The Proposed Regional Pest Management Plan for the Bay of Plenty Region: Meeting the Biosecurity Act requirements

Contents

Part 1:

Proposed Regional Pest Management Plan for the Bay of Plenty region

Meeting the Biosecurity Act requirements

Under **Section 100D(5)** of the Biosecurity Act, the proposal:

Requirement		Comment on compliance
(a)	must state whether the proposal is to amend, revoke, revoke and replace, or leave unchanged the plan or part of the plan.	This proposal is to revoke the Regional Pest Management Plan for the Bay of Plenty 2011 – 2016 and replace it with the Proposed Regional Pest Management Plan 2018 (PRPMP).
(b)	must give reasons for the proposal.	The proposal is required following determination that the Regional Pest Management Plan 2011-2016 is inconsistent with the National Policy Direction for Pest Management. Also due to changes in the nature of pest infestations in the Bay of Plenty region since the previous Regional Pest Management Plan was developed; an updated proposal is required to adequately provide for current pest management requirements in the region.
(c)	must,— (i) if the proposal is to amend the plan or part of the plan, set out any proposed amendments in full; or (ii) if the proposal is to revoke and replace the plan or part of the plan, set out the replacement plan or part.	The proposed replacement plan is set out in the accompanying Proposed Regional Pest Management Plan.
(d)	must comply with section 61, 70, 81, or 90 to the extent to which the sections are relevant and reading in any necessary modifications.	Section 70 applies to a Proposed Regional Pest Management Plan. See assessment below.
(e)	may propose that a pest or pathway, as appropriate, be added to the plan, whether or not the review is of the whole plan.	Council proposes that 55 pests be included in the PRPMP. This includes 43 pests that are in the existing RPMP. Meanwhile 89 pests have been removed from the existing RPMP. (Note Council will continue to provide education and advice on the management of these pests).

Section 70 sets out the first step of initiating a plan proposal:

Requirement	Comment on compliance
1 The first step in the making of a plan is a proposal made by— (a) the council; or (b) a person who submits the proposal to the council.	The proposal is made by the Bay of Plenty Regional Council.
2 The proposal must set out the following (a) the name of the person making the proposal	Bay of Plenty Regional Council is making the proposal**.**
(b) the subject of the proposal, which means— (i) the organism proposed to be specified as a pest under the plan or the organisms proposed to be specified as pests under the plan; or (ii) the class or description of organism proposed to be specified as a pest under the plan or the classes or descriptions of organisms proposed to be specified as pests under the plan:	The organisms proposed to be specified as pests in the plan are set out in the accompanying Proposed Regional Pest Management Plan.
(c) for each subject,— (i) a description of its adverse effects: (ii) the reasons for proposing a plan: (iii) the objectives that the plan would have: (iv) the principal measures that would be in the plan to achieve the objectives: (v) other measures that it would be reasonable to take to achieve the objectives, if there are any such measures, and the reasons why the proposed measures are preferable as a means of achieving the objectives: (vi) the reasons why the plan is more appropriate than relying on voluntary actions: (vii) an analysis of the benefits and costs of the plan: (viii) the extent to which any persons, or persons of a class or description, are likely to benefit from the plan: (ix) the extent to which any persons, or persons of a class or	The reason for proposing a plan is to support and/or require action that will achieve the objectives of the plan. This applies for each subject. For each subject, the Proposed Regional Pest Management Plan sets out: (i) a description of its adverse effects. (ii) The overall reasons for the proposal are given in section 1.1 (purpose). These apply to all pests within the proposal. (iii) the objectives that the plan would have: (iv) the principal measures that would be in the (v) plan to achieve the objectives including rules. (vi) For each subject, the Cost Benefit Analysis sets out alternatives considered. This includes the reasons why the proposal and subsequent plan, is more appropriate than relying on voluntary action. (vii) an analysis of the benefits and costs of the plan (viii) For each subject, the Cost Allocation Analysis sets out: (ix) the extent to which any persons, or (x) persons of a class or description, are likely to (xi) benefit from the plan (xii) the extent to which any persons, or persons of

Requirement		Comment on compliance
	description, contribute to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan: (x) the rationale for the proposed allocation of costs: (xi) if it is proposed that the plan be funded by a levy under section 100L, how the proposed levy satisfies section 100L(5)(d) and what matters will be specified under section 100N(1): (xii) whether any unusual administrative problems or costs are expected in recovering the costs allocated to any of the persons whom the plan would require to pay the costs:	a class or description, contribute to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan (xiii) the rationale for the proposed allocation of costs. (xiv) It is not proposed that the plan be funded by a levy under section 100L. (xv) No unusual administrative problems or costs are expected in recovering the costs allocated to any of the persons whom the plan would require to pay the costs.
	(d) any other organism intended to be controlled:	There are no other organisms intended to be controlled.
	(e) the effects that, in the opinion of the person making the proposal, implementation of the plan would have on— (i) economic wellbeing, the environment, human health, enjoyment of the natural environment, and the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga: (ii) the marketing overseas of New Zealand products:	For each subject, the Cost Benefit Analysis sets out the effects that, in the opinion of Bay of Plenty Regional Council, implementation of the plan would have on: (i) economic wellbeing, the environment, human health, enjoyment of the natural environment, and the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga: (ii) the marketing overseas of New Zealand products is identified in Cost Benefit assessments where relevant (e.g. potential impacts to volume and quality of exported seafood from marine pests).
	(f) if the plan would affect another pest management plan or a pathway management plan, how it is proposed to co-ordinate the implementation of the plans.	The plan may affect implementation of Regional Pest Management Plans of neighbouring regions. Co-ordination among regions has occurred during the drafting of the proposed plan to maximise alignment. Operational co-ordination will also be implemented following plan adoption.
	(g) the powers in Part 6 that it is proposed to use to implement the plan:	Section 8 outlines the powers to be used to implement the plan.
	(h) each proposed rule and an explanation of its purpose:	For each proposed programme, the Proposed Regional Pest Management Plan sets out each proposed rule and an explanation of its purpose.
	(i) the rules, if any, that are intended to be good neighbour rules.	The Proposed Regional Pest Management Plan does not contain good neighbour rules.

Requirement			Comment on compliance
	(j)	the rules whose contravention is proposed to be an offence under this Act:	The Proposed Regional Pest Management Plan sets out that all rules within the proposed plan are proposed to be an offence under this Act when contravened.
	(k)	the management agency:	The Proposed Regional Pest Management Plan identifies that Bay of Plenty Regional Council is the management agency.
	(l)	the means by which it is proposed to monitor or measure the achievement of the plan's objectives.	For each subject, the Proposed Regional Pest Management Plan sets out the means by which it is proposed to monitor or measure the achievement of the plan's objectives.
	(m)	the actions that it is proposed local authorities, local authorities of a specified class or description, or specified local authorities may take to implement the plan, including contributing towards the costs of implementation:	As the management agency, Bay of Plenty Regional Council will contribute the costs of the relevant service delivery, advisory, enforcement and other components of implementing the plan. It is also proposed that Council will contribute costs towards implementing the plan in respect of meeting Council's obligations as a land manager subject to rules in the plan (for example regional parks). Local authorities must comply with all relevant rules on land that they own, occupy or administer.
	(n)	the basis, if any, on which the management agency is to pay compensation for losses incurred as a direct result of the implementation of the plan:	The Proposed Regional Pest Management Plan does not propose to pay any compensation for losses incurred as a direct result of the implementation of the plan.
	(o)	information on the disposal of the proceeds of any receipts arising in the course of implementing the plan:	The Proposed Regional Pest Management Plan sets out that should the disposal of a pest or associated organism provide any net proceeds, a person will be paid disbursement in the manner noted under s100I (3)(a) of the Biosecurity Act.
	(p)	whether the plan includes portions of road adjoining land it covers, as authorised by section 6, and, if so, the portions of road proposed to be included:	The Proposed Regional Pest Management Plan sets out responsibility for pest management on road reserves. Where the road reserve boundary is unknown this will be taken as 10 m from the road centreline. There are exceptions. In some cases, adjacent landowners are responsible for controlling pests on road reserves. These are: • unformed paper roads that they occupy. • where fences encroach onto a surveyed road reserve, the occupier adjoining the road reserve shall be responsible for pests within that fenced area. • where adjacent occupiers do not support the use of toxins to control pests (e.g. organic farming practices). In this case, the occupier adjoining the road reserve shall be responsible for pest control in the road reserve.

