

MAF - Didymo and other
freshwater pests:
Economic Impact Assessment



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1. Executive summary

This report presents the findings of a review of the predicted and current economic impact of didymo and a review of the economic impacts of other freshwater pest plants managed under national, regional, or industry programmes – for example, national interest pest response or national pest plant accord, or a regional pest management strategy (RPMS), and includes collated information on current expenditure (defensive expenditure, management programmes, and research investment).

Didymo

We estimate that didymo has caused \$127.8 million in negative impacts from 2006-2011, and will lead to between \$210.6 and \$854.8 million from 2011 to 2020.

The impact of didymo between 2006 and 2011 is estimated to be \$127.8 million, while the earlier assessments expected the impacts to be between \$50.3 million to \$234.0 million. The main reason for the low impact is due to didymo not spreading to the North Island. Additionally, the number of households in New Zealand is estimated to have grown by approximately 94,000, which was not taken into account in the previous assessment. The growth in households increases the number of people affected by didymo, increasing the total impact on household recreational and existence values.

Most of the expected economic damage between 2011 and 2020 from didymo is concentrated in the Central South Island and North Island. This is due to the large number of rivers and lakes in the Central South Island, and the large population bases in both regions. For didymo, the largest impact is expected to be through reduced recreational values.

Sensitivity analysis examined the impact of reducing the spread of this pest. Already, actual damage is lower because didymo has not spread to the North Island.

In the sensitivity analysis around our didymo estimate, we found that a 2 year delay in didymo spreading to the North Island would reduce negative impacts by between \$17.9 million and \$91.6 million. If instead, the rate of spread within regions was to be slowed by 2 years, then the impacts of didymo could be reduced by between \$15.6 million and \$80.4 million.

These reduced impacts could be used as a cost guide for any government intervention that would delay didymo from spreading to other regions, or slowing the rate of spread within a region.

Other Freshwater Pests

For our analysis of the economic impact of other freshwater pests, data limitations prevented us from carrying out as thorough an analysis as that completed for didymo. However, we were able to estimate present-day annual impacts in terms of management costs – both preventative and reactive.

The current estimated cost of pest management programmes for other freshwater pest plants is approximately \$4.6m and represents more than 20 distinct pest management initiatives. Within this, the largest financial contribution (over \$3m) is an investment by a hydropower operator to stop pest plants entering water intake systems.

We have observed that these pests impact a wide range of commercial and social activities, however the extent to which these activities is currently impacted remains relatively unknown. There are pockets of good information, but a longer-term information gathering process will be needed in order to determine the full extent of other freshwater pest impacts.

The scope of this study was restricted to the impact of fresh water pest plants; Elodea, Hornwort, Hydrilla, Lagarosiphon, Parrot's Feather, Salvinia, Water Hyacinth and Water Lilly.

Data on marginal aquatic pest plant species such as Manchurian Wild Rice, Phragmites, Reed Sweet Grass, and Senegal Tea was not included in this study. Data on the cost of these marginal pests does not distinguish between terrestrial and aquatic impacts. However the economic impact of these pests on freshwater ecology, irrigation and drainage systems is significant and future analysis should consider the similar pathway spread characteristics of these pests.

2. Introduction

The Ministry of Agriculture and Forestry (MAF) contracted Deloitte to carry out an independent review of the predicted and current economic impact of didymo, and a review of the economic impacts of other freshwater pest plants managed under national, regional, or industry programmes.

The long-term management programmes and associated “Check Clean Dry” social marketing campaign are regularly reviewed to assess whether they are delivering the desired outcome in an effective and efficient way.

The purpose of this report is to update the 2006 NZIER report to determine the current economic impact of didymo, and to extend the assessment to include the economic impacts of other freshwater pest plants.

In carrying out this work, Deloitte partnered with NZIER. This allowed us to use the same model as in the 2006 didymo research with updated figures, thereby ensuring comparability of the results.

2.1. *Didymosphenia geminata*

Didymo germinata (didymo) was first found in the lower Waiau and Mararoa rivers in Southland in October 2004. Since then it has spread to over 150 South Island rivers, but to date has not been detected in the North Island.¹

Didymo is an invasive *alga* of freshwater streams, rivers and lakes. It is a microscopic pest that can form dense mats that have the texture and appearance of dirty brown cotton wool. These mats

- Degrade river and lake ecosystems
- Can affect aquatic species which could affect fish and bird species
- Could impact on recreational activities
- Could lower the aesthetic appeal of New Zealand’s rivers and lakes.

In November 2004, MAF Biosecurity New Zealand, with the support of others, initiated response actions to reduce the further spread of Didymo. This included: collecting information on its distribution and impacts; researching possible control methods; and using a social marketing campaign to increase awareness of the problem and change the behaviours of freshwater users.

¹MAF Biosecurity New Zealand, *Didymo*, available at: <http://www.biosecurity.govt.nz/pests/didymo>.

2.2. Data Gathering Methodology

The methodology used to collect the data which informs the economic analyses involved four steps:

1. Identifying participants
2. Distribution of surveys
3. Survey returns and collating
4. Follow-up phone interviews

Identification of participants was carried out in conjunction with MAF, and included identifying contacts within regional authorities as well as industry contacts from power companies, industry groups, and recreational organisations.

The survey was designed in conjunction with MAF staff to ensure the right information was captured and that it was understandable for the participants. We delivered the survey as an excel spreadsheet and captured data according to the following subsections:

Infestation

Infestation data was targeted to gain an understanding the degree of infestation of a given pest in a given region, the severity of the infestation, and the expected severity if the pest goes unchecked over the next decade. The specific data points for this section of the survey were as follows:

- Species type
- Location (region)
- Time since infestation
- Current severity (high/med/low)
- Expected severity in 10 years (high/med/low)

Management Programmes

This section gathered information on previous management programmes, programmes currently underway, and any planned future programmes. The purpose of this section was to gather financial and impact data on pest management programmes, and also to understand the degree of public/private funding for these programmes. The specific data points for this section of the survey were as follows:

Previous Programmes

- Programme Name
- Cost Of programme
- Impact on infestation level

Current and Future Programmes

- Programme Name
- Purpose
- Commencement Data
- Funding structure
- Contribution value
- Contribution type (in-kind, monetary)
- Effectiveness
- Performance measures

Impacts

The impacts were divided into categories: commercial, social, public health, and cultural/environmental. Within each of these categories a range of relevant impacts could be described by the participants.

