Didymosphenia geminata economic impact assessment

Final report to Biosecurity New Zealand

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Preface

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Summary

Methodology

This assessment models the potential impacts of *Didymosphenia geminata* (didymo) on New Zealand in the absence of government intervention to control its spread under three scenarios with regard to its distribution and effects:

- low impact scenario:
  - high and persistent biomass in high risk river reaches;
- medium impact scenario:
  - high and persistent biomass in high risk river reaches;
  - moderate and occasional biomass in medium risk river reaches;
  - low biomass in lakes;
- high impact scenario:
  - high and persistent biomass in high and medium risk river reaches; and
  - moderate and occasional biomass in lakes.

These seek to represent probable scenarios, according to the opinion of the Didymo Technical Advisory Group on the most likely types and magnitudes of effects, to inform decisions on incursion response options to avoid or reduce these impacts.

Results

This assessment estimates potential present value 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 and existence values associated with extinction of native species, over the eight years 2004/05 to 2011/12, to total:

- $57.798 million under the low impact scenario;
- $167.233 million under the medium impact scenario; and
- $285.132 million under the high impact scenario.

Weighting the three scenarios by their relative probabilities suggests expected present value total impacts over this period of $157.599 million.

Total impacts are dominated by 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. Total impacts are greatest in the North Island and central South Island. Although the lower South Island has the largest amount of highest risk environment for survival of didymo and is where impacts occur earliest, the central South Island and North Island have substantially larger human populations to suffer reduced recreation and existence values.

Sensitivity analysis

Without the loss of native species, present value total impacts over the period 2004/05 to 2011/12 would be reduced to between $39.525 million and $230.312 million.

A two year delay to the arrival of didymo in the North Island would reduce the present value total impacts incurred over the longer period 2004/05 to 2013/14 by between $5.024 million and $62.419 million (9 and 22 per cent). Slowing the spread of didymo through each region (from five to seven years) would reduce the present value total impacts incurred over the longer period 2004/05 to 2013/14 by between $26.302 million and $142.748 million (46 and 50 per cent).

Additional impacts

Additional to the above estimated impacts are other potential impacts not quantified in this assessment due to data limitations or materiality – impacts on cultural values, including customary fishing, alluvial gold mining, exports of used fishing and boating gear, including in personal effects, and human health, from eye irritation in swimmers and injuries from slipping on rocks.

Contents

1. Introduction

Didymosphenia geminata (Lyngbye) Schmidt (didymo) is an invasive alga of freshwater streams, rivers and lakes. It is a microscopic organism, which in bloom forms dense fibrous mats with the texture and appearance of dirty brown cotton wool. Depending on biomass, these degrade river and lake ecosystems, affecting aquatic plant/algal species and invertebrates and potentially affecting fish and bird species, and can interfere with recreational activities and decrease aesthetic appeal. Didymo can foul fishing and boating gear, make river beds and rocks slippery and block water intakes. It does not pose a significant risk to human health – fish and eels caught in affected rivers and lakes are safe to eat and extracted water is safe to drink – but it can cause eye irritation to swimmers (Kilroy, 2005).

Didymo is normally found in cool, temperate, northern hemisphere river systems and has been spreading through Europe and North America since the mid 1980s. It was discovered in Southland's lower Waiau and Mararoa Rivers in October 2004, its first detection in the Southern Hemisphere. It is not known how it came to be established in Southland. To date, it has been found in several rivers in Southland, Otago and the West Coast. Biosecurity New Zealand implemented containment measures to minimise spread and is continuing delimiting surveys to identify any further locations.

The purpose of this economic impact assessment is to model the potential impacts on New Zealand of the establishment and spread of didymo to inform Biosecurity New Zealand's decisions on incursion response options.

2. Methodology

The assessment presented below models potential impacts according to the opinion of the Didymo Technical Advisory Group on the most likely types and magnitudes of effects of didymo.

It estimates the full annual impacts resulting from the presence of didymo throughout its potential range and the total impacts accumulating over the period of its spread.

Current prices and technology are assumed throughout. In this simple assessment, sector sizes are treated as constant (i.e. not incorporating forecast growth or decline). All values are expressed in real terms (i.e. net of inflation) in June 2005 New Zealand dollars. In expressing future impacts in terms of their present value in 2005, the discount rate is set at 10 per cent.