Requirement		Comment on compliance
(q)	the anticipated costs of implementing the plan:	The Cost Benefit Analysis sets out the anticipated costs of implementing the plan on a programme by programme basis. However, there will be efficiencies as the CBA requires us to consider each pest independently e.g., the costs of excluding marine pests is not the sum of excluding each specific pest rather the cost for excluding all marine pests is the same as excluding just one.
(r)	how it is proposed that the costs be funded:	The Cost Allocation Analysis sets out how it is proposed that the costs be funded.
(s)	the period for which it is proposed the plan be in force:	The plan is proposed to be in force for a period of 10 years unless reviewed prior.
(t)	the consultation, if any, that has occurred on the proposal and the outcome of it:	Consultation to date has been documented in Council reports. A plan for consultation is being presented to Council on12 September 2018 for approval, thus recognising more consultation will be required.
(u)	any matter that the National Policy Direction for Pest Management (NPD) requires be specified in a plan:	The proposed plan and supporting documentation set out all matters that the national policy direction requires be specified in a plan.
(v)	the steps that have been taken to comply with the process requirements in the NPD, if there were any.	The Proposed Regional Pest Management Plan, the Cost Benefit Analysis and the Cost Allocation Analysis comply with the process requirements in the National Policy Direction for Pest Management (NPD), including: **Clause 4: Directions for setting objectives.** All objectives used in the Proposed Regional Pest Management Plan cover all components required in sub-clause 4.1 of the NPD. **Clause 5: Directions for programme descriptions.** The only programme types used in the Proposed Regional Pest Management Plan are those listed in sub-clause 5.1 of the NPD. **Clause 6: Directions for analysing benefits and costs.** When choosing the appropriate level of analysis, consideration was given to the factors listed in sub-clause 6.1 of the NPD. Issues listed in sub-clauses 6.2, 6.3 and 6.4 of the NPD are considered in Part 2 of this Cost Benefit Analysis. **Clause 7: Directions on proposed allocation of costs for Pest and Pathway Management Plans.** The Cost Allocation Analysis itemises each of the considerations set out in Clause 7 of the NPD. **The process requirements of Clause 9:**

Requirement	Comment on compliance
	Directions on timing of inconsistency determination were complied with, through council resolution on 12 May 2016 determining inconsistency of the existing Regional Pest Management Plan for the Bay of Plenty 2011 – 2018 with the NPD on 14 February 2017.

If the council is satisfied that section 70 has been complied with, the council may take the second step (Section 71) in the making of a plan, which is to consider whether the council is satisfied—

Requirement	Comment on compliance
(a) that the proposal is not inconsistent with—	The Proposed Regional Pest Management Plan is not inconsistent with:
(i) the NPD; or	(i) the NPD; or
	The Proposed Regional Pest Management Plan is consistent with all clauses of the NPD, including in setting of objectives and programmes, and in analysis of costs, benefits and cost allocation. Note, no Good Neighbour Rules are proposed.
(ii) any other pest management plan on the same organism; or	(ii) any other pest management plan on the same organism; or
	Council has reviewed Gisborne and Hawke's Bay's RPMPs and does not consider any inconsistencies with these plans. Waikato is proposing to commence an early review of their RPMP.
	Council has also consulted with these regions during the development of the PRPMP to align pest programmes where appropriate.
(iii) any pathway management plan; or	(iii) any pathway management plan; or
	No such pathway plan exists within the Bay of Plenty region or our adjoining regions at this stage and therefore there is no inconsistency.
	Note that Bay of Plenty Regional Council is working collaboratively with other North Island Regional Councils to develop an Inter-regional Marine Pathway Management Plan that will ensure alignment of marine pathways.
(iv) a regional policy statement or regional plan prepared under the Resource Management Act 1991; or	(iv) a regional policy statement or regional plan prepared under the Resource Management Act 1991; or
	The Regional Policy Statement (RPS) promotes the sustainable management of the region's natural and physical resources. The RPS recognises that biosecurity incursions present a threat to the rural production sector, the regional economy and the region's biodiversity. The RPS adopts an integrated approach towards the management of biosecurity issues and implementation of plans to control biodiversity and biosecurity risks.
(v) any regulations; and	

Requirement	Comment on compliance
	Biosecurity and biodiversity protection are inherently linked. The RPS contains a range of objectives, policies and methods aimed at providing for biodiversity maintenance through both regulatory and non-regulatory approaches. Regional Plans developed under the RMA must give effect to the RPS. The Regional Natural Resources Plan and the Regional Coastal Environment Plan contain provisions that promote integrated management and require consideration of pest species and how they might be managed. The Regional Air Plan also needs to be considered during pest management operations (e.g., weed spraying). All of these provisions are consistent with, and complement, those in the RPMP. (v) any regulation. Council is not aware of any regulations with which the PRPMP provisions are inconsistent.
(b) that, during the development of the proposal, the process requirements for a plan in the NPD, if there were any, were complied with; and	During the development of the PRMP, the accompanying Cost Benefit and Cost Allocation analyses and the process requirements for a plan in the NPD were complied with, including: **Clause 4: Directions for setting objectives.** All objectives used in the PRPMP cover all components required in sub-clause 4.1 of the NPD. **Clause 5: Directions for programme descriptions.** The only programme types used in the PRPMP are those listed in sub-clause 5.1 of the NPD. **Clause 6: Directions for analysing benefits and costs.** When choosing the appropriate level of analysis, consideration was given to the factors listed in sub-clause 6.1 of the NPD. Issues listed in sub-clauses 6.2, 6.3 and 6.4 of the NPD are considered in the Cost Benefit analysis. **Clause 7: Directions on proposed allocation of costs for Pest and Pathway Management Plans.** The Cost Allocation Analysis itemises each of the considerations set out in Clause 7 of the NPD. **Clause 8: Directions on Good Neighbour Rules.** There are no good neighbour rules in the PRPMP. **The process requirements of Clause 9.** Directions on timing of inconsistency determination were complied with, through council resolution on 12 May 2016 determining inconsistency of the existing Regional Pest Management Plan for the Bay of Plenty 2011 – 2018 with the National Policy Direction for Pest Management on 14 February 2017.

Requirement	Comment on compliance
(c) that the proposal has merit as a means of eradicating or effectively managing the subject of the proposal, which means – (i) the organism proposed to be specified as a pest under the plan or the organisms proposed to be specified as pests under the plan; or (ii) the class or description of organism proposed to be specified as a pest under the plan or the classes or descriptions of organisms proposed to be specified as pests under the plan;	For each subject contained within the proposed plan, the proposal has merit as a means of eradicating or effectively managing the subject, as all programmes have been drafted with regard to technical considerations relating to the pest organism, available control methods, appropriate level of funding and alternative management options as they relate to outcomes sought.
(d) that each subject is capable of causing at some time an adverse effect on 1 or more of the following in the region: (i) economic wellbeing: (ii) the viability of threatened species of organisms: (iii) the survival and distribution of indigenous plants or animals: (iv) the sustainability of natural and developed ecosystems, ecological processes, and biological diversity: (iv) soil resources: (v) water quality: (vi) human health: (vii) social and cultural wellbeing: (ix) the enjoyment of the recreational value of the natural environment: (w) the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga: (xi) animal welfare; and	As set out in the Cost Benefit Analysis and the CBA narrative, each subject contained within the PRPMP is capable of causing at some time an adverse effect on 1 or more of the values listed.
(e) that, for each subject, the benefits of the plan would outweigh the costs, after taking account of the likely consequences of inaction or other courses of action; and	As set out in the Cost Benefit Analysis, for each subject contained within the proposed plan the benefits of the plan would outweigh the costs, after taking account of the likely consequences of inaction or other courses of action.

Requirement	Comment on compliance
(f) that, for each subject, persons who are required, as a group, to meet directly any or all of the costs of implementing the plan— (i) would accrue, as a group, benefits outweighing the costs; or (ii) contribute, as a group, to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan; and	As set out in the Cost Allocation Analysis, for each subject, persons who are required, as a group, to meet directly any or all of the costs of implementing the plan— (i) would accrue, as a group, benefits outweighing the costs; or (ii) contribute, as a group, to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan.
(g) that, for each subject, there is likely to be adequate funding for the implementation of the plan for the shorter of its proposed duration and 5 years; and	For each subject, there is likely to be adequate funding for the implementation of the plan for the shorter of its proposed duration and 5 years, as the proposal that is being consulted on aligns with Long Term Plan decisions. The proposal may be amended following consultation if the outcome of those processes does not align funding with proposed outcomes. At such time, further consultation may be required.
(h) that each proposed rule— (i) would assist in achieving the plan's objectives; and (ii) would not trespass unduly on the rights of individuals; and	Each proposed rule— (i) would assist in achieving the plan's objectives. (ii) would not trespass unduly on the rights of individuals. All rules have been drafted to align with the objectives and outcomes sought for the corresponding programme. The Cost Benefit and Cost Allocation analyses have identified qualitative as well as quantitative costs that may arise from the proposed programmes and concluded that those costs are reasonably and fairly allocated according to the extent to which parties are beneficiaries or exacerbators.
(i) that the proposal is not frivolous or vexatious; and	The proposal is not frivolous or vexatious as all programmes contained therein have been subject to rigorous Cost Benefit and Cost Allocation analyses and all programmes have been created to achieve outcomes that contribute to the public good.
(j) that the proposal is clear enough to be readily understood; and	The proposal is based on a template designed to support Regional Pest Management Plans and is clear enough to be readily understood, and is supported by a user guide to aid understanding.
(k) that, if the council rejected a similar proposal within the last 3 years, new and material information answers the council's objection to the previous proposal.	Council has not rejected a similar proposal within the last 3 years.

Part 2:

Proposed Regional Pest Management Plan for the Bay of Plenty region

Meeting the National Policy Direction for pest management requirements

Clause 6 – Directions on analysing benefits and costs

Clause 6 (1)

When determining the appropriate level of analysis of the benefits and costs of the plan for each subject for the purposes of a proposal for a pest management plan or pathway management plan, a proposer must consider:

(a) the level of uncertainty of the impacts of the subject, or an organism being spread by the subject, and of the effectiveness of measures; and

(b) the likely significance of the subject, or an organism being spread by the subject, or of the proposed measures, in terms of stakeholder interest and contention, and total costs of the proposed plan; and

(c) the likely costs of the programme relative to the likely benefits; and

(d) the level of certainty and the quality of the available data.

