquaculture

Both stock and any on farm disease can be transferred either by inter-farm stock movements, or by water exchange, either normal discharge of used farm water, or unintentionally due to equipment failure or flooding.

A disease such as whirling disease is potentially devastating to salmonids, with potential to spread into wild stocks of both exotic and native species. Activities of the aquaculture industry are subject to regulatory control, with the industry itself motivated to manage disease risk.

Waterway Management

Aggregate extracted from rivers can contain weed seeds and plant fragments, including many terrestrial species. With the sale and transfer of the aggregate weeds are widely relocated, often to roadways which utilise river aggregate extensively. Movements of aggregate extraction machinery to new locations provides further opportunity for pest spread.

Control activities targeting aquatic weeds in rivers and lakes can aggravate pest problems. Debate is ongoing regarding the cost versus benefit of releasing the herbivorous grass or silver carp for weed control. The transfer process itself is a further risk pathway if water and other organisms are transferred with the carp. One source location of carp is known to also have *Gambusia* present for example. Other weed control activities involve the use of machinery, either spraying or physically removing weed. In addition to the obvious pathway of pest transfer via unclean machinery and vehicles, spray operators occasionally fill their tanks from natural water bodies creating a further pathway of water movement between catchments.

Other drainage and harvesting machinery can similarly spread a wide range of species. One instance saw excavated drain material containing alligator weed used to level paddocks.

Species may also be released into natural water bodies for a functional purpose, such as *Gambusia* for mosquito control[65].

Exotic species are often planted for bank stabilisation, some of which may prove to be a problem in the longer term.

Land Irrigation and Hydroelectric Power Generation

Irrigation can result in transfer of water and hence pests between water bodies and catchments. This is via the construction of artificial waterways (either canals or piped systems), and possibly by the transfer of terrestrial weed seeds and fragments directly onto land also.

Hydroelectric power generation similarly involves construction of artificial waterways which are able to effect transfers of pests such as *Didymo* and *Salvinia* between previously isolated water bodies. Construction can also create barriers within catchments. Where consent conditions require species such as eels to be actively moved upstream of such barriers, an attendant risk of also moving other aquatic species exists.

Sport and Recreation

Freshwater fishing activities give rise to a range of risk pathways. As with commercial fishing, pests can be inadvertently moved via boats, fishing equipment, nets and by trailers and vehicles. Weed fragments can be readily transported with trailered boats. Porous material such as carpet buffer pads on boat trailers or felt soles in waders remain damp and maintain *Didymo* in a viable state for quite some time.

Further to such unintentional activities, deliberate releases of coarse fish species such as rudd and tench by recreational fishers are an ongoing problem in many parts of New Zealand.

Multi-sport events are popular and attract national and international participants. National events can see thousands of multi-sporters converge on certain river systems from far and wide. Kayaks are able to retain a quantity of water which can be introduced to whichever river the participant has travelled to. Many such events are now controlled to ensure that all kayaks going into the river are “Check, Clean, Dry”.

Besides fishing and multi-sporting, a range of other water based recreational activities occur. Risk pathways associated with these are largely associated with use of boats, trailers and

[65] “Gambusia (*Gambusia affinis*) have been widely spread under the misconception that this species would control mosquitoes, with their common name of mosquitofish alluding to this.” (Champion et. al. 2002).

equipment. Some water ballasted recreational craft can retain and discharge water providing a further means of pest transfer between water bodies. Diving equipment can remain damp for long periods creating a potential pathway for *Didymo* transfer.

Recreational 4 wheel drives (or any other type of off-road vehicle) travel along and across rivers, with the wheels, axles and undercarriage able to entrain substantial quantities of soil, sediment and plant material. This creates a pathway for transfers of pests both within and between catchments.

Central and Local Government

A range of land management activities undertaken by central and local government agencies results in off-road vehicle movements, creating risk pathways as for the recreational off-roaders. Other activities including spraying and waterway management involve the previously described pathways related to vessel and machinery movements, and contractor activities.

Military exercises within New Zealand can include extensive off-road vehicle use between catchments and also between islands. Thorough cleanup procedures are observed at the completion of the exercise, but less regularly during any exercise.

Waterway Beautification

Ornamental planting of waterways is a common activity, and unfortunately some popular species such as water buttercup also display pest characteristics. Plants can be sourced for planting either privately, such as gifts, swaps and people's own properties, or less commonly from commercial sales. Most weedy aquatic ornamentals are now banned from sale and listed on the National Pest Plant Accord (NPPA).