Commercial Impacts

The commercial impacts were described in terms of the change in output levels, output quality, and/or production losses. These impacts were described across the following commercial activities:

Fishing	Wild Stocks
	Eel Fisheries
	Salmon fisheries
	Other fisheries
Tourism	Jet-boating
	Kayaking
	Diving
	Other tourism
Municipal, industrial, and agricultural water intakes	

Boats and shipping
Ports and harbour operations
Other commercial impacts

Social Impacts

Social Impacts were largely described in terms of impact on recreation values across the following activities

- Fishing
- Jet-boating
- Kayaking
- Swimming
- Other Recreation

Public Health

Public health impacts were focussed on the impact of the pest on commercial or municipal drinking water, with space given to other general public health impacts. The key variables collected were

- Impact on disease rates
- Impact on personal injury rates
- Impact on prevention costs

Cultural & Environmental

There was a very wide range of potential questions relating to cultural and environmental impacts of pest incursions. We elected to keep these questions open to allow participants to describe the impacts rather than being overly structured in this aspect of data capture. The impact areas covered were:

- Native species
- Rivers
- Other cultural or environmental impacts

We have provided MAF with a copy of the survey template so that all the data fields and overall capture schema may be revised and reused in subsequent survey updates.

Surveys were completed by participants and emailed back to Deloitte where the data was stored and collated. After carrying out a gap analysis to identify sections with missing information, we made a series of follow up phone-calls to gather and fine-tune our data.

3. Summary of previous assessment

In 2006, NZIER completed an assessment of the economic impact from didymo on New Zealand. Due to the lack of information about the expected impacts of didymo, that assessment modelled the possible impacts across low, medium, and high impact scenarios. For the eight year period from 2004/05 to 2011/12², the estimated impact of didymo across the three scenarios, in 2005 dollars, was:

- \$57.80 million under the **low** impact scenario
- \$167.23 million under the **medium** impact scenario
- \$285.13 million under the **high** impact scenario
- These scenarios were weighted by relative probabilities to provide an expected total impact over that period of \$157.60 million.

Within these scenarios, estimates were provided for the potential impacts of didymo on New Zealand's:

- Commercial eel fisheries
- Municipal, industrial and agricultural water intakes
- Community, municipal and domestic drinking water
- Local recreation values
- International and domestic tourism expenditure
- Local and national existence values
- Existence values associated with extinction of native species.

The largest estimated impacts from didymo were reduced recreation values, loss of existence values associated with extinction of native species and reduced tourism expenditure, followed by increased costs for water intakes and reduced local and national existence values.

² The time period modelled in the previous assessment differs from the time period that NZIER was asked to estimate in this update.

Total impacts were largest in the North Island and central South Island. This was mainly due to the larger populations in these regions, which increased the impact of reduced recreation and existence values.

Not all of the potential impacts of didymo were included in the previous assessment due to a lack of data or materiality. Didymo could also have impacts on:

- Cultural values including customary fishing
- Alluvial gold mining
- Exports of used fishing and boating gear
- Human health, from eye irritation in swimmers and injuries from slipping on rocks.

4. Impact Assessment Refresh

4.1. Approach

This update followed the same methodology as was used in the previous assessment. Where available we use more detailed or more recent data. This more recent data includes:

- Survey responses
- Official statistics
- Studies completed since the 2006 assessment
- MAF Biosecurity New Zealand's economic impact assessment stocktake (MAF Biosecurity New Zealand, 2007).

Where more recent data has not been available, the existing impact levels have been adapted to 2011 values based on inflation rates (Statistics New Zealand, 2011).

Table 1 briefly outlines the main differences in approach, with full details of the methodology provided in Appendix A.

Table 1 Differences in approach between 2006 assessment and 2011 update

2006 assessment		2011 update
Baseline scenario	No didymo presence in New Zealand	Same as 2006
Range of impacts	Low, medium, high impact scenarios	Same as 2006
Potential range of didymo	Percentage of high-order streams at risk of containing didymo (Kilroy et. al., 2005)	Percentage of high-order streams that are predicted to support didymo cover of at least 1.0 percent and 0.1 percent (Kilroy et. al., 2007)
Rate of spread	Didymo spreads throughout New Zealand between 2004/05 and 2011/12	Didymo spreads throughout New Zealand between 2005 and 2017
Commercial eel fisheries	Reduction in rate of return on eel fishery assets (Statistics New Zealand, 2005)	Same as 2006 (updated value of eel fishery assets, Statistics New Zealand, 2010a)
Water intakes	Additional capital costs of self-cleaning water intake screens (costs sourced from	Same as 2006 (updated costs sourced from Bosch Irrigation)

	Bosch Irrigation)	Number of regional water intakes sourced from Aqualinc (2010) Annual costs associated with didymo impacting on hydro generation filters in Manapouri, the Tekapo Canals, and the Waitaki Valley.
Drinking water	Additional water management and treatment costs for carbon filters to remove unpleasant odour or taste (costs sourced from Hamilton City Council)	Same as 2006 (updated costs sourced from Hamilton City Council)
Recreation values	White and Sharp (2002) estimates of average cost per household per year of local recreational use	Same as 2006, but in 2011 dollars (Statistics New Zealand, 2011)
Tourism expenditure	Ministry of Tourism (2004) estimates of tourism spending on freshwater activities.	Same as 2006, (updated to 2010 tourism expenditure, Tourism Strategy, 2010)
Existence values	White and Sharp (2002) estimates of Manawatu-Wanganui households' willingness-to-pay for existence of that region's freshwater assets.	Same as 2006 (updated to 2011 dollars, Statistics New Zealand, 2011)
Loss of native species	Estimated impact of loss of native species based on Kerr and Sharp (2003)	Same as 2006 (updated to 2011 dollars, Statistics New Zealand, 2011)
Intervention costs	Not included	Based on responses from Deloitte-administered survey
Expected impacts	Relative probabilities for low, medium, and high impact scenarios informed by the Didymo Technical Advisory Group (TAG)	Same as 2006