Determining the most suitable level of analysis of the benefits depends on four criteria listed in the NPD and the interactions and weighting between them. Council has scored these criteria based on a qualitative judgement of whether they are high, medium or low. Appendix 1 steps through the assessment criteria and provides a table showing the assessment for each pest.

Clause 6 (2)

In the proposal for a pest management plan or pathway management plan, an analysis of the benefits and costs of the plan for each subject must:

(a) identify, and quantify (if practicable), the impacts of the proposed subject or an organism being spread by the subject; and

(b) identify two or more options for responding to the subject or an organism being spread by the subject (one option must be either taking no action or taking the actions that would be expected in the absence of a plan); and

(c) identify, and quantify (if practicable), the benefits of each option; and

(d) identify, and quantify (if practicable), the costs of each option; and

(e) state the assumptions (if any) on which the impacts, benefits and costs are based; and

(f) be at an appropriate level of detail as determined in accordance with sub clause (1); and

(g) take into account any risks that each option will not achieve its objective; and

(h) identify any realistic mitigation options for the risks identified in sub clause (2)(g); and

(i) adjust the benefits and costs for each option as appropriate to take account of sub clause (2)(g) and (h); and

(j) clearly identify which option is preferred.

Cost benefit analyses have been undertaken for each pest included in this proposal. The NPD has comprehensive cost benefit requirements.

After undertaking the necessary assessment of costs and benefits (including quantitative and qualitative considerations), Council proposes 55 pests are included in the RPMP (See Appendix 2).

Council used the AgResearch tool 'Cost Benefit Analysis for Regional Pest Management (https://www.agresearch.co.nz/cba/cba.php)[1]' for pests requiring a low - medium level of analysis[2]. These results are in Appendix 3. The methods and inputs used for the AgResearch Cost Benefit Assessment is in Appendix 4.

For pests with medium - high risks Council commissioned Wildland Consultants Limited to undertake the cost-benefit assessment. The results including the methodology and assumptions supporting the analysis is provided in Appendix 6.

Clause 6 (3) & (4)

When taking into account any risks that each option will not achieve its objective under sub-clause (2)(g), a proposer must consider:

(a) the technical and operational risks of the option; and

(b) the extent to which the option will be implemented and complied with; and

(c) the risk that compliance with other legislation will adversely affect implementation of the option; and

(d) the risk that public or political concerns will adversely affect implementation of the option; and

(e) any other material risk.

When taking into account any risks that each option will not achieve its objective under sub-clause (2)(g), a proposer must:

(a) for analyses where the benefits are fully quantified, either:

(i) estimate the residual risks as a probability of success and calculate the expected benefits of the option by multiplying the benefits by the probability of success; or

(ii) state the residual risks to the programme and calculate what the probability of success would need to be to make the expected benefits equal the costs; and

(b) for all other analyses (where the benefits are not fully quantified):

(i) state the residual risks to the programme and, where practicable, give an indication of likelihood and impact; and

(ii) specify which of the benefits are most likely to be affected if the risk eventuated.

The risks, including risks to success, relating to pest management in our region are assessed and reported annually. Previous pest management performance results have been considered in the development of the PRPMP and have informed decisions about which pests to include and the level of management required.

Appendix 5 sets out our risk assessment according to the objectives for each programme.

[1] https://www.agresearch.co.nz/cba/cba.php.
[2] The exception being wasps which are known to be widespread with high impacts but costs to control them are very high. Council is currently supporting on-going national research into wasp management.

Clause 7 Direction on Proposed Allocation of Costs for Pest and Pathway Management Plans

Section 7(1) of the NPD requires that when grouping pests for cost allocation analysis Council must consider:

- similarity of exacerbators and beneficiaries for the pests;
- similarity of legislative responsibilities for the exacerbators under the Plan; and
- similarity of stage of infestation and management objectives.

This report examines the pests under the Plan and groups them as appropriate for cost allocation. In many cases it makes sense that pest species are grouped for the purposes of cost allocation. To deal with each pest separately would be inefficient and would result in unnecessary repetition, high costs and an arbitrary assignment of each pest's contribution to the cost.

Section 7(2) of the NPD lists the considerations a proposer must make when deciding the appropriate cost allocation. These are to:

- identify and estimate the direct and indirect costs of the Plan;
- identify exacerbators and beneficiaries;
- decide whether cost should be borne by exacerbators, beneficiaries, or both. This requirement lists 15 factors to aid the allocation decision. Some of these factors are also in section 7(1); and
- consider which mechanism(s) to use to impose the costs (e.g. general rates, targeted rates, levies, cost to occupiers of rule compliance).

To avoid duplication and aid certainty on meeting Section 7 requirements, this report lists the factors used in deciding cost allocation and cites the applicable clause(s) from the NPD. Council considers that two of the 15 factors, the degree of urgency to make the Plan and the need for transitional cost allocation arrangements, bear no weight on who should pay. However, the current RPMP expires in 2018 and is inconsistent with the NPD, so the need to review the RPMP is high. To avoid repetition, these two considerations are not included in decisions about allocation mechanisms described below.

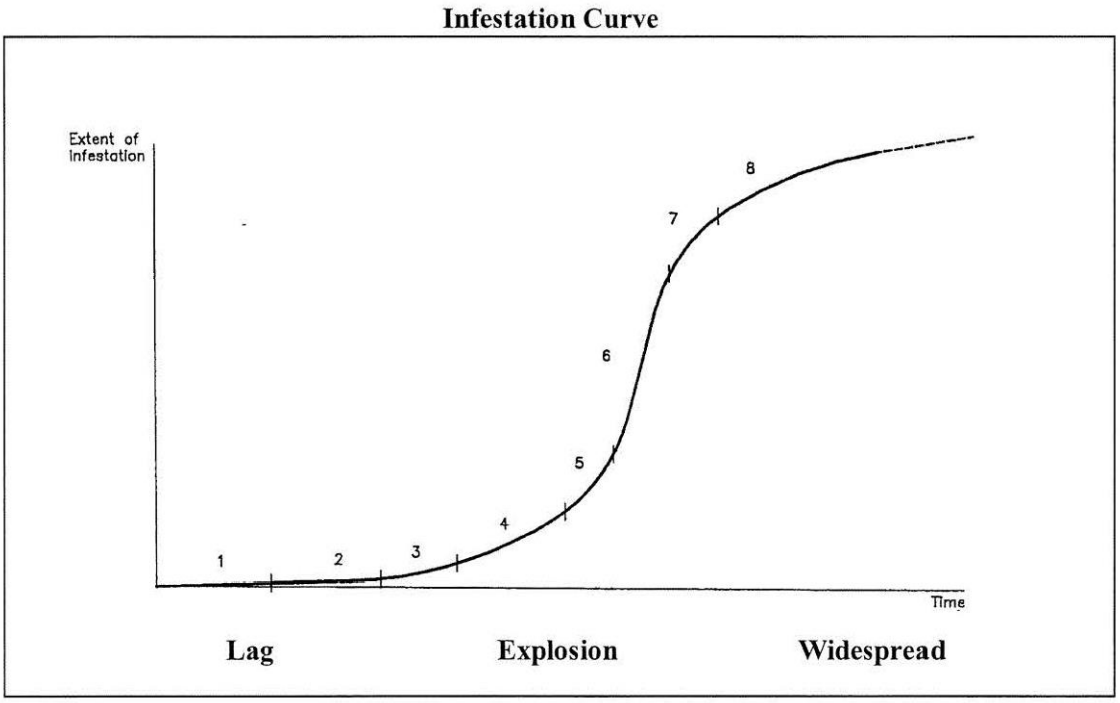
The following list provides the groupings for cost allocation. Each section is led by the name of the pest or group of pests as in the proposed plan and concludes, with the best cost imposition mechanisms for funding the Plan. The conclusions are consistent with Council's current Long Term Plan for funding biosecurity related services.

- Exclusion (except marine and aquatic).
- Eradication (except marine and aquatic).
- Marine pests: Asian Paddle crab, Australian droplet tunicate, clubbed tunicate, Mediterranean fanworm, pyura.
- Aquatic plant pests: egeria, elodea, hornwort, lagarosiphon.
- Freshwater fish: catfish, Koi carp, perch, tench, rudd.
- Council- led Progressive Containment plant pests: including African feather grass, Asiatic knotweed, yellow flag iris, alligator weed*.
- Council led progressive containment animal pests: wallabies and feral goats*.
- Wilding conifers (all species listed in PRPMP).
- Progressive containment: apple of sodom, boneseed, Darwin's barberry, Italian buckthorn, variegated thistle, climbing spindle berry*, lantana*, old man's beard, spiny emex, wild kiwifruit*, woolly nightshade*[3].
- Sustained control: climbing spindleberry*, gorse, lantana*, old man's beard*, wild ginger, wild kiwifruit*, woolly nightshade*, blackberry, ragwort, wilding conifers (except lodgepole).

[3] * indicates pests with programme classifications split across the region.

The assessment of allocation of costs for pest and pathway management plans must be documented and made publically available with the proposal. This report has been prepared by Council as part of the documentation that is associated with the preparation of the PRPMP under the Biosecurity Act and the NPD, and should be read in conjunction with the Plan.

The following pest infestation curve is referred to in the following analysis to indicate the level of infestation for particular pest groupings.