2.1 Approach

2.1.1 Baseline scenario

This assessment models the potential impacts of didymo in the absence of government intervention to control its spread. This provides a baseline relative to which to assess incursion response options. The avoidance of or reduction in these impacts comprises the benefits of intervention, for comparison with control costs including the impacts of movement or access restrictions. Implicit in this baseline are the likely reactions of affected sectors in terms of corrective or preventative actions taken by individuals to mitigate the impacts of which they are at risk.

2.1.2 Range in impacts

Internationally, there is little scientific information available on didymo. Although Biosecurity New Zealand has commissioned a number of studies in the past year, to the extent that New Zealand has rapidly become the world expert on this species, there remains considerable uncertainty as to didymo's potential distribution and effects in the New Zealand environment. To reflect this uncertainty, but represent a probable range, potential impacts under the above baseline are modelled for three scenarios:

- low impact scenario:
  - high and persistent biomass in high risk river reaches;
- medium impact scenario:
  - high and persistent biomass in high risk river reaches;
  - moderate and occasional biomass in medium risk river reaches;
  - low biomass in lakes;
- high impact scenario:
  - high and persistent biomass in high and medium risk river reaches; and
  - moderate and occasional biomass in lakes.

2.2 Distribution

2.2.1 Potential range of didymo

Kilroy *et al*. (2005) assesses the suitability of New Zealand for survival of didymo, based on the species' environmental requirements and preferences. Southland, Otago, Canterbury rivers on the Eastern flanks of the Southern Alps, the Kaikoura ranges and the North Island's central volcanic plateau are indicated to be of highest suitability. Scattered rivers in Fiordland, the West Coast, Marlborough and the north west Nelson region, plus some rivers in the higher altitude areas of the North Island, such as Wanganui, Rangitikei and Hawke's Bay, are also identified as highly suitable.

As the potential range of didymo, throughout which to model its impacts, we use the percentages of high-order stream sections[1] at risk in each region (Kilroy, 2006), for high risk river reaches only under the low impact scenario and both high and medium risk river reaches under each of the

[1] Larger, more visible waterways, which people recognise as "rivers" and use for recreational and other purposes, in contrast to all mappable stream sections.

medium and high impact scenarios, as in Table 1, below. With growth fluctuating year to year (Kilroy, 2005), these percentages are treated as the annual average percentage of river reaches affected in each region.

Table 1: Potential range of didymo

Region	Percentage of high-order river reaches containing didymo		
	Low impact scenario	Medium impact scenario	High impact scenario
Northland	0%	85.5%	85.5%
Auckland	0%	78.8%	78.8%
Waikato	15.7%	89.9%	89.9%
Bay of Plenty	6.1%	70.8%	70.8%
Gisborne	4.0%	98.1%	98.1%
Hawke's Bay	30.4%	94.8%	94.8%
Taranaki	0.3%	92.3%	92.3%
Manawatu-Wanganui	33.7%	94.7%	94.7%
Wellington	21.5%	98.4%	98.4%
Tasman-Nelson	73.9%	98.4%	98.4%
Marlborough	77.0%	98.7%	98.7%
West Coast	68.2%	93.4%	93.4%
Canterbury	68.9%	93.4%	93.4%
Otago	85.7%	99.6%	99.6%
Southland	88.2%	99.4%	99.4%

Didymo's potential range, above, and impacts on affected sectors are modelled by council region, but for the purposes of modelling spread and reporting results, council regions are grouped into four areas:

- North Island;
- upper South Island – Tasman, Nelson and Marlborough;
- central South Island – West Coast and Canterbury; and
- lower South Island – Otago and Southland.

2.2.2 Rate of spread

Although wildlife might spread the alga, in New Zealand the main mechanism is considered likely to be human assisted dispersal. Didymo can be spread as microscopic particles attached to fishing and boating gear and clothing, vehicles, animals or anything that has been in contact with affected water and is not cleaned or allowed to dry completely before entering other watercourses.