Source: NZIER

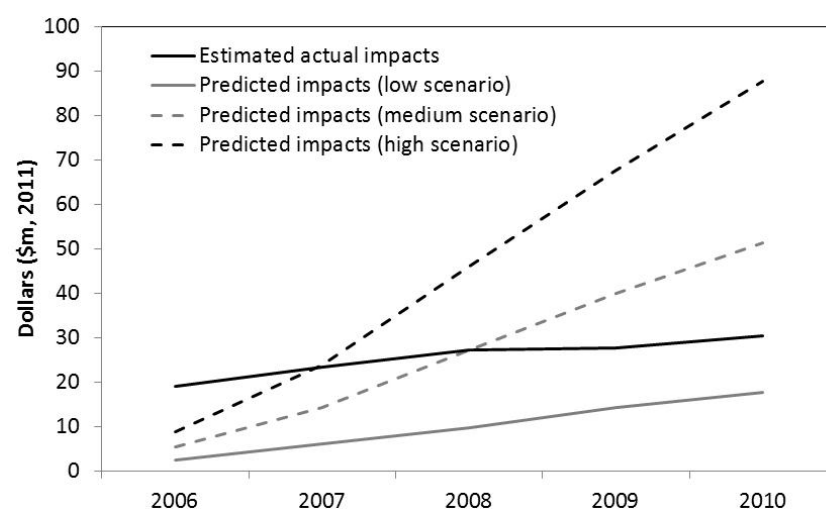
4.2. Estimated actual impacts 2006-2010

The initial economic impact assessment was completed in 2006. In this section we estimate the actual impacts of didymo between 2006 and 2010.

Since the initial discovery of didymo in 2004, it has been detected in over 150 waterways in the South Island, but it has not been reported in the North Island. This suggests that the North Island will only have been impacted by the national effects of reductions in existence values, or the loss of native species.

Based on official statistics, information from the scientific literature, MAF Biosecurity New Zealand's economic impact assessment stocktake, and the survey response data, we estimate the total impact of didymo between 2006 and 2010 to be \$127.8 million, in 2011 dollars. As shown in Figure 1, this estimate is between the low and medium impact scenarios of NZIER's earlier assessment for the same time period, which ranged from \$50.3 million to \$234.0 million, in 2011 dollars.

Figure 1: Estimated annual impacts of Didymo 2006-2010



Source: NZIER

The main differences between the estimate of actual impacts and the earlier assessment are:

- The previous assessment includes impacts on the North Island, while didymo has not been detected in the North Island between 2006 and 2010.
- The number of households in New Zealand grew by an estimated 94,334 between 2006 and 2010. These additional households are included in this estimate of actual impacts, but not in the previous assessment. This means that the reductions in value associated with the number of households in a region (recreational values, existence values) will be greater in the current estimate than in the previous assessment.

5. Updated impact assessment: 2011-2020

5.1. Annual impacts

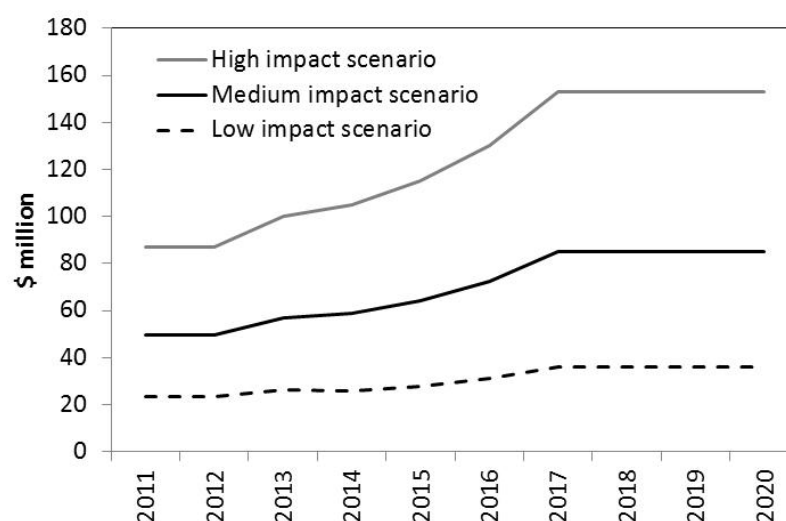
We estimate that, once didymo has fully spread throughout New Zealand, the full annual impact on the country's commercial eel and salmon fisheries, municipal, industrial and agricultural water intakes, drinking water, local recreational values, domestic and international tourism expenditure, local and national existence values, and existence values associated with the loss of native species will be in the range of:

- \$36.0 million under the low impact scenario
- \$85.1 million under the medium impact scenario
- \$152.9 million under the high impact scenario.

This is the range of expected annual impacts once didymo is fully spread throughout New Zealand, which occurs in the model in 2017.

Weighting these estimates by the relative probabilities discussed in Appendix I, the expected full annual impacts are \$83.0 million. Figure 2 presents the estimated annual impacts of didymo over the 10 years from 2011 to 2020.

Figure 2: Estimated annual impacts of Didymo 2011-2020



Source: NZIER

5.2. Present value total impacts

At a discount rate of 8 percent, the present value in June 2011 of the potential impacts of didymo over the period 2011-2020 total:³

- \$210.6 million under the **low** impact scenario
- \$479.4 million under the **medium** impact scenario
- \$854.8 million under the **high** impact scenario

Weighting these scenarios by their relative probabilities suggests the expected present value of the total impacts of didymo between 2011 and 2020 to be \$468.5 million.

Table 2 and Table 3 show how these total impacts are distributed across sectors and regions.

³ The previous assessment used a 10 percent discount rate. Since August 2008, Treasury have advised using an 8 percent discount rate, which is applied in this estimate (Treasury, 2008).

Table 2 Present value impacts of Didymo 2011 to 2020, by sector

Sector	\$ million (% of total)		
	Low	Medium	High
Commercial eel fisheries	0.26 0.1%	0.48 0.1%	0.96 0.1%
Water intakes	4.27 2.0%	6.86 1.4%	8.69 1.0%
Drinking water	8.16 3.9%	13.82 2.9%	18.43 2.2%
Recreation values	77.85 37.0%	192.35 40.1%	345.70 40.4%
Tourism expenditure	34.21 16.2%	94.78 19.8%	189.56 22.2%
Existence values	35.14 16.7%	74.59 15.6%	149.17 17.5%
Loss of native species	45.79 21.7%	91.58 19.1%	137.37 16.1%
Intervention costs	4.93 2.3%	4.93 1.0%	4.93 0.6%
Total	210.56	479.39	854.80

Source: NZIER

Recreation values are the most impacted from didymo, and account for between 37.0 percent and 40.4 percent of total impacts. Other large impacts are felt from the loss of native species, reduced tourism expenditure, and reduced existence values from degraded water systems.