Source: Guidance Document Meeting the requirements of the National Policy Direction for Pest Management 2015

Exclusion pests (except marine and aquatic pests)

Alligator weed*, batwinged passionflower, Chilean flame creeper, Chilean needle grass, Darwin's barberry, field horsetail, Italian Buckthorn

Grouping for cost allocation

Exclusion Pests are thought to be absent from the region and have therefore been assessed as less than Level 1 (no infestation) on the infestation curve set out in the NPD Guidance Document. Council's management objective is to keep the region free of these pests.

These pests are only legislated for under the Biosecurity Act 1993.

The benefits of keeping the region free of these pests include regional and national interests through protection of environmental and community values. The exclusion of some production pests may benefit specific industry sectors (such as farmers) more directly than the wider community, but extracting payment from individuals for pests that have not yet arrived may not be practical. Council considers the beneficiaries for this group of pests sufficiently similar. Exacerbators are defined in the NPD Guidance were people/groups who could change their behaviour to avoid the pest problem. These people/groups are generally difficult to identify specifically, which is a characteristic common to all the Exclusion pests.

Programme	Beneficiaries	Exacerbators
Exclusion	The regional community benefits from prevention of potential future damage to biodiversity and public values (e.g. social and cultural). Industry sectors potentially receive direct economic benefits from prevention of damage to production values. This results in indirect economic benefits to the regional community. The region benefits from surveillance for these pests as early detection is likely to result in lower management costs and increases the chance of exclusion.	Persons involved with movement of people, goods, animals, machinery, vessels and vehicles.

Allocation of costs

Direct and indirect costs, and who bears them

The costs associated with the preferred option are covered by the annual cost of Council's active surveillance and awareness programmes. There is a potential cost (indirect) on occupiers or exacerbators associated with an incursion response for example, potential income and production loss due to restrictions in place.

Cost Type	Description	Cost
Direct costs	Annual active surveillance and awareness programmes (Council).	$97,500.
Indirect costs	Cost of managing incursions (Council and/or in some cases exacerbator).	$300-500 per hectare.

Most effective agents

The Regional Council is best equipped to undertake surveillance for these pests through its existing surveillance regime. Council is the most effective agency to undertake co-ordination if an incursion response is required.

Sharing direct and indirect costs between beneficiaries and exacerbators

Council as the bearer of the costs of surveillance represents the regional beneficiaries.

Regional beneficiaries include urban and rural communities. For urban and rural communities the benefits of managing environmental pests are considered similar. Rural communities may seem to benefit more than urban from the management of production pests, but overall the regional community benefits economically from the management of these production pests.

Mechanisms to recover a share of costs from the national community, through central government funding, are best applied as a direct cost imposition for funding incursion responses rather than attempting to seek cost sharing of the surveillance programme. There is no mechanism to attribute the degree of exacerbation; in most cases exacerbators cannot be sufficiently identified to allocate the costs of surveillance.

Cost allocation for incursions

100% weighting is given to regional beneficiaries, i.e. all ratepayers.

Although potential exacerbators could be identified, actual exacerbators cannot be until an incursion occurs, so they cannot be allocated any of the direct costs of the Plan.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is efficient and practical to fund Council costs from rates. The funding of the surveillance programme is secured by way of the Local Government Long Term Plan (LTP) process.

The surveillance programme for all exclusion pests is an integrated programme implemented across the region. This is a more efficient and effective approach than individual surveying for exclusion pest species, and is administratively efficient.

It is not possible to identify every current or future exacerbator, and therefore not practical to seek costs from exacerbators.

Council's approach would be to lead and fund this programme. If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding, and may also be administratively onerous.

Fair and reasonable

The regional community is the main beneficiary, therefore it is fair and reasonable that the regional community pays the full cost of the direct costs of the Exclusion Programme. It is reasonable to expect that costs of incursions are rates-funded in cases where no one is at fault and an incursion response results in protecting regional interests.

Cost imposition mechanisms

Council proposes general rating as the tool to impose costs for the exclusion programme. Other considerations were:

- targeted rates are not suitable because most people in the region are a beneficiary or an exacerbator. It is not possible to reliably separate the benefits of the individual people or groups (beneficiaries and exacerbators) to determine a targeted rate.
- the beneficiary/exacerbator argument against charges is similar as for the targeted rate. In addition, charges should be set at a level to encourage good behaviour in exacerbators. Finding the correct level to create the right incentives is difficult and incorrect levels can result in perverse incentives.
- levies require a specific group. Again the inability to separate the benefits for individuals or groups makes this unviable.
- Council would willingly accept voluntary payments from individuals or sectors, but this is not a secure source of funding.

Conclusion

General rates provide the best mechanism for managing exclusion pests on the following basis:

- exclusion of these pests provides public good benefits.
- most people in the region benefit directly or indirectly from the Exclusion Programme, or are potential exacerbators.
- there are a range of pests to be managed together under the exclusion approach. Splitting the cost by pest and exacerbator is administratively complex.
- there may be an opportunity to prosecute if an occupier or landowner has deliberately released an exclusion pest or not taken reasonable care, this may result in some degree of cost recovery.

Eradication pests

Alligator weed*, coast tea tree, creeping gloxinia, feral goat*, horse nettle, kudzu vine, lantana, nassella tussock, noogoora bur, purple loosestrife, rooks, sagitarria, Senegal tea, spartina, stout bamboo grass, white edged nightshade

Grouping for cost allocation

The infestation level for the eradication pests is assessed as less than Level 3 on the infestation curve graph (relatively low level of infestation and pre-population explosion). Council's management objective is to eradicate these pests from the region in the short to medium term.

These pests are only legislated for under the Biosecurity Act 1993.

The beneficiaries of this group of eradication pests are widespread – comprising industry sectors and the wider regional community. Although some direct economic benefits may fall to specific industry sectors, the region benefits indirectly from these sectors through regional income and provision of jobs. Further, the wider community benefit through maintenance of environmental, social and cultural values which can be lost through pest incursions. Therefore, Council considers the beneficiaries are a broad group and sufficiently similar across this pest group. The exacerbators for these pests are made up of a broad group, and are sufficiently similar.

Programme	Beneficiaries	Exacerbators
Eradication	Regional community through protection of biodiversity and public values (social and cultural) Industry sectors (land-based and marine) receive direct economic benefits from prevention of potential damage to production values (e.g. crop damage). This results in indirect economic benefits to the regional community. The region benefits from surveillance for these pests as early detection is likely to result in lower management costs and increases the chance of eradication.	Persons involved with movement of people, goods, animals, vehicles, vessels and contaminated equipment.

Allocation of costs

Direct and indirect costs, and who bears them

The cost associated with the preferred option is covered by the annual cost of Council's active surveillance, pest management operations and monitoring programmes. There are potential indirect costs on land owners and occupiers (who may also be exacerbators) associated with an incursion response such as income and production losses due to restrictions in place e.g. restriction on movement of farm machinery and restricted access.

Cost Type	Description	Cost
Direct costs	Surveillance, pest removal, ongoing monitoring (Council).	$170,700 (current direct costs to Council).
	Cost of managing incursions should they arise (Council mainly and in some cases exacerbators).	$300-500 per hectare.
Indirect costs		

Most effective agents

Council is the most effective agency to undertake coordination of ongoing surveillance, management and monitoring an incursion response if required.

Sharing direct and indirect costs between beneficiaries and exacerbators

Council (funded by the ratepayer) is the bearer of the costs of these eradication pests and represents regional beneficiaries. Regional beneficiaries include urban and rural communities; their benefits for environmental pests are considered similar. Rural communities and individuals may benefit more than urban from the management of pests that impact on production (e.g. farm pests), but considering the regional economic benefit of production, 100% weighting is given to regional beneficiaries, i.e. all ratepayers.

Council endeavours to partner with other agencies where appropriate such as MPI or DOC. There is no mechanism to attribute the degree of exacerbation; in most cases exacerbators cannot be sufficiently identified to allocate the costs of surveillance.

Cost allocation for incursions:

100% weighting is given to regional beneficiaries, i.e. all ratepayers.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is most efficient and practical to fund Council costs from rates. The funding of eradication activity is secured by way of the Local Government Long Term Plan (LTP) processes.

Eradicating these pests requires urgent and on-going action, co-ordination and use of best pest management technologies and practices. Eradication led by the Regional Council is more efficient and effective than individual management eradication of pest species, and is administratively efficient.

It is not possible to identify every current or future exacerbator, and therefore not practical to seek costs from exacerbators except where an incursion occurs, and then only if an exacerbator/s can be identified. As a matter of equity and incentive, exacerbators through deliberate release or lack of reasonable care must be considered. In these instances, Council's approach would be to lead and fund this programme. If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding, and may also be administratively onerous.

Fair and reasonable

The regional community is the main beneficiary; therefore it is fair and reasonable that the regional community pays the full costs of the direct costs of the Eradication Programme. It is reasonable to expect that the cost of incursions are also rates-funded where no one is at fault and the control action results in protecting regional interests.

Cost imposition mechanisms

Council proposes general rating to fund the eradication programme. Other options considered were:

- fines are not an option at this stage as there are no supporting regulations under the Biosecurity Act. Bio managers are working with MPI to develop regulations and therefore fines may be a cost mechanism that could be used in the future.
- targeted rates are not suitable because most people in the region are a beneficiary or an exacerbator. It is not possible to reliably separate the benefits of the individual people or groups (beneficiaries and exacerbators) to determine a targeted rate.
- the beneficiary/exacerbator argument against charges is similar as for the targeted rate. In addition, charges should be set at a level to encourage good behaviour in exacerbators. Finding the correct level to create the right incentives is difficult and incorrect levels can result in perverse incentives.
- levies require a specific group. Again the inability to separate the benefits for individuals or groups makes this unviable.
- Voluntary payments. While the council would willingly accept voluntary payments from individuals or sectors, this is not a secure source of funding.