Available evidence suggests that didymo may have been present in New Zealand for at least five years (Ministry of Agriculture and Forestry, 2005a). Having remained unobserved previously, however, it is modelled as not starting to impact significantly on affected sectors until 2004/05. Without government intervention to control its spread, didymo is modelled as spreading from first establishment in the lower South Island throughout its remaining potential range within a further seven years to 2011/12. Table 2 identifies the period of spread modelled for each region, ranging from the year in which impacts start to be significant to the year in which they reach full annual magnitude (June years).

Table 2: Spread of didymo

Region	First impacts	Full impacts
North Island	2007/08	2011/12
Upper South Island	2005/06	2009/10
Central South Island	2006/07	2010/11
Lower South Island	2004/05	2008/09

To approximate the "S-curve" pattern of spread typical of pests and diseases, impacts within each region are phased in over the above periods of spread at the rate of a 50 per cent increase in annual impacts each year until reaching full annual magnitude.

2.3 Sector impacts

Consideration of the benefits and costs of incursion response options should encompass the full range of effects across all sectors – commercial, environmental, social, human health and well-being and Māori cultural and spiritual, as well as government expenditure (Ministry of Agriculture and Forestry, 2004). The organism impact assessment of Campbell (2005) examines the risk didymo poses to these sectors in New Zealand.

This economic impact assessment models 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; and
- existence values associated with extinction of endangered native species.

Additionally, not quantified in this assessment due to data limitations or materiality, are other potential impacts of didymo on:

- cultural values, including customary fishing;
- alluvial gold mining, in obstructing extraction and clogging filters;
- exports of used fishing and boating gear, including in personal effects, if additional cleaning and/or inspection requirements are imposed or entry prohibited by countries in which didymo is not yet but has potential to become established; and
- human health, from occasional eye irritation in swimmers and injuries from slipping on rocks.

Overseas, didymo's growth varies year to year to the extent that the occurrence of blooms in a given river reach is reported to be unpredictable and not necessarily every year (Kilroy, 2005). The coefficients adopted in modelling the potential impacts of didymo in New Zealand, as outlined below, represent annual averages.

2.3.1 Commercial eel fisheries

There have been instances reported in the USA of didymo reducing fish populations (e.g. trout fisheries declining by up to 90 per cent locally, Environmental Protection Agency, 2005), although Campbell (2005) highlights that these are anecdotal and lack supporting empirical or manipulative evidence.

At the regional level, this assessment models the potential impact of didymo as reducing the annual return on investment in New Zealand's commercial eel fisheries by 5 per cent under the low impact scenario, 10 per cent under the medium impact scenario and 20 per cent under the high impact scenario, given the hardiness of this species. These reductions are applied to an assumed average 10 per cent rate of return on freshwater eel fishery asset values (Statistics New Zealand, 2005a, extrapolated to the North Island; updated to 2005 dollars, Statistics New Zealand, 2005b), according to the potential range of didymo (p.6, above).

Insufficient data could be obtained on the value of commercial whitebait fisheries nationally to model the potential impacts of didymo on this sector.

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

2.3.2 Water intakes

Didymo can cause significant clogging of water intake screens, which has prompted a switch to self-cleaning screens in the USA.

The difference in annualised capital costs between a self-cleaning screen and a standard screen, mid-range in size, is $206.25, with allowance for didymo reducing the expected life of screens from ten to eight years (Bosch Irrigation, 2005). This additional cost is modelled for 50, 75 and 95 per cent of municipal, industrial and agricultural consented surface water intakes, including in hydroelectricity generation (extrapolated from White *et al*., 2004), under the low, medium and high impact scenarios respectively, according to the potential range of didymo (p.6, above).

Screens may be upgraded under existing routine maintenance and replacement. Where upgrades are left until in response to severe clogging, additional costs may arise in terms of unscheduled disruption of activities dependent on water intakes and temporary clearance to minimise the period of this disruption. The latter is a particular concern in hydroelectricity generation, where further research and possibly development is required of currently available technology. We have therefore included in the sensitivity analysis of section 3.3, below, the possibility of a few disruptions in the first couple of years of didymo spread.

2.3.3 Drinking water

Although safe to drink, water sourced from river reaches affected by didymo may require treatment for an unpleasant odour and taste.

Additional to existing potable water management and treatment practices, didymo is modelled as incurring operating costs of $0.01 per metre^3 of water per year (Hamilton City Council, 2005) for carbon filters to treat 20, 30 and 40 per cent of surface water for community, municipal and domestic use, under low, medium and high impact scenarios respectively.