Table 3 Present value impacts of Didymo 2011 to 2020, by region

Region	\$ million (% of total)		
	Low	Medium	High
North Island	78.36 37.2%	185.67 38.7%	322.14 37.7%
Upper South Island	6.47 3.1%	13.64 2.8%	23.43 2.7%
Central South Island	92.32 43.8%	210.99 44.0%	387.45 45.3%
Lower South Island	28.47 13.5%	64.16 13.4%	116.84 13.7%
Intervention costs	4.93 2.3%	4.93 1.0%	4.93 0.6%
Total	210.56	479.39	854.80

Source: NZIER

The impacts of didymo are greatest in the Central South Island. This reflects the large number of rivers and lakes in this region, the large population base, and the fact that didymo is fully spread through the region by 2009.

The impacts on the North Island are the next largest. This reflects the large population base, and the high degree of tourism spending that occurs in the North Island.

5.3. Sensitivity analysis

There is a high degree of uncertainty about the spread and impact of didymo in New Zealand. As a result there is uncertainty around the estimates provided as part of this assessment. We have undertaken sensitivity analysis of a number of the variables that were modelled. The results of this analysis are presented in Table . The range of sensitivity in each scenario of the model is as follows:

- \$124.3 million to \$233.6 million in the **low** impact scenario
- \$387.8 million to \$541.4 million in the **medium** impact scenario
- \$717.4 million to \$954.1 million in the **high** impact scenario.

If the North Island can be kept free of didymo for another two years, then the expected impact falls by between \$17.9 million and \$91.6 million to a range of \$192.6 million to \$763.2 million. Likewise, if the spread of didymo throughout the regions took two years longer, then the total impacts would reduce to between \$195.0 million and \$774.4 million.

If no native species become extinct because of didymo, then the total impacts will fall by between \$45.8 million and \$137.4 million, to a range of \$164.8 million to \$717.4 million.

Table 4 Sensitivity analysis

Coefficient	Change to coefficient	Present value total impacts (\$ million and % change)		
		Low	Medium	High
Initial estimate		210.56	479.39	854.80
Sensitivity range	minimum in each scenario	124.33	387.80	717.43
		-41.0%	-19.1%	-16.1%
	maximum in each scenario	233.63	541.43	954.08
		11.0%	12.9%	11.6%
Potential range	Full spread of Didymo is changed to percentage of streams with average cover greater than 10 percent (low) and greater than 1 percent (high)	124.33	450.15	800.47
		-41.0%	-6.1%	-6.4%
Rate of spread	2 year delay to arrival in North Island	192.64	429.75	763.22
		-8.5%	-10.4%	-10.7%
	2 years more to spread through each region	194.97	435.90	774.40
		-7.4%	-9.1%	-9.4%
	1 year less to spread through each region	219.16	501.58	894.96
		4.1%	4.6%	4.7%
Water intakes	half rate required	208.43	475.96	850.46
		-1.0%	-0.7%	-0.5%
	100% require self-cleaning screens	214.83	481.67	855.26
		2.0%	0.5%	0.1%
	Disruption of hydroelectricity generation ¹	210.56	479.39	867.67
Drinking water	no treatment required	202.41	465.56	836.37
		-3.9%	-2.9%	-2.2%
	100% of water treated	243.18	511.64	882.45
		15.5%	6.7%	3.2%

Notes: (1)Models four disruptions per year in 2012 and 2013 only, in the lower South Island, under the high impact scenario, each incurring two days lost revenue and costs of temporary clearance and generation restart.

Source: NZIER

Coefficient	Change to coefficient	Present value total impacts (\$ million and % change)	

		Low	Medium	High
Estimate		210.56	479.39	854.80
Recreation values	half the reduction in value	187.50	417.34	755.52
	per household	-11.0%	-12.9%	-11.6%
	50% greater reduction in value	233.63	541.43	954.08
	per household ²	11.0%	12.9%	11.6%
Boating and other recreation	half the reduction in value	199.65	455.90	807.82
	per household	-5.2%	-4.9%	-5.5%
	50% greater reduction in value	221.48	502.88	901.78
	per household	5.2%	4.9%	5.5%
Tourism expenditure	half the reduction in expenditure	193.46	432.00	760.02
		-8.1%	-9.9%	-11%
	50% greater reduction in expenditure	227.66	526.77	949.58
		8.1%	9.9%	11%
	half the % of expenditure associated	193.46	432.00	760.02
	with freshwater activities	-8.1%	-9.9%	-11%
	50% greater % of expenditure associated with freshwater activities	227.66	526.77	949.58
		8.1%	9.9%	11%
Existence values	half the reduction in value	192.99	442.09	780.22
	per household	-8.3%	-7.8%	-8.7%
	twice the reduction in value	228.13	516.68	929.38
	per household	8.3%	7.8%	8.7%
Loss of native species	half the value per household	187.67	433.60	786.12
		-10.9%	-9.6%	-8.0%
	loss of one species in high impact scenario only	164.77	387.80	763.22
		-21.7%	-19.1%	-10.7%
	no loss	164.77	387.80	717.43
		-21.7%	-19.1%	-16.1%
Intervention costs	programmes continue until fully spread throughout country (2017)	214.48	483.30	858.72
		1.9%	0.8%	0.5%

Note: (2) Capped at maximum 100 percent loss in value under high impact scenario

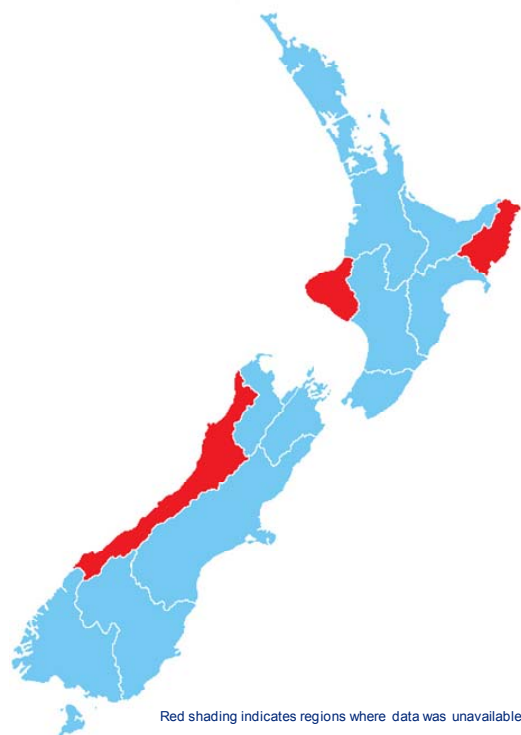
Source: NZIER

6. Other freshwater pest impacts

This section of the research was primarily carried out through surveying relevant individuals within Regional Councils and industry groups to obtain data on the level of infestation and costs of managing these pests.