Conclusion

General rates provide the best mechanism for managing eradication pests on the following basis:

- eradication of these pests provides public good benefits
- most people in the region benefit directly or indirectly from an Eradication Programme and/or are potential exacerbators
- there are a range of pests to be managed together under the eradication approach. Splitting the cost by pest and exacerbator is administratively complex.
- there may be an opportunity to prosecute if an occupier of landowner has deliberately released an eradication pest or not taken reasonable care, this may result in some degree of cost recovery.
- Council may also consider direct charging of actual costs when a particular point in the compliance (or non-compliance) process is met. For example, in instances when a Section 122 Notice is issued, costs for all work (including administration by any staff, inspections, costs of prep and issue of notices, title searches, control work under section 128 BA and cancelling the Notice of Direction) is chargeable to the land occupier.

Marine pests

Asian paddle crab, Australian droplet tunicate, clubbed tunicate, Mediterranean fanworm, pyura

Grouping for cost allocation

Marine pests are pests that threaten the quality of our coastal environment. Some of these pests are known to be in parts of our coastal marine areas and absent in other areas. For example, clubbed tunicate is now present in southern Tauranga harbour but not yet spread throughout the harbour.

Marine pests are managed together due to the potential impact on environmental and production values. While each pest will have a different infestation level throughout the region, the purpose of the Plan is to support the protection of our coastal environment and the infestation level is presently below 2 (as set out in the NPD Guidance Document). These pests share a common management objective and management regime.

These pests are only legislated for under the Biosecurity Act 1993.

The beneficiaries of management of marine pests are widespread, and include industry sectors and individuals. While the eradication of some production pests may directly benefit the aquaculture and marine industry, the economic benefits are experienced indirectly by the wider community. Benefits to the wider community also include social and cultural benefits, such as the ability to source kai moana. In this way the beneficiaries are a broad group and considered sufficiently similar across this pest group.

Programme	Beneficiaries	Exacerbators
Marine pests	The regional community through protection of biodiversity and public values (environmental, social and cultural). The marine industry, particularly in relation to seafood production, is likely to have direct benefits from management and protection from pests that threaten economic values. These benefits are likely to flow-on to the local communities through the local economy and jobs.	Persons involved with movement of vessels and contaminated equipment. This includes vessels from overseas (managed by MPI via the Craft Risk Management Standard (Biofouling) and Import Health Standard (Ballast water)), local and visiting boat owners, mussel farmers and fisherman who may transport pests from one location to another.

Allocation of costs

Direct and indirect costs, and who bears them

The cost associated with the preferred option is covered by the annual cost of Council's active surveillance, pest management operations and monitoring programmes. There is a potential cost (indirect) on the regional community, occupiers or exacerbators associated with an incursion response for example, income and production loss due to restrictions in place e.g. restriction on movement of vessel owners and restricted access.

Cost Type	Description	Cost
Direct costs	Surveillance, control work, ongoing monitoring and compliance, education and advocacy (Council) Occupiers (anti-fouling and ensuring equipment is new or clean)	$270,000 (current direct costs to Council) $180 - $3,600 per boat per year.
Indirect costs	Lost opportunity for recreationalists/industry/iwi should access to parts of the marine environment be restricted while marine pest management is undertaken.	

Most effective agents

Council is the most effective agency to undertake control and surveillance for marine pests.

Council is a partner to the "Top of the North" Marine Biosecurity Partnership (TON). TON aims to improve the management of marine pests and pathways within the top of the North Island, through increased consistency, efficiency and effectiveness of management actions. TON is currently preparing a discussion document to explore the possibility of developing an inter-regional marine pathway plan to manage the biosecurity risk of inter-regional vessel movements.

Council will deliver its roles and responsibilities as set out in the National Plan of Action for Pest Management.

Many exacerbators cannot be identified or targeted through regional council rules. Overseas boats (managed by MPI's CRMS and HIS) (e.g. yachts visiting New Zealand) coming through our ports and the large number of geographically dispersed private boats in New Zealand makes effectively targeting these exacerbators challenging.

Sharing direct and indirect costs between beneficiaries and exacerbators

MPI currently support the management costs of Mediterranean fanworm and Asian paddle crab surveillance and control.

Council's share of the costs of managing these pests represent the regional beneficiaries. Costs include surveillance, ongoing monitoring, control work, enforcement, advocacy and education.

Vessels and associated equipment moving through Bay of Plenty waters are known potential exacerbators and this plan requires vessel/equipment owner responsibility. Direct costs are applied to exacerbators through rule compliance which targets movement of vessels and marine industry equipment.

Attributing pest management responsibility for the coastal environment is inherently complex. It is not possible to identify every user and exacerbator.

Cost allocation for incursions:

The primary bearer of costs to manage marine pests is the regional community.

Boat owners also incur a cost through rule compliance.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is most efficient and practical to fund Council costs from rates. The funding of marine pest management is secured by way of the Local Government Long Term Plan (LTP) processes.

Regional management of marine pests is a more efficient and effective approach than individual effort. The marine aquaculture industry in the Bay of Plenty region is in its infancy - the rules in this PRPMP are intended to complement industry codes of practice that require biosecurity compliance.

It is not possible to identify every current or future exacerbator, and therefore not practical to seek costs from exacerbators in advance of incursions. This is why incursions are proposed to be rates funded.

However, as a matter of equity and incentive, active exacerbators still need to be considered. In these instances, Council's approach would be to lead and fund this programme. If Council believed an occupier or vessel owner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding, and may also be administratively onerous.

Contaminated vessels and equipment are known sources of pest spread. Managing this through adherence to rules about hull-cleaning is a direct cost to vessel owners, who are in the best position to undertake this work.

Fair and reasonable

The regional community is the main beneficiary; therefore it is fair and reasonable that the regional community pays the full costs of the direct costs of the marine pest programme. It is reasonable to expect that the cost of incursions are also rates-funded where no one is at fault and the control action results in protecting regional interests.

It is reasonable and fair to require owner responsibility for vessels or equipment as contaminated vessels and equipment are known sources of pest spread.

Cost imposition mechanisms

Council proposes general rating as the tool to impose costs for marine pests. Other considerations were:

- fines are not an option at this stage as there are no supporting regulations under the Biosecurity Act. Bio managers are working with MPI to develop regulations and therefore fines may be a cost mechanism that could be used in the future.
- it is not possible to reliably separate the benefits of the individual people or groups (beneficiaries and exacerbators) to determine a targeted rate or charges.
- levies require a specific group. Council considered a levy charge for the marine industry but dismissed this option on the basis that the marine industry has its own codes of good practice.
- targeted rates could be a funding option, however due to timing of different Council processes (setting rates through the Local Government Rating Act 2002 and PRPMP development) targeted rates have not been included in this PRPMP. Council will continue to keep a watching brief as targeted rates are progressed and implemented around the country and they could be an avenue to explore in future.
- Council currently accepts contributions from other agencies, but this is not a secure ongoing source of funding.

Conclusion

General rates provide the best mechanism for managing marine pests on the following basis:

- management of marine pests provides public good benefits
- most people in the region benefit directly or indirectly from marine pest management, and/or are potential exacerbators
- splitting the cost of the marine pest programme by pest and exacerbator is administratively complex and expensive.

- Council may also consider direct charging of actual costs when a particular point in the compliance (or non-compliance) process is met. For example, in instances when a Section 122 Notice is issued, costs for all work (including administration by any staff, inspections, costs of prep and issue of notices, title searches, control work under section 128 BA and cancelling the Notice of Direction) is chargeable to the person who was issued the notice.
- There may be an opportunity to prosecute if an occupier or vessel owner has deliberately released a pest or not taken reasonable care, which may result in some degree of cost recovery.

Aquatic pests

Egeria, elodea, hornwort, lagarosiphon, water poppy

Grouping for cost allocation

Aquatic pests threaten the quality of our water bodies. Some of these pests are currently present in some our fresh water bodies and absent in others. For example, hornwort is widespread throughout Bay of Plenty's waterways but still absent from several Rotorua Te Arawa Lakes.

Aquatic pests are managed together due to the potential effect on environmental and public values. While each pest will have a different infestation level throughout the region, the purpose of the Plan is to support the protection of our waterbodies. These pests share a common management regime.

These pests are legislated for under the Biosecurity Act (by virtue of being in many regional pest management plans and because some are Unwanted Organisms). Egeria, hornwort and lagarosiphon are also covered by the Conservation Act 1987 by virtue of being classified as "aquatic life". Both legislative instruments regulate or otherwise prohibit the transfer of these organisms from one water body to another where they are absent. Due to the similarity of the legislative approaches, the proposed management regime does not conflict with existing rights and legislative obligations for each pest.

The control and management of aquatic plant pest in the Rotorua Te Arawa Lakes is primarily the responsibility of Land Information New Zealand (LINZ), on behalf of the Crown, (resulting from the Deed of Settlement of the Te Arawa Lakes Historical Claims and Remaining Annuity Issues).

The benefits of managing these pests include regional and national interests in general through protection of environmental and public values. Council considers the beneficiaries for this group of pests to be sufficiently similar. The identified exacerbators are common for aquatic pests.