Companion Animals

Aquaria species (e.g. fish and turtles) are commonly kept as pets. However, these animals often become unwanted for various reasons. If they can't be given away or sold, then they may be released into a natural waterway, along with any aquatic vegetation or disease organisms in the aquaria.

The pet trade supplies species to the market, and this is largely unregulated for species present in New Zealand. A further pathway associated with the retail industry is the use of natural water bodies to grow commercial stock. An example is the planting of *Egeria* into water bodies to supply the aquarium trade.

Since 1960s, 3 of 6 newly naturalised fish species in New Zealand are ornamentals, and more and more are appearing in the wild in Australia also.[66]

Research

Any research using potential or known freshwater pest organisms gives rise to potential pathways of pest spread by the disposal or escape of the organisms themselves, or via the disposal of water used to sustain those organisms.

[66] N Grainger pers com., DOC.

Appendix 3: Marine Pathway Descriptions

The marine environment is continuous and many species are able to extend their range without human assistance. Beyond the 12 mile limit there exists effectively no jurisdiction to regulate activities, and even within the 12 mile limit regulatory tools are limited, particularly in relation to foreign vessels. The "Top of the South" initiative relies on voluntary partnerships and reflects the reality that pest management responsibilities are not clearly demarcated or assigned for the marine environment.

The following descriptions of pathways include examples in a general sense which have been communicated by the contributors (appendix 5), and without further reference. Further specific examples are presented in the case studies (Part five).

Maritime Transport

Commercial shipping includes both domestic and foreign ships. Many foreign ships travel between multiple ports in New Zealand after their arrival, and may take on and discharge ballast water during that time. Both domestic and foreign ships can therefore contribute to domestic pest spread via ballast water transfers. The *Gymnodinium* toxic algal bloom first noted off the North West coast of the North Island in the 1990's probably arrived via ballast water.

In addition to ballast water, hull fouling is identified as a means of moving potential pest organisms around the country. Most large ships are fast, with hulls necessarily maintained to a reasonable level of cleanliness to ensure fuel efficiency. However sea chests (indentations in the hull from which water is taken on and/or discharged) are protected from the high speed water flow across the rest of the hull and may experience significant biofouling.

Slow commercial vessels, particularly barges, are not able to rely on high speed water flow to keep their hulls clean and biofouling is not a troublesome in a commercial sense as it is for faster vessels.

Mining

Offshore mining operations utilise large structures. These typically remain in place for extended periods of time providing opportunity for marine organisms to attach themselves. When these structures are occasionally moved, they may be carrying a significant biofouling load.

Commercial Fishing

As with all vessels, commercial fishing vessels can transfer potential pests via the biofouling pathway. In addition, deployment of fishing equipment such as nets and dredges can result in the entrainment and transfer of species living in the water column and on the seabed.

Recreation

Recreational vessels are subject to biofouling and anchor gear pathways. Anchor gear can entrain material from the seabed, and since most anchor lockers are enclosed, the gear can stay damp for quite some time creating opportunity for extended survival organisms. The presence of *Styela* at Opua and Whangarei can probably be attributed to biofouling on recreational vessels, and at the entrance to the Tauranga Harbour the presence of *Undaria* was first noted directly under recreational moorings.

Recreational fishers deploy equipment to the water column and the seafloor creating potential pathways of spread similar to commercial fishers.

Diving equipment can potentially entrain pest organisms.

Mariculture (Marine Aquaculture)

Seed stock for shellfish is commonly collected from the wild, with a limited number of locations in New Zealand well suited to collection. Typically lines are laid in or below the intertidal zone, encouraging juvenile shellfish to settle. These lines (spatlines) are then transported to marine farms around New Zealand along with any other organisms that have settled on the lines.

Interfarm stock movements are a potential pathway, though this practice is not common.

Service vessels, including barges, are potentially able to transfer pests via the biofouling pathway where they operate between farms. The vessels may also move farm equipment (e.g. buoys and lines) between farms. Initial spread of *Undaria* through Hauraki gulf, Coromandel and Great Barrier is believed to have been correlated with mussel farming activity.

Processing of harvested product is usually at a land based facility. If such facilities discharge waste water into the sea the possibility of transfer of viable marine organisms exists.

Research

Any research using potential or known marine pest organisms gives rise to potential pathways of pest spread by the disposal or escape of the organisms themselves, or via the disposal of water used to sustain those organisms.

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The following people contributed their specialised knowledge and experience to this report (or provided feedback on the draft consultation document). Your collective input is greatly appreciated. Our apologies if any contributors are inadvertently omitted from this list.

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