There was some difficulty in obtaining data from regional councils on the range and costs of other pests. The difficulty in obtaining comprehensive and reliable data meant that a full economic impact analysis was not possible across the class of other freshwater pests.

However, we are able to provide an assessment of the current level of annual spending on freshwater pest management programmes. Please note that cost figures cited in this section may be derived from incomplete data and therefore should be interpreted as a lower bound.



6.1. Summary of Impacts

We have gathered data which details the respective management programmes, and (where possible) an indication of the programme costs.

The data used to estimate the impacts of other freshwater pests comprises a range of species of varying distribution around the country. We have gathered data on the following pest species:

- Elodea
- Hornwort
- Hydrilla
- Lagarosiphon
- Parrot's Feather
- Water Hyacinth
- Water Lily
- General

We collated this data on a regional basis, however cost information was unavailable for several regions. See the map above for regional data coverage.

Current Programmes

There is range of management programmes currently in place, covering public, private, and mixed funding models. Incompleteness of the data means it is not possible to break out exact and reconcilable figures for management programmes by region and funding type. However, we present below the cost estimates (per annum) for programmes currently underway by pest type.

Pest Species	Annual Programme Costs
General	\$392,300
Elodea	\$20,000
Hornwort	\$3,298,325
Hydrilla	\$123,809
Lagarosiphon	\$1,458,928
Parrot's feather	\$1,500
Salvinia & Water Hyacinth	\$60,000
Water Lilly	\$1,500
Total	\$5,356,362

Note that the General pest category may contain programmes for other pests in the table, however it is not possible to determine the cost split for the pest species.

Many of the programmes involve a substantial capital investment up front, such as water intake covers, with an annual operating component in addition to this. The capital figures available show that the majority of capital investment is to implement management systems for protecting hydropower generation.

Programme Costs by Type

It is possible to breakdown the costs in the above table by the type of programme being implemented. We split programme types into preventative and monitoring. Preventative programmes are those which target a specific pest in a given area and either prevent further infestation or reduce the current infestation level. Monitoring programmes are those which gather information on infestation levels, spread, and area in order to feed into the decision making process around use of resources and future management programmes.

Programme Type	Cost
Preventative	\$4,359,500
Monitoring	\$996,862
Total	\$5,356,362

6.2. Other impacts of Freshwater Pests

In this section we refer generally to the range of freshwater pests considered above.

The discussion above considered the costs of intervention programmes. These programmes represent direct costs of the pest species. If intervention leads to complete control of a pest species, then intervention represents the total economic cost. However, total control is rare. Instead, pest species have economic impacts in addition to the control costs.

Commercial

The most significant commercial impact of freshwater pests occurs in electricity generation. A number of freshwater pests can block and cause damage to water intake mechanisms within hydro stations. Without adequate screening and monitoring, such blockages can cause production losses to the order of \$100,000 per day. Please note that to ensure no double-counting occurs, the cost of production losses are excluded from the figures cited in this report.

Accordingly there is a relatively high degree of investment by private companies to ensure that blockages do not occur. A number of prevention and monitoring programmes are co-funded by public and private organisations which allow both monetary and in-kind contributions.

Programmes which ensure hydro stations do not lose functionality are of very high importance for New Zealand. The potential impact of an ongoing loss of electricity production can have long reaching consequences across the country.

In addition to electricity generation, there are a number of fisheries and aquaculture operations which are affected by freshwater pests. A good example of this is in the eel fisheries, where production value is lost due to the time and effort required in clearing and cleaning equipment. Unlike the electricity sector, the relatively small eel fishing industry is fairly widespread and does not have the resources to carry out targeted pest reduction. However many industry groups are willing to make in-kind contributions to pest management programmes, as well as providing monitoring information where possible.

The final commercial impact of other freshwater pests is on the tourism sector. We do not have specific data relating to economic losses in tourism as a result of freshwater pests, however there are two points which must be noted:

1. Tourism revenues will fall if freshwater pests prevent tourism offerings from utilising freshwater resources. The scale of the impact is heavily dependent on the scale of pest infestation and the type of pests. The tourism sector has engaged well in prevention programmes, somewhat mitigating the risk posed by freshwater pest incursions.
2. Tourism itself can contribute to the spread of freshwater pests. Prevention programmes are well engaged in by tourism operators, however the free and independent class of tourist can contribute to the spread of freshwater pests.

Overall there is limited information available on the impact of tourism on freshwater pests, and we strongly encourage the continued engagement with the wider tourism sector to understand the impact of tourism activities on freshwater pest infestations.

Recreational and Social

The key impact of freshwater pests on recreational values is across fishing and boating. The impacts on fishing can be quite severe and while there may not be a significant commercial value attached to recreational fishing, it is an important aspect of many people's lives. Specific impacts of other freshwater pests on recreational fishing include:

- Reduced number of license carriers
- Diminished feed availability
- Reduced wild stocks
- Higher cost to travel to alternative fishing locations

In addition to the impacts on fishing, there is an associated impact on boating. Significant pest incursions can cause:

- Fewer boats on the water
- Diminished tourism operations
- Increased cleaning requirements
- Engine and equipment failures

A number of the industry organisations cited the visual impact of freshwater pests as a significant problem as it reduces willingness to participate in recreational activities, and for boating can increase the risk of accidents occurring.

New Zealand lakes and rivers, as well as the areas around them, are used for other forms of recreation, too. These activities may be affected by freshwater pests. The impact of pests on swimming, tramping, picnicking and other activities is unknown.

As with didymo, other freshwater pests also affect social or non-market values associated with waterways. These values include existence values and loss of native species. The impacts that these freshwater pests have on non-market values is unknown. In addition, it is unclear how values may be different with the presence of one pest species versus several species. There is therefore insufficient data on New Zealand to generate estimates of the total value of non-market impacts of freshwater pest species.

It is important to note that in the case of didymo, economic values associated with recreation, existence values, and loss of native species were greater than the cost of intervention programmes. If the same pattern holds for other freshwater pests, then the total economic impacts could be three times the costs of the prevention programmes or more.

6.3. Conclusions

The economic impact of other freshwater pests is potentially very significant. We have observed that these pests impact a wide range of commercial and social activities, however the extent to which these activities is currently impacted remains relatively unknown. There are pockets of good information, particularly among hydro power operators, but a more detailed information gathering process is required to determine the full extent of impacts.