Programme	Beneficiaries	Exacerbators
Aquatic pests	The regional community through protection of biodiversity and public values, including social and cultural values National community, through the protection of fresh water body ecosystems that are nationally important. Management of aquatic pests has benefits for the national economy, e.g. tourism.	Persons involved with movement of vessels and contaminated equipment. This may include businesses and private boat owners.

Allocation of costs

Direct and indirect costs, and who bears them

The cost associated with the preferred option is covered by the annual cost of Council's active surveillance, pest management operations, awareness and education, and monitoring programmes. The table below identifies the direct and indirect costs of the Plan, and where those costs fall.

Cost Type	Description	Cost
Direct costs	Surveillance, ongoing monitoring and compliance, education and advocacy (Council). Occupiers (ensuring equipment such as boats and trailers are clean).	$177,000 (current direct costs to Council). Just boat owner time to check and hand remove any attached weed.
Indirect costs	Cost of managing incursions should they arise (Council) Lost opportunity for recreationalists/iwi should access to lakes be restricted while marine pest management is undertaken.	

Most effective agents

Regional management of aquatic pests is a more efficient and effective approach than individual effort and Council considers it is best placed to most effectively oversee management of these pests. Containing these pests requires a co-ordinated effort.

Over recent years Council and LINZ have worked together to develop Aquatic Management Plans. This collaborative approach to manage aquatic weeds in the Rotorua Te Arawa Lakes remains the most effective way to achieve co-ordinated management of aquatic pest plants.

LINZ fund and manage the control of aquatic pest plants to reduce risk of spread to other water bodies and improve amenity. Council supports this by monitoring control work and undertaking surveillance for new incursions. Both agencies work collaboratively to control any incursion that is detected.

Sharing direct and indirect costs between beneficiaries and exacerbators

Attributing pest management responsibility for water bodies is inherently complex. It is not possible to identify every user and possible exacerbator.

Cost allocation for costs including incursion response

Council, as a bearer of costs for surveillance and advocacy, represents the regional beneficiaries. Costs include surveillance, monitoring, rule compliance, advocacy and education.

Cost allocation to other beneficiaries

Crown agencies bear some costs to manage aquatic pests on lakes administered by the Crown. For example, LINZ, on behalf of the crown, manage aquatic pest plants in the Rotorua lakes. MPI contribute to freshwater biosecurity advocacy . This is not counted as a cost of the Plan, as the decision to undertake work is independent of the Plan.

Cost allocation – exacerbators identified

Lake users can be identified as a group of potential exacerbators, but the cost of administering the collection of contributions is likely to outweigh the value contributed.

Individual exacerbators are difficult to identify and target, so are not able to be allocated any cost of the Plan. For fairness the cost of compliance events should be charged to them if they could be individually identified.

Vessels and associated equipment moving through Bay of Plenty waters are known potential exacerbators and this plan requires vessel/equipment owner responsibility. Costs to exacerbators are through rule compliance e.g. clean boats.

Cost allocation for incursions:

100% exacerbator cost (via prosecution) if exacerbator can be identified and the presence of the pest is due to deliberate action or reasonable lack of care.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is most efficient and practical to fund Council costs from rates. The funding of progressive containment of these pests is secured by way of the Local Government Long Term Plan (LTP) processes.

While not considered a cost of the Plan, funding from MPI assists in the extensive coverage of advocacy work presently achieved. The present arrangement with MPI to undertake advocacy is more efficient, effective, and practical than the two agencies undertaking divided approaches.

It is difficult (administratively) to universally seek funding from the occupiers of lakes especially in the case of the Rotorua Lakes where the occupier is not the responsible person (Te Arawa are excluded from managing lake weeds on lake beds). It would be unfair to allocate a non-exacerbating (i.e. willing) occupier a share of the cost of the programme for the public biodiversity benefits that accrue. By the time a small share of that cost was allocated, the administration costs themselves would likely outweigh the funding gained.

It is not possible to identify every current or future exacerbator, and therefore not practical to seek costs from exacerbators in advance. Management of incursions is proposed to be rates funded. In the case of an incursion, Council's approach would be to lead and fund this programme.

If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding, and may also be administratively onerous.

Fair and reasonable

Based on the level of benefits accruing to the regional and national community from management of aquatic pests, it is fair and reasonable that the regional and national community pay most of the cost of the Plan.

It is fair and reasonable to require vessel/equipment owner responsibility as contaminated vessels and equipment are known sources of pest spread.

It is fair and reasonable that the cost of work undertaken to destroy a new incursion resulting from an intentional introduction (active exacerbation) be borne by the exacerbator if they can be identified.

Cost imposition mechanisms

Council proposes employing general rating as the tool to impose costs for managing aquatic pests. Other considerations were:

- fines are not an option at this stage as there are no supporting regulations under the Biosecurity Act. Bio managers are working with MPI to develop regulations and therefore fines may be a cost mechanism that could be used in the future.
- targeted rates are not suitable because most people in the region are a beneficiary in terms of the environmental values associated with aquatic weed management.
- the beneficiary/exacerbator argument against charges is similar to the targeted rate. In addition, beneficiaries are a widespread and diverse making identification of groups or individuals challenging.
- levies could be required from lake users. At this stage, levies seem administratively complicated but it could be a cost imposition option to be consulted on in the future.
- Council would willingly accept voluntary payments from individuals or sectors, but this is not a secure source of funding.

Conclusion

General rates provide the best mechanism for management of aquatic pests on the following basis:

- management of aquatic pests provides public good benefits

- most people in the region benefit directly or indirectly from management of aquatic pests, and/or are potential exacerbators
- there may be an opportunity to prosecute if a boat owner has deliberately released an exclusion pest or not taken reasonable care, which may result in some degree of cost recovery.

Freshwater pest fish

Koi carp, perch, tench, rudd, catfish

Grouping for cost allocation

Freshwater pest fish are present in and threaten the quality of some of the region's water bodies. Pest fish are grouped due to their potential effect on environmental and public values. While each pest will have a different infestation level throughout the region, the purpose of the Plan is to support the protection of our water bodies. The infestation level varies from not present to established. Council's management objective is to prevent the establishment of these fish where they are not present and where they are present contain and where practicable reduce their geographic distribution.

Section 26Q(1) of the Conservation Act 1987 states that the function of each council of Fish and Game New Zealand shall be to manage, maintain and enhance the sports fish and game resource in the recreational interests of anglers and hunters

Regulation of 2A of the Freshwater Fisheries Regulations 1983, created by Order in Council declares that perch, tench, rudd (rudd in the Auckland Fish and Game region only) specified in Schedule 1 to these Regulations are sports fish.

The benefits of eradicating these pests include regional and national interests in general through protection of environmental and public values. Council considers these beneficiaries for the group of pests are sufficiently similar. The identified exacerbators are common for these fish species.

Programme	Beneficiaries	Exacerbators
	The national community, through the protection of fresh water body ecosystems that are nationally important.	Persons involved with movement of vessels and contaminated equipment.
	The regional community through the environmental, social and cultural values associated with the lakes, rivers and streams in the region.	Persons who intentionally release these species into our region's water bodies

Allocation of costs

Direct and indirect costs, and who bears them

Cost Type	Description	Cost
Direct costs	Surveillance, control, ongoing monitoring and compliance, education and advocacy (Council).	$303,000 (current direct costs to Council).
Indirect costs	Cost of managing incursions should they arise (Restricted access while management of pest is undertaken).	

The costs associated with the preferred option are covered by the annual cost of Council's active surveillance, control, monitoring and advocacy programme. There is a potential cost (indirect) on occupiers or exacerbators associated with an incursion response for example, potential income and production loss due to restrictions in place.

Most effective agents

The Regional Council is the most effective agency to undertake control and surveillance of pests in the region's water bodies. Containing these pests requires a co-ordinated effort. The Regional Council leads water management in the region.

Regional management of these pests is a more efficient and effective approach than individual effort and Council considers it is best placed to most effectively oversee management of these pests.

Sharing direct and indirect costs between beneficiaries and exacerbators

Attributing pest management responsibility for water bodies is inherently complex. It is not possible to identify every user and possible exacerbator.

Cost allocation for costs including incursion response

Council, as a bearer of costs for surveillance and advocacy, represents the regional beneficiaries. Costs will include surveillance, ongoing monitoring, rule compliance, advocacy and education.

Cost allocation to other beneficiaries

MPI contributes voluntary funding on behalf of the national beneficiaries, although this is not counted as a cost of the Plan, as it would be contributed without the Plan. DOC is ultimately responsible for management of koi carp/ rudd/ tench and perch but Council will partner with DOC to manage these fish. This is also not counted as a cost of the Plan, as the decision to undertake work is independent of the Plan.

Cost allocation – exacerbators identified

Individual exacerbators cannot be identified, so they cannot be allocated any cost of the Plan. However, for fairness the cost of compliance events should be charged on to them if they can be identified individually.

Water body users can be identified as a group of potential exacerbators, but the cost of administering the collection of contributions is likely to outweigh the value contributed.

Vessels and associated equipment moving through Bay of Plenty waters are known potential exacerbators and this plan requires vessel/equipment owner responsibility. Costs to exacerbators are through rule compliance e.g. clean boats.

Cost allocation for incursions:

100% exacerbator cost if exacerbator can be identified and the presence of the pest is due to deliberate action or inaction.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is most efficient and practical to fund Council costs from rates. The funding of managing these pests is secured by way of the Local Government Long Term Plan (LTP) processes.