2.3.4 Recreation values

A particular difficulty in assessing the full range of effects across all sectors is lack of information on the value to society of impacts of types for which markets do not exist and values cannot be observed directly. This is particularly the case for environmental impacts, including impacts on individual species, biological systems and biodiversity, and social impacts, including on lifestyle and cultural values.

There exist a range of methods for economic valuation of non-market impacts. Cost-based approaches measure value in terms of costs incurred or averted. These often fail to reflect full value, however, in that impacts may be valued in excess of simply the costs they incur or avert. A more complete measure of value is willingness-to-pay to secure a positive impact or to avoid a negative impact (or willingness-to-accept compensation to forgo a positive impact or to tolerate a negative impact). This reflects not only immediate use value, both direct and indirect, but also option value – the value placed on retaining the option for use, including for purposes yet unknown, in future years or by others – and existence value – the value placed on continued existence independent of current and anticipated future use. There are two categories of techniques for attempting to elicit willingness-to-pay – revealed preference methods, which seek to derive values from transactions in related markets, and stated preference methods (e.g. contingent valuation), which seek to establish hypothetical markets through use of survey techniques depicting trade-offs between costs and benefits under a range of scenarios.

Atkinson & Rapley Consulting (2005) reports a recent survey of the "perceived impacts" of didymo in three regions of New Zealand. The findings, while providing an indication of how a range of people regard the effects of didymo, unfortunately cannot be used to determine willingness-to-pay to avoid didymo's impacts because of the way the survey was structured and conducted.

From White and Sharp (2002), the average cost per household per year (in 2005 dollars, Statistics New Zealand, 2005b) of local recreational use of the Manawatu-Wanganui region's freshwater assets is:

- fishing – $21.48;
- hunting – $40.65;
- boating – $40.65; and
- other recreation (swimming, picnics, etc.) – $9.20.

As costs, these represent the lower bounds of the benefit values to users, as indicated above. There have been a number of studies of the benefit value of angling, most often per angler day (Robb and Bright, 2004). Depending on household uptake, the above value for fishing is close to the lower end of the range reported in these studies.

To reflect regional differences in the importance of rivers and lakes for recreational activities, including the quality of recreational experiences, we scale the above values by the number of rivers and lakes potentially of national importance for recreation in each region relative to Manawatu-Wanganui (Ministry for the Environment, 2004).

Didymo may affect recreational values through increasing costs (such as increased travel costs to less affected river reaches, increased effort in cleaning fouled fishing and boating gear or taking longer to catch the same number of fish) and reducing benefits (in terms of lower quality of recreational experience, such as less pleasurable swimming or lower fish catch rates, which may in turn reduce numbers of users).

Given a 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 above values, under low, medium and high impact scenarios respectively:

- fishing – 20, 50 and 80 per cent reductions;
- hunting – no significant impact;
- boating – 5, 10 and 20 per cent reductions; and
- other recreation – 10, 20 and 50 per cent reductions.

These are multiplied by numbers of households (Statistics New Zealand, 2005c), according to the potential range of didymo (p.6, above).

2.3.5 Tourism expenditure

Beyond the value of freshwater assets to local recreational users, didymo may also affect the value to international and domestic tourists. We model the latter as reflected in a reduction in tourism expenditure, although this may undervalue willingness-to-pay.

Ministry of Tourism (2004) reports total expenditure by international visitors who engaged in at least one freshwater activity to comprise around half of total expenditure by all international visitors. Of this, the importance of freshwater activities will range from visitors for whom freshwater activities were peripheral to their holiday to others for whom they were the primary purpose of their visit to New Zealand. Expenditure directly associated with freshwater activities will vary accordingly. For modelling purposes, we assume the average to be 10 per cent for international visitors, skewed by the high-end, international market for angling trips, and 5 per cent for domestic visitors.