Furthermore the ongoing impact of these pests is unknown. Where the pests cause a direct loss of production value, the impact is clear, however the wider economic costs of damage to the tourism sector could be very significant. To gain a better picture of the potential risks of freshwater pests engagement with the tourism sector and participants in recreational boating and fishing must be increased. As with the power companies, there may be scope to form a greater degree of public and private co-funding in monitoring and controlling the spread of freshwater pests. The impacts on other types of recreation and impacts on other non-market values should also be studied further, in order to determine the appropriate scale for intervention programmes.

Appendix 1 – Detailed Methodology

The scenarios and scale of the impacts in the previous assessment were informed by the Didymo Technical Advisory Group (TAG). This update follows the same methodology as the 2006 assessment, but makes use of more recent data where available. Some of the sector impacts have been reviewed. The reviews were informed by

- Responses to the recent survey of relevant agencies that was administered by Deloitte
- Studies completed since the 2006 assessment
- MAF Biosecurity New Zealand's economic impact assessment stocktake (MAF Biosecurity New Zealand, 2007).

The remainder of this section discusses our approach to the key aspects of our assessment, and details any differences between this and the previous assessment.

Baseline scenario

We consider a baseline scenario where there have been no impacts from didymo. The continuing impact of didymo is assessed by comparing the outcomes of affected sectors against this baseline. This update models the impacts of didymo continuing to spread throughout the New Zealand from its initial detection in the South Island in 2004 through to a potential infestation of the North Island.

Range of impacts

At the time of the previous assessment, little scientific information was available on the spread and impact of didymo. While a number of studies have been completed since then, there remains a lot of uncertainty about the didymo's potential spread and effects in New Zealand. To reflect this situation, we follow the previous assessment's methodology and model the impacts of didymo across low, medium, and high impact scenarios.

Distribution

Predicted range of didymo

The geographical spread of didymo that informed the earlier economic impact assessment made use of a didymo Likely Environments Map (LEM), produced by Kilroy et al. (2005). This map was based on the limited information that was available when didymo was first detected in New Zealand.

Kilroy et al. (2007) updated this earlier work with information not previously available and also followed a different statistical modelling approach. We use the outcomes from this modelling as the potential geographical range of didymo in New Zealand.

Kilroy et al. (2007) present percentages of high-order stream sections in each island that are estimated to support different levels of didymo cover⁴. For example:

- 74% of high-order streams in the North Island are expected to be able to sustain didymo covering, on average, at least 1.0 percent of the stream
- 91% of high-order streams in the North Island are expected to be able to sustain didymo covering, on average, at least 0.1 percent of the stream.⁵

These levels of average cover are applied as the maximum range of didymo throughout the country for the low, and the medium and high impact spread scenarios. These scenarios can be interpreted as the minimum average level of cover required for didymo to have an impact.

These thresholds are described in Kilroy et al. (2007) as 'just noticeable' and 'visually absent' for the low and high scenarios, respectively. This implies that, under the high impact scenario, less didymo is needed to have a negative impact. We acknowledge that these thresholds are high and cover a significant proportion of reaches in each Island. We undertook sensitivity analysis of using thresholds for 1 percent and 10 percent cover.

The percentages of streams predicted to be affected in each island under these thresholds are reported below. We consider these to be the annual average percentage of river reaches affected in each region. As in the previous assessment, we model the same medium and high impact scenarios for the predicted range of didymo. The sector specific impacts are then varied across the three scenarios.

⁴ We note that the figures used in Kilroy et al (2007) have been updated since 2007. However to maintain the comparison with the original research we continued to use the original Kilroy estimates. Future research should use the updated data which includes all order streams (1 – 8) and positives since 2007.

⁵ Table 5.1, Kilroy et al. (2007)

Predicted range of Didymo

Region	Range (% of river reaches)		
	Low impact scenario	Medium impact scenario	High impact scenario
North Island	74%	91%	91%
South Island	96%	99%	99%

Source: NZIER, Kilroy et al (2007)

Didymo's potential range and spread are modelled by island, and some of the sector impacts are considered by regional council. For reporting purposes we group the regions into the following groups:

- North Island
- Upper South Island – Tasman, Nelson and Marlborough
- Central South Island – West Coast and Canterbury
- Lower South Island – Otago and Southland.

Rate of spread

Didymo was first reported in the lower South Island in 2004/05. Since then it has spread to over 150 South Island rivers, but is not currently in the North Island. We reflect this by modelling the geographic spread of didymo as beginning in the lower South Island in 2004, progressing to the central South Island in 2005, and the upper South Island in 2006. As didymo has not been reported in the North Island, for the purposes of the model, we assume that it reaches the North Island by 2013.

We model the spread of didymo throughout a region to allow the impacts to be phased in as a 50 percent increase on the previous year until they reach the full impact. As in the previous assessment, we model the full impacts on a region to be reached five years following the initial discovery.

The details of the spread of didymo through each of the regions is shown in the below table. The time period of interest for our updated assessment is 2011-2020. This implication of the modelled spread of didymo is that the South Island will face the full impacts of didymo for the whole decade, while the North Island will be fully impacted by didymo for three of the ten years.

Spread of didymo

Region	First impacts	Full impacts
North Island	2013	2017
Upper South Island	2006	2010
Central South Island	2005	2009
Lower South Island	2004	2008

Source: NZIER

Sector impacts

To provide a complete understanding of the impact it has on the country, all of the effects that didymo has on New Zealand should be considered. The full range of effects will cover:

- Commercial
- Environmental
- Social
- Human health and well-being
- Māori cultural and spiritual values
- Government spending.

Not all of these effects are able to be quantified due to a lack of available data. The impacts that this assessment does cover include:

- Commercial eel fisheries
- Municipal, industrial and agricultural water intakes
- Drinking water
- Local recreational values
- Tourism expenditure (domestic and international)
- Local and national existence values
- Existence values associated with the loss of native species.

Other sectors are likely to be impacted, but are not included in the model due to data limitations:

- Cultural values including customary fishing
- Alluvial gold mining
- Exports of used fishing and boating gear
- Human health, from eye irritation in swimmers and injuries from slipping on rocks.

The types of information used in this update include official statistics from Statistics New Zealand, sector specific data provided by industry bodies, previous estimates from the literature, and the responses from a Deloitte-administered survey of key agencies.