It is difficult (administratively) to universally seek funding from the occupiers of land with lakes because some of these lands are non-rateable and under multiple ownership. It would be unfair to allocate a non-exacerbating (i.e. willing) occupier a share of the cost of the programme for the public biodiversity benefits that accrue. By the time a small share of that cost was allocated, the administration costs themselves would likely outweigh the funding gained.

It is not possible to identify every current or future exacerbator, and therefore not practical to seek costs from exacerbators in advance. This is why incursions are proposed to be rates funded.

However, as a matter of equity and incentive, exacerbators through deliberate action or lack of reasonable care still need to be considered. In these instances, Council's approach would be to lead and fund this programme. If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding and may also be administratively onerous.

Fair and reasonable

Based on the weight of benefitting attributed to the regional and national community for these "environmental" pests, it is most fair and reasonable that the regional community pay most of the cost of the Plan.

It is reasonable and fair to require vessel/equipment owner responsibility as contaminated vessels and equipment are known sources of pest spread.

Cost imposition mechanisms

Council proposes employing general rating as the tool to impose costs for managing these fish. Other considerations were:

- fines are not an option at this stage as there are no supporting regulations under the Biosecurity Act. Bio managers are working with MPI to develop regulations and therefore fines may be a cost mechanism that could be used in the future.
- targeted rates are not suitable because most people in the region are a beneficiary in terms of the environmental values associated with aquatic weed management.
- the beneficiary/exacerbator argument against charges is similar as for the targeted rate. In addition, beneficiaries are a widespread and diverse making identification of groups or individuals challenging.
- user-pays charges for water body usage has been considered but dismissed. This approach would be appropriate because risk of incursion is related to the degree of lake usage, however charges would be less efficient to administer and would not be a secure means of funding the Plan. The Plan does not prevent lake owners from administering charges that contribute to non-regulatory management of pests.
- levies could be required from lake users. At this stage, levies seem administratively complicated but it could be a cost imposition option to be consulted on in the future.
- Council would willingly accept voluntary payments from individuals or sectors, but this is not a secure source of funding.

Conclusion

General rates provide the best mechanism for managing freshwater fish pests on the following basis:

- management of aquatic pests provides public good benefits.
- most people in the region benefit directly or indirectly from management of aquatic pests, and/or are potential exacerbators
- there may be an opportunity to prosecute if an occupier or landowner has deliberately released a freshwater pest fish or not taken reasonable care, which may result in some degree of cost recovery.

Progressive containment plant pests – Council-led programmes

African feather grass, Asiatic knotweed, yellow flag iris and alligator weed.

Grouping for cost allocation

The infestation level for this group of pests is assessed as below Level 4, which is a moderate level of infestation and pre-population explosion. Council's management objective is to lead action to progressively contain these pests and over time reduce their density and distribution.

These pests are only legislated for under the Biosecurity Act 1993.

The benefits of containing these pests accrue to the community in general, through protection of environmental and public values. The progressive containment of some production pests may benefit industry more directly than the regional community. In these cases the regional community is likely to experience some flow-on economic benefit. Council considers the beneficiaries for the group of pests are sufficiently similar. The identified exacerbators are common for these progressive containment pests.

Programme	Beneficiaries	Exacerbators
Progressive Containment (Council-led programmes)	The regional community through protection of biodiversity and public values (social and cultural). Industry sectors may receive direct economic benefits. Where this is the case these benefits are likely to flow-on through the economy to the wider community. Land owners and occupiers may benefit from increased productivity as a result of progressive containment of these pests.	Persons involved with movement of people, goods, animals, vehicles, vessels and contaminated equipment Owners or occupiers of land not complying with direction or restricted place notices.

Allocation of costs

Direct and indirect costs, and who bears them

The costs associated with the preferred option are covered by the annual cost of Council's active surveillance programme. There is a potential cost (indirect) on occupiers or exacerbators associated with an incursion response for example, potential income and production loss due to restrictions in place.

Landowners are likely to manage this pest on their own land when the benefits of doing so are greater than the costs, and in those cases will face some private direct costs.

Cost Type	Description	Cost
Direct costs	Surveillance, pest removal, ongoing monitoring (Council).	$81,500.
Indirect costs	Cost of managing incursions should they arise (Council mainly).	$300-500 per hectare.

Most effective agents

The Regional Council is the most effective agency to progressively contain these pests through existing pest management activities. These pests are in the Progressive Containment Programme because they cannot be realistically eradicated in the short to medium term. Council considers management of these pests is a priority and has made and/or has the potential to make good progress containing these pests.

Sharing direct and indirect costs between beneficiaries and exacerbators

Council, as the bearer of the costs for these progressive containment pests, represents the regional beneficiaries.

Regional beneficiaries include urban and rural communities as their benefits for the control of environmental pests are considered similar. Rural communities and individuals may benefit more than urban from the management of pests that impact on production (e.g. farm pests), but overall the regional community benefits economically from the management of these pests.

Cost allocation for incursions:

100% weighting is given to regional beneficiaries, i.e. all ratepayers.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is efficient and practical to fund Council costs from rates. The funding of progressive containment of these pests is secured by way of the Local Government Long Term Plan (LTP) processes.

Containing these pests requires a co-ordinated effort. Regional Council leading management of these pests is a more efficient and effective approach than individual effort, and Council considers it is best placed to most effectively contain these pests.

It is not possible to identify every current or future exacerbator, when an incursion occurs, and therefore not practical to seek costs from exacerbators. This is why incursions are proposed to be funded through rates.

As a matter of equity and incentive, active exacerbators still need to be considered. In these instances, Council's approach would be to lead and fund this programme. If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to take prosecute although there is no guarantee this would secure funding, and may also be administratively onerous.

Fair and reasonable

These pests have a relatively limited distribution and there are regional benefits in securing their containment. On that basis, it is fair and reasonable to expect that the cost of incursions are also rates-funded where no one is at fault and the control action results in protecting regional interests.

Given that these pests are now in the region, it is unreasonable to expect the individual landowner or occupier who have this pest bear all of the cost of management and preventing its spread. Producer groups receive direct economic benefits from management while the balance of the community receive indirect economic benefits. Therefore the share of costs better lie on a wider community of beneficiaries.

Cost imposition mechanisms

Council proposes general rating as the tool to impose costs for progressive containment pests. Other considerations were:

- fines are not an option at this stage as there are no supporting regulations under the Biosecurity Act. The Regional Sector Bio managers Group are working with MPI to develop regulations and therefore fines may be a cost mechanism that could be used in the future.
- targeted rates are not suitable because most people in the region are a beneficiary or an exacerbator. It is not possible to reliably separate the benefits of the individual people or groups (beneficiaries and exacerbators) to determine a targeted rate.
- the beneficiary/exacerbator argument against charges is similar as for the targeted rate. In addition, charges should be set at a level to encourage good behaviour in exacerbators. Finding the correct level to create the right incentives is difficult and incorrect levels can result in perverse incentives.
- levies require a specific group. Again the inability to separate the benefits for individuals or groups makes this unviable.
- voluntary payments would be willingly accepted by Council from individuals or sectors, however this is not a secure source of funding.

Conclusion

General rates provide the best mechanism for managing these progressive containment pests.

- Progressive containment of these pests provides public good benefits.
- Most people in the region benefit directly or indirectly from the Progressive Containment Programme, or are potential exacerbators.
- There are a range of pests to be managed together under the Progressive Containment approach. Splitting the cost by pest and exacerbator is administratively complex.

- There may be an opportunity to prosecute if an occupier of landowner has deliberately released a progressive containment pest or not taken reasonable care, which this may result in some degree of cost recovery.
- Council may also consider direct charging of actual costs when a particular point in the compliance (or non-compliance) process is met. For example, in instances when a Section 122 Notice is issued, costs for all work (including administration by any staff, inspections, costs of prep and issue of notices, title searches, control work under section 128 BA and cancelling the Notice of Direction) is chargeable to the land occupier.

Progressive containment pests – wilding conifers

The infestation level for this pest is assessed as below Level 4, which is a moderate level of infestation and pre-population explosion.

Council's management objective is to progressively contain lodgepole pine and over time reduce its density and geographic distribution and manage the impacts of all other wilding conifers listed in the PRPMP.

Programme	Beneficiaries	Exacerbators
Progressive Containment	The regional community through protection of biodiversity and public values (social and cultural). Land owners and occupiers may benefit from increased productivity as a result of progressive containment of this pest.	Owners and occupiers of land who do not undertake ongoing pest management on their properties. Owners and occupiers of land who maintain *pinus contorta* shelterbelts or woodlots on their properties. The community where the pest is spread through lack of management on public land.

Allocation of costs

Council is guided by the *New Zealand Wilding Conifer Management Strategy 2015-2030, when considering allocation of costs.* All decisions around costs to manage wilding pines are aligned with this strategy.

Progressive containment (specified plant pests)

Apple of sodom, boneseed, Darwin's barberry, Italian buckthorn, variegated thistle, climbing spindle berry, lantana, woolly nightshade, spiny emex and old man's beard.

Grouping for cost allocation

These plant pests tend to be fairly well established in the region, or parts of the region. Based on the infestation curve (NPD Guidance) the species that make up this group are assessed as lying between Level 4 (toward the end of the "explosion" phase) and Level 8 ("widespread"). The level of infestation varies across the region with some areas largely free of these pests. Council's management objective is to progressively contain these pests, and over time reduce their density and distribution.

The Biosecurity Act 1993 is the only legislation that regulates these pests.