We model didymo as reducing domestic visitors' expenditure on freshwater activities by 1, 2.5 and 5 per cent, under low, medium and high impact scenarios respectively, given that these encompass a range of activities affected by didymo to varying degrees and domestic tourists have greater flexibility than local recreational users to substitute alternative destinations. International visitors are modelled as twice as reactive – reducing expenditure on freshwater activities by 2, 5 and 10 per cent, under low, medium and high impact scenarios respectively – given that didymo may deter some visitors for whom freshwater activities would have been their primary reason for visiting New Zealand and international visitors may be more likely to substitute alternative destinations in other countries.

Note that the above reductions represent long-term averages. With adverse publicity, reactions may be greater initially but gradually revert to and stabilise at more moderate levels. These reductions are also net of substitution of alternative destinations in New Zealand. Regions without didymo may experience an increase in tourism expenditure.

The above effects of didymo are weighted to reflect regional differences in importance for tourist freshwater activities (Ministry of Tourism, 2004) before applied to international and domestic tourism expenditure (Tourism Research Council of New Zealand, 2005), according to the potential range of didymo (p.6, above).

2.3.6 Existence values

White and Sharp (2002) adopts $105.28 per household per year (in 2005 dollars, Statistics New Zealand, 2005b) average willingness-to-pay by Manawatu-Wanganui households for the existence of this region's freshwater assets beyond their use. This 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). As above, to reflect regional differences in the importance and quality of the freshwater environment, we scale this value by the number of rivers and lakes potentially of national importance for recreation in each region relative to Manawatu-Wanganui (Ministry for the Environment, 2004).

The perceived impacts reported in Atkinson & Rapley Consulting (2005) have been overstated, as although the presence of didymo would reduce the value of rivers and lakes, they would remain present and possess a wide range of desirable attributes. With a high correlation between environments most suitable for didymo and highest profile rivers and lakes, however, didymo is modelled as causing 2.5, 5 and 10 per cent reductions in the above existence values, under low, medium and high impact scenarios respectively. These are multiplied by the numbers of households in regions with didymo, according to its potential range (p.6, above), to represent the impacts on local existence values (Statistics New Zealand, 2005c).

The presence of didymo in a given region may also reduce the existence values held by households beyond this region (e.g. households in the North

Island may also value Southland's rivers and lakes and be concerned about didymo's impacts there, even if they do not plan to visit 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. For simplicity, we apply this to all households in each region across New Zealand (in effect, households therefore face two impacts on existence values – one from the presence of didymo in New Zealand, the second and larger from the presence of didymo in their local region where applicable).

Loss of native species

Didymo may also reduce biodiversity. This impact is represented in simplified form as equivalent to the loss of existence values associated with extinction of one, two and three endangered native fish or bird species under the low, medium and high impact scenarios respectively. Algal and invertebrate species may also be at risk.

Kerr and Sharp (2003) estimates the local existence value associated with loss of a single native fish species to be $11.58 per household per year (in 2005 dollars, Statistics New Zealand, 2005b). Similar studies for bird species have tended to focus on high profile iconic 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.

We highlight that this is a very simplistic approach, which belies the complexity of valuing biodiversity losses and may not accurately represent the public's willingness-to-pay to prevent biodiversity losses or cumulative species losses due to didymo.

2.4 Expected impacts

The relative probabilities of the three impact scenarios modelled are unknown. It is uncertain which set of circumstances could be considered most likely to occur in New Zealand, but the Didymo Technical Advisory Group currently regards the medium impact scenario to be the most probable. For the purpose of weighting estimated impacts to derive "expected impacts", the relative probabilities of the three scenarios are assumed to be:

- low impact scenario – 25 per cent;
- medium impact scenario – 60 per cent; and
- high impact scenario – 15 per cent.