Commercial eel fisheries

The previous assessment noted instances in the United States where didymo reduced fish populations. Recent evidence in New Zealand is conflicting. Survey responses from eel traders report high impacts on output and production related to didymo. In its 2007 stocktake of didymo related economic impacts, MAF Biosecurity New Zealand states that there had been no reports at that stage of impacts on commercial eel fisheries (MAF Biosecurity New Zealand, 2007). It does note that there have been impacts on freshwater salmon farming through more stringent voluntary decontamination requirements.

The Cawthron Institute (2007) modelled trout growth potential based on samples of invertebrate drift from three sites on two Southland rivers that were affected by didymo. They found that didymo did not sufficiently alter invertebrate drift to negatively affect trout growth. The authors note that these results should be used with caution as they are based on small samples.

Discussions with some freshwater salmon farms have indicated that the farms that have didymo present are currently not being negatively impacted. This is because either they are not exposed to didymo, or the existing cleaning systems are adequately dealing with the didymo build up on nets.⁶ For this reason, we have not modelled any quantitative impacts of didymo on freshwater salmon fisheries.

Due to the conflicting nature of the New Zealand evidence, we follow a similar procedure as the previous assessment and model the impacts on freshwater eel fisheries alone. At the island level, the potential impact of didymo on commercial eel fisheries is modelled as reducing the annual return on investment in New Zealand's commercial eel fisheries by 5 percent, 10 percent, and 20 percent, under the low, medium, and high impact scenarios, respectively.

⁶Based on personal communication, 16 and 17 August 2011.

These reductions are applied to an assumed average 10 percent rate of return on freshwater eel fishery asset values (Statistics New Zealand, 2010a, extrapolated to the North Island based on Jellyman, 2007⁷; updated to 2011 dollars, Statistics New Zealand, 2011), according to the potential range of Didymo (0, above).

Insufficient data is available to model the potential impacts on other commercial freshwater fisheries, such as the whitebait and trout sectors.

The potential impacts of didymo on recreational fishing are included in modelling potential impacts on local recreation values, outlined below.

Water intakes

Didymo can build up and restrict the flow of water through water intake screens. This build up will require clearing, which is a cost of didymo. One alternative to physically cleaning the screens is to install screens with a self-cleaning function.

The additional costs for water intakes from the introduction of didymo will be the difference in cost between a standard screen, and a self-cleaning screen. This is because the cost of a standard screen would be spent regardless of whether that intake was affected by didymo or not.

The difference in annualised capital costs between a self-cleaning screen and a standard screen, mid-range in size, is \$241.38, with allowance for didymo reducing the expected life of screens to eight years (Bosch Irrigation, 2011). As in the previous assessment, this additional cost is modelled for 50, 75 and 95 percent of municipal, industrial and agricultural consented surface water intakes (Aqualinc, 2010), under the low, medium and high impact scenarios respectively, according to the range of didymo (as discussed in 0, above).

Additionally we include \$1.56 million in annual costs associated with didymo impacting on water filters associated with hydro generation in Manapouri, the Tekapo canals, and the Waitaki Valley.

Screens may be upgraded under routine maintenance and replacement plans. Where the upgrades are in response to severe blocking, other activities that are depended on water may be disrupted, causing additional costs. Examples of these other activities could include irrigation schemes. While these additional costs are impacted by didymo, they have not been included in this assessment due to a lack of available data. The impacts on hydro-electricity are modelled as part of the sensitivity testing.

⁷This is based on the North Island contributing 64 percent of the total catch for New Zealand over the last 14 years (Jellyman, 2007).

Drinking water

While it is safe to drink, it is possible that water sourced from didymo-affected rivers could have an unpleasant odour or taste that would need to be treated. MAF Biosecurity New Zealand (2007) notes that, at that time, the existing treatments for drinking water has been sufficient. Responses from the recent survey indicate concern about the possible toxicity of didymo on drinking water.

We follow the same procedure as the previous assessment, which models the additional water management and treatment costs for carbon filters for 20, 30 and 40 percent of surface water allocated for drinking, under low, medium and high impact scenarios respectively. The additional cost is modelled as \$0.012 per metre³ of water per year (Hamilton City Council, 2011). Surface water allocation levels are taken from Aqualinc (2010).

Recreation values

It is difficult to estimate all of the effects that didymo might have across all sectors. This is particularly relevant to the sectors where markets do not exist, as values cannot be observed. The environmental impact of didymo is one example where we cannot observe the value that people place on environmental impacts, including impacts on individual species, biological systems and biodiversity, and social impacts, including on lifestyle and cultural values.

There are, however, a range of methods that can economists use to value non-market impacts. These include:

- Cost-based approaches, which measure value in terms of costs paid or avoided
- Willingness-to-pay approaches, which measures value in terms of willingness-to-pay to avoid a negative impact, or willingness-to-accept compensation for a negative impact

Cost-based approaches can under-represent value, as people are likely to value something at a higher level than just the associated costs. The willingness-to-pay approaches are generally considered to be a more complete estimate, as they reflect the value of immediate use, option values, and existence values.

We follow the approach in the previous assessment and make use of White and Sharp (2002), which reports the average cost per household per year (in 2011 dollars, Statistics New Zealand, 2011) of local recreational use of the Manawatu-Wanganui region's freshwater assets as:

- Fishing – \$26.22
- Hunting – \$49.63
- Boating – \$49.63
- Other recreation (swimming, picnics, etc.) – \$11.24.

To allow for differences across regions, we scale these values by the number of rivers and lakes that are potentially of national importance for recreation in each region relative to Manawatu-Wanganui (Ministry for the Environment, 2004).

Didymo may also impact recreational values by increasing costs and reducing benefits. Examples of impacts on other recreational value are:

Increased costs

- Travel costs to unaffected areas
- Additional cleaning requirements for fishing or boating equipment
- Extra time required to catch the same number of fish

Reduced benefits

- Worse swimming experience
- Lower fish catch rates

Source: NZIER

To reflect the high correlation between environments most suitable for didymo and areas most popular for recreational activities, didymo is modelled as causing the following reductions in the per-household values reported above, under low, medium and high impact scenarios respectively:

- Fishing – 20, 50 and 80 percent reductions
- Hunting – no significant impact
- Boating – 5, 10 and 20 percent reductions
- Other recreation – 10, 20 and 50 percent reductions.

These are multiplied by numbers of households (Statistics New Zealand, 2010b), according to the potential range of didymo.