3. Results

3.1 Full annual impacts

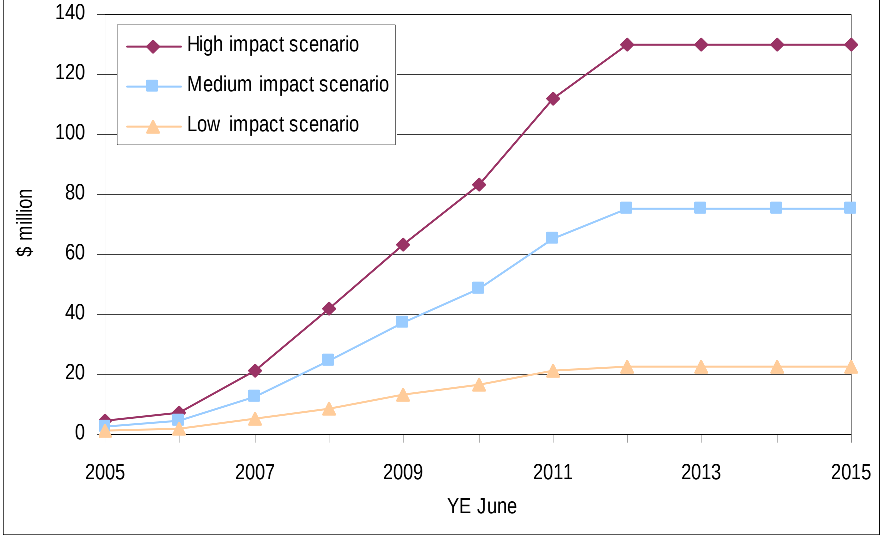
This assessment estimates that, in the absence of government intervention to control its spread, didymo could have full annual impacts on New Zealand's commercial eel fisheries, municipal, industrial and agricultural water intakes, community, municipal and domestic drinking water, local recreation values, international and domestic tourism expenditure, local and national existence values and existence values associated with the extinction of native species, upon completing spread throughout its potential range in 2011/12, of:

- $22.883 million under the low impact scenario;
- $75.199 million under the medium impact scenario; and
- $129.761 million under the high impact scenario.

Weighting the three scenarios by the above relative probabilities suggests expected full annual impacts from 2011/12 of $70.304 million.

Estimated annual impacts over the eight year period from first significant impacts in 2004/05 to full annual impacts from 2011/12 are as illustrated in Figure 1.

Figure 1: Annual impacts of didymo



3.2 Present value total impacts

At a discount rate of 10 per cent, the present value[2] in June 2005 of the potential impacts of didymo over this eight year period totals:

- $57.798 million under the low impact scenario;
- $167.233 million under the medium impact scenario; and
- $285.132 million under the high impact scenario.

Weighting the three scenarios by their relative probabilities, as above, suggests expected present value total impacts over 2004/05 to 2011/12 of $157.599 million.

[2] Discounting reduces all future annual costs or benefits to their present values at a single point in time, in this case June 2005, according to their relative timing to make them directly comparable.

The distribution of present value total impacts by sector and region are shown in Table 3 and Table 4.

Table 3: Present value total impacts 2004/05 to 2011/12 by sector

Sector	$ million (% of total)		
	Low impact scenario	Medium impact scenario	High impact scenario
Commercial eel fisheries	0.019 0.03%	0.237 0.14%	0.525 0.18%
Water intakes	10.785 19%	21.834 13%	27.656 9.7%
Drinking water	3.048 5.3%	7.716 4.6%	10.288 3.6%
Recreation values	12.706 22%	49.102 29%	88.248 31%
Tourism expenditure	6.091 11%	31.747 19%	63.493 22%
Existence values	6.875 12%	20.051 12%	40.102 14%
Loss of native species	18.273 32%	36.547 22%	54.820 19%
Total	57.798	167.233	285.132

Total impacts are dominated by 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.

Impacts are greater on international than domestic tourism, at 84 to 88 per cent of the reduction in tourism expenditure. The impact on existence values is higher locally than nationally. The impact on local existence values ranges between 67 and 78 percent of the total reduction in existence values.

Table 4: Present value total impacts 2004/05 to 2011/12 by region

Region	$ million (% of total)		
	Low impact scenario	Medium impact scenario	High impact scenario
North Island	17.665	67.847	116.437
	31%	41%	41%
Upper South Island	2.457	5.905	9.772
	4.3%	3.5%	3.4%
Central South Island	23.391	61.395	104.783
	40%	37%	37%
Lower South Island	14.285	32.086	54.141
	25%	19%	19%
Total	57.798	167.233	285.132

Total impacts are greatest in the North Island and central South Island. Although the lower South Island has the largest amount of highest risk environment for survival of didymo and is where impacts occur earliest, the central South Island and North Island have substantially larger human populations to suffer reduced recreation and existence values.

3.3 Sensitivity analysis

The impacts modelled are estimated under considerable uncertainty as to the spread and effects of didymo in the New Zealand environment. The sensitivity of estimated present value total impacts to key uncertainties with regard to distribution and severity of impacts is summarised in Table 5, below.

Without the loss of native species, present value total impacts over the period 2004/05 to 2011/12 would be reduced to between $39.525 million and $230.312 million.

A two year delay to the arrival of didymo in the North Island would reduce the present value total impacts incurred over the longer period 2004/05 to 2013/14 by between $5.024 million and $62.419 million (9 and 22 per cent). Slowing the spread of didymo through each region (from five to seven years) would reduce the present value total impacts incurred over the longer period 2004/05 to 2013/14 by between $26.302 million and $142.748 million (46 and 50 per cent).

3.4 Additional impacts

Additional to the above estimated impacts are other potential impacts not quantified in this assessment due to data limitations or materiality – on cultural values, including customary fishing, alluvial gold mining, exports of used fishing and boating gear, including in personal effects, and human health, from eye irritation in swimmers and injuries from slipping on rocks.

Table 5: Sensitivity analysis

Coefficient	Change to coefficient	Present value total impacts ($ million and % change)		
		Low impact scenario	Medium impact scenario	High impact scenario
Estimate[1]		57.798	167.233	285.132
Rate of spread	2 year delay to arrival in North Island[2]	73.154 -8.7%	199.415 -21%	338.279 -22%
	2 year delay to arrival in central South Island and North Island[2]	59.059 -33%	162.722 -43%	275.801 -44%
	2 years more to spread through each region[2]	51.876 -46%	151.181 -50%	257.949 -50%
	1 year less to spread through each region[3]	71.018 23%	208.962 25%	356.879 25%
Water intakes	half rate required	52.406 -9.3%	156.316 -6.5%	271.304 -4.8%
	100% require self-cleaning screens	68.583 19%	174.511 4.4%	286.588 0.51%
	Disruption of hydroelectricity generation[4]	57.798 0%	167.233 0%	295.545 3.7%

[1] To 2011/12. Present value total impacts to 2013/14 are $75.704 million under the low impact scenario, $225.369 million under the medium impact scenario and $378.148 million under the high impact scenario.
[2] Comparisons of present value total impacts to 2013/14.
[3] Comparisons of present value total impacts to 2011/12.
[4] Models four disruptions per year in 2006 and 2007 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.

Coefficient	Change to coefficient	Present value total impacts ($ million and % change)		
		Low impact scenario	Medium impact scenario	High impact scenario
Drinking water	no treatment required	54.750 -5.3%	159.517 -4.6%	274.844 -3.6%
	100% of water treated	69.991 21%	185.238 11%	300.565 5.41%
Recreation values				
Fishing	half the reduction in value per household	54.033 -6.5%	151.394 -9.5%	259.789 -8.9%
	50% greater reduction in value per household[5]	61.563 6.5%	183.072 9.5%	297.804 4.4%
Boating and other recreation	half the reduction in value per household	55.210 -4.5%	158.521 -5.2%	266.351 -6.6%
	50% greater reduction in value per household	60.386 4.5%	175.945 5.2%	303.913 6.6%
Tourism expenditure	half the reduction in expenditure	54.752 -5.3%	151.360 -9.5%	253.386 -11%
	50% greater reduction in expenditure	60.844 5.3%	183.106 9.5%	316.879 11%
	half the % of expenditure associated with freshwater activities	54.752 -5.3%	151.360 -9.5%	253.386 -11%
	50% greater % of expenditure associated with freshwater activities	60.844 5.3%	183.106 9.5%	316.879 11%

[5] Capped at maximum 100 per cent loss in value under high impact scenario.

Coefficient	Change to coefficient	Present value total impacts ($ million and % change)		
		Low impact scenario	Medium impact scenario	High impact scenario
Existence values	half the reduction in value per household	54.361 -5.9%	157.208 -6.0%	265.081 -7.0%
	twice the reduction in value per household	64.673 12%	187.284 12%	325.234 14%
Loss of native species	half the value per household	48.661 -16%	148.960 -11%	257.722 -9.6%
	loss of one species in high impact scenario only	39.525 -32%	130.687 -22%	248.586 -13%
	no loss	39.525 -32%	130.687 -22%	230.312 -19%

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