Tourism expenditure

New Zealand's rivers and lakes are one of its attractions for both domestic and international tourists. Didymo may impact on the attractiveness of these rivers and lakes to tourists. We model this as a reduction in tourism expenditure, although this may undervalue the willingness of tourists to pay to avoid these impacts.

Ministry of Tourism (2004) reports that expenditure by international visitors who participated in at least one freshwater activity accounts for around half of total expenditure by all international visitors. These visitors will range from those who primarily travelled to New Zealand to participate in those activities, to tourists that came for other attractions. For modelling purposes, we follow the previous assessment's methodology and assume the average to be 10 percent for international visitors, skewed by the high-end, international market for angling trips, and 5 percent for domestic visitors.

We model the impact on domestic tourists as a reduction in domestic tourism expenditure by 1, 2.5 and 5 percent, under the low, medium and high impact scenarios. This range encompasses a number of activities that could be affected by didymo to varying degrees, and reflects that domestic tourists are more flexible than local recreational users in being able to substitute to alternative destinations. International visitors are modelled as twice as reactive – reducing expenditure on freshwater activities by 2, 5 and 10 percent, under low, medium and high impact scenarios respectively. This reflects that some of the international visitors that were coming to New Zealand primarily because of its freshwater attractions may now visit other countries.

The modelled reductions represent long-term averages. Negative publicity may cause a larger initial reaction that may return to a more moderate level. These reductions are also net of substitution of alternative destinations in New Zealand. Regions without didymo may experience an increase in tourism expenditure.

The modelled effects of didymo are weighted to reflect regional differences in importance for tourist freshwater activities (Ministry of Tourism, 2004) before being applied to international and domestic tourism expenditure (Tourism Strategy Group, 2010, in 2011 dollars, Statistics New Zealand, 2011), according to the potential range of didymo.

Existence values

An environmental resource can be of value to people simply by existing. That is, people do place value on the existence of environments and species they will never experience. By lowering the quality of that resource, didymo can reduce the existence values that households place on New Zealand's rivers and lakes.

To model the impact on existence values, we follow the method used in the previous assessment. White and Sharp (2002) adopts \$128.53 per household per year (in 2011 dollars, Statistics New Zealand, 2011) average willingness-to-pay by Manawatu-Wanganui households for the existence of that region's freshwater assets.⁸ We reflect regional differences by scaling this effect by the number of rivers and lakes of national importance, relative to the Manawatu-Wanganui region (Ministry for the Environment, 2004).

⁸This is roughly mid-range of a number of national, regional and local level studies of existence values associated with maintaining or restoring the quality of freshwater assets (Sharp and Kerr, 2005).

A river or lake that is impacted by didymo will maintain a range of characteristics that are valued by households, and the community. This means that the impacted rivers and lakes will maintain some existence value. As with the previous approach, and given the high correlation between high profile rivers and lakes, and those that are most suitable for didymo, we model reductions in existence values of 2.5, 5, and 10 percent under the low, medium, and high scenarios. These are then multiplied by the number of households in each region (Statistics New Zealand, 2010b).

Didymo may also reduce the existence values held by households beyond the impacted region (e.g. North Islanders may also value Southland's rivers and lakes and worry about didymo's impacts there, even if they have not been to Southland). As existence values tend to decline with distance, we model the average reduction in existence value per household nationally as one fifth the average reduction in local existence values (in effect, households are impacted twice from existence values – one from the presence of didymo in New Zealand, the second and larger from the presence of didymo in their region).

Loss of native species

Didymo may also negatively impact biodiversity. We follow the same method as the initial assessment and model this impact in a simplified form as equivalent to the loss of existence values associated with the extinction of one, two and three endangered native fish or bird species under the low, medium and high impact scenarios.

Kerr and Sharp (2003) estimates the local existence value associated with loss of a single native fish species to be \$12.73 per household per year (in 2011 dollars, Statistics New Zealand, 2011). Similar studies for bird species have tended to focus on high profile species, so may not be representative of all species at risk. We adopt local existence value across native fish and bird species at risk of extinction due to didymo averaging double the estimate of Kerr and Sharp (2003). With familiarity with these species declining with distance, we adopt an average of one fifth of this local value, as above, for all households nationally.

Placing a value on the loss of biodiversity is complex. As noted in the previous assessment, the approach taken here is very simplistic. It may not accurately represent households' willingness-to-pay to prevent biodiversity losses that are caused by didymo.

Costs of intervention

A number of programmes have been implemented to slow or mitigate the impacts of didymo. None of these programmes were in place at the time of the previous economic impact assessment. The costs associated with these programmes are an impact of didymo and are taken into account within this update.

The programmes and associated costs are based on responses from Deloitte's survey of key agencies. Examples of these agencies include:

- Ministry of Agriculture and Forestry
- Department of Conservation

- Regional Councils

The objective of a number of programmes is to prevent didymo spreading to the North Island. We consider that these programmes will not continue to receive funding once didymo is reported in the North Island. Additionally, some programmes target multiple pests. We have focussed on the programmes where didymo is the primary target.

Expected impacts

It is uncertain which of the three scenarios is most likely to occur in New Zealand. In the previous assessment, each scenario was assigned a relative probability of occurrence. These probabilities were informed by the TAG and were assumed to be:

- Low impact scenario - 25 percent
- Medium impact scenario - 60 percent
- High impact scenario - 15 percent

As no additional information is available about the likelihood of each scenario, we have maintained these relative probabilities.

Auckland

Deloitte Centre
80 Queen Street, Auckland 1010
Private Bag 115033
Shortland Street, Auckland 1140
New Zealand
Tel: +64 (0) 9 303 0700
Fax: +64 (0) 9 303 0701

Hamilton

Deloitte House
24 Bridge Street, Hamilton East
Hamilton 3216
PO Box 17, Hamilton 3240
New Zealand
Tel: +64 (0) 7 838 4800
Fax: +64 (0) 7 838 4810

Christchurch

60 Grove Road
Christchurch 8011
PO Box 248
Christchurch 8140
New Zealand
Tel: +64 (0) 3 379 7010
Fax: +64 (0) 3 366 6539

Wellington

Deloitte House
Levels 11-16, 10 Brandon Street
Wellington 6011
PO Box 1990, Wellington 6140
New Zealand
Tel: +64 (0) 4 472 1677
Fax: +64 (0) 4 472 8023

Dunedin

Otago House
481 Moray Place
Dunedin 9016
PO Box 1245, Dunedin 9054
New Zealand
Tel: +64 (0) 3 474 8630
Fax: +64 (0) 3 474 8650

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