These species require management due to the potential effect primarily on biodiversity values and to some extent, production values. These pests can be grouped as they have a similar management approach, similar beneficiary and exacerbators, and similar legislative responsibility.

While the infestation size and location for each pest varies — and thus the cost impact on occupiers is potentially different for each pest — the cost allocation rationale applied is equally applicable to these species. Upon considering these factors, it makes sense that these species are presented as grouped for the purposes of cost allocation.

Programme	Beneficiaries	Exacerbators
Progressive containment – pests affecting predominantly production values	The regional community through protection of biodiversity and public values (social and cultural). Rural occupiers for the long-term protection of economic values. Land-based production sectors such as farming and horticulture derive economic benefits from management. There is likely to be flow-on positive economic effects to the regional community as a result. The regional and national community via environmental benefits.	Owners and occupiers of land (including the Crown) who do not manage the spread of pests from their properties.

Allocation of costs

Direct and indirect costs, and who bears them

The significant costs associated with the preferred options (progressive containment of these species), are the annual cost of compliance assessments, and the cost of removal and/or destruction of pests imposed on all occupiers.

Cost Type	Description	Cost
Direct costs	Annual compliance monitoring programme (Council). Estimated cost of compliance with Rules (Occupiers).	$176,400 (Current cost to council). $300 - $500 per hectare.
Indirect costs	None identified.	-

Most effective agents

The most effective agency to undertake control is the occupier as the main beneficiary and / or the main exacerbator.

Council is the most effective agency to undertake compliance assessments due to its capacity to co-ordinate the implementation of the Plan across the region and ability to collect rates to fund compliance assessment.

Sharing direct and indirect costs between beneficiaries and exacerbators

Landowners will make decisions about what level of pest control makes sense in relation to productivity returns or protecting their land. Where the benefits of control are greater than the costs associated with these pests, landowners could be expected to undertake control voluntarily.

Occupiers will bear the costs of controlling progressive control pests on their land and preventing them from spreading to neighbouring land.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is efficient and practical to fund Council costs from rates. The funding of the programme is secure by way of the Local Government Long Term Plan (LTP) processes and does not rely on the funding decisions of agencies external to Council.

It is efficient and effective to have individual land owners or occupiers assume responsibility for the cost of managing these pests on the land they occupy.

Fair and reasonable

The regional community benefits from the protection of biodiversity values. Owners or occupiers of production land also benefit from management of production pests and it is fair and reasonable to weight the share of the Plan costs onto this community through rule compliance. The regional community and occupiers contribute through general rates for Council costs such as rule compliance.

While not bound by good neighbour rules it is fair and reasonable for Crown agencies to have a role in managing pests on land they occupy. This is reflected in the MOUs.

Cost imposition mechanisms

While Council offers advice on control of these pests owners or occupiers are best placed to decide the most cost effective way to comply with the rules.

Where landowners or occupiers refuse to comply with rules, Council can carry out work by default under section 128 of the Biosecurity Act and recover costs associated with this work from the landowner or occupier.

Conclusion

The costs arising from progressive containment lie with the individual occupiers who directly benefit from reduction of spread or occupiers who exacerbate spread by having these pests on the boundaries of land that is clear of or being cleared of these pests.

These beneficiaries and exacerbators can be identified as those who have the pests present and a cost can be fairly assigned to them through compliance with a rule to prevent or contain these pests.

There are direct and indirect benefits to communities of people who benefit from the economic activity that arises from maintaining the productive capacity of the land and/or benefit from the protection of ancillary environmental values.

Council may fund management of some of these pests through its site-led approach.

Progressive containment animal pests – Council–led programmes

Wallabies and feral goats

The infestation for wallabies is assessed at below Level 4, which is a moderate level of infestation, pre-population explosion. Feral goats have a similar infestation level to wallabies for parts of the region and a lower level of infestation east of the Mōtū River. Council's management objective is to progressively contain these pests and reduce their density (including eradication of feral goats east of the Mōtū River).

Wallabies are legislated for under the Biosecurity Act 1993. Transitional provisions under the Biosecurity Law Reform Act 2012 provides for existing permits issued under the Wild Animal Control Act 1977, but as far as Councils is aware, there are no such permits operative in the region.

Feral Goats are subject to the Wild Animal Control Act.

Beneficiaries are broad, with direct benefits accruing to the entire community, including economic benefits to producers such as farmers and horticulturalists. Direct exacerbators, such as people releasing these pests, would be difficult to identify. The pest problem is exacerbated through ineffective pest management or inaction on both privately owned properties and public conservation land.

Programme	Beneficiaries	Exacerbators
Progressive containment - wallabies	Farmers directly and the regional and national community indirectly through protection from economic losses. Regional and national community directly through the protection of indigenous ecosystems and biological diversity. Social and cultural benefits are also relevant.	Anyone moves these animals around the region. Land owners or occupiers who allow these animals to expand their feral range on their properties.

Allocation of costs

Direct and indirect costs, and who bears them

There is a potential cost (considered indirect) on occupiers or exacerbators associated with an incursion response.

Cost Type	Description	Cost
Direct costs	Surveillance, ongoing monitoring, research and pest management (Council).	$210,000.
Indirect costs	Cost of managing incursions outside the containment area should they arise (Council and exacerbator).	

Most effective agent

Wallabies are managed collaboratively by Bay of Plenty Regional Council, Waikato Regional Council and the Department of Conservation. MPI is now investigating better options for better co-ordination at a national level for the management of wallaby populations in New Zealand.

Like wallabies, goats in the eastern Bay of Plenty are managed collaboratively. Bay of Plenty Regional Council works with the Department of Conservation, Nga Whenua Rahui and Gisborne District Council on controlling goats populations east of the Rangitaiki River.

In some circumstances the most effective agent may be the occupier, particularly within the containment area where wallabies and goats are impacting production values.

Sharing direct and indirect costs between beneficiaries and exacerbators

Council as the bearer of the costs of surveillance, monitoring, research and management represents the regional beneficiaries.

Regional beneficiaries include urban and rural communities; their benefits for environmental pests are considered similar. Rural communities and individuals may benefit more than urban from the management of pests that impact on production (e.g. farm pests), but considering the regional economic benefit of production, 100% weighting is given to regional beneficiaries, i.e. all ratepayers.

There could be a cost to the regional community and landowners through restricted access.

Cost allocation for incursions:

All New Zealanders benefit from containing wallabies to their current range, particularly with respect to protecting the biodiversity values.

Council as the bearer of costs (through its wallaby programme) represents the regional beneficiaries.

If Council believed an occupier or landowner acted deliberately or without reasonable care, it may look to prosecute although there is no guarantee this would secure funding and may also be administratively onerous.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is most efficient and practical to fund costs from rates. The funding of the passive surveillance programme is secure by way of the Local Government Long Term Plan (LTP) processes and does not rely on the funding decisions of external agencies.

Council's approach would be to lead and fund this programme.

Fair and reasonable

Given the benefits attributed to the regional and farming community, it is most fair and reasonable that the regional community and farming community (through general rating) pay a share of the direct costs of wallaby and goat management. It would be unreasonable for occupiers to solely cover the costs as an incursion may not be their fault and the control action results in protecting regional and farming interests.

Council considers it is fair and reasonable for Crown Agencies to contribute towards the costs of wallaby management, as there is a national benefit for control, and the Crown is an exacerbator if they do not manage wallabies and goats on land they occupy. Crown Agencies are attributed a share of the cost by allocating funds as per the MOUs.

Cost imposition mechanisms

Council proposes employing a mix of general rating and Crown Agency contribution as tools to impose costs for wallaby and feral goat management. Other considerations were:

- targeted rates are not suitable because most people in the region are a beneficiary or an exacerbator. It is not possible to reliably separate the benefits of the individual people or groups (beneficiaries and exacerbators) to determine a targeted rate.
- the beneficiary/exacerbator argument against charges is similar to the targeted rate. In addition, charges should be set at a level to encourage good behaviour in exacerbators. Finding the correct level to create the right incentives is difficult and incorrect levels can result in perverse incentives.
- levies require a specific group. Again the inability to separate the benefits for individuals or groups makes this unviable.
- Council would willingly accept voluntary payments from individuals or sectors, but this is not a secure source of funding.

Conclusion

General rates along with Crown Agency contribution are the best mechanisms for managing wallabies and feral goats in the region. The reasons for this decision are:

- containment of wallabies provides public good benefits, at a regional and national level.
- on balance, the weight of the share of costs arising from the containment of wallabies lies with the regional community due to the combined economic and environmental benefits.
- occupiers of rateable land can be expected to manage these pests if the costs of doing so are less than the costs imposed by their presence.
- occupiers of non-rateable land and the national community benefit from surveillance and any intervention on rateable land.
- on Crown estates, the national benefit is likely to be higher than the regional benefit, and this should be considered in the prioritisation process as set out in the MOU with Crown Agencies.
- there may be an opportunity to prosecute if an occupier or landowner has deliberately released or harbours wallabies or feral goats or has not taken reasonable care, which may result in some degree of cost recovery.

Progressive containment and sustained control

Wild kiwifruit

The infestation level for wild kiwifruit is assessed at below Level 4, which is a moderate level of infestation and pre-population explosion. Council's management objective is to manage the impacts of wild kiwifruit and in some parts of the region reduce its density and geographic distribution.

Containing this pest will provide environmental, social and cultural benefit to the regional community. Management will also benefit land-based rural sectors, and in particular kiwifruit growers. In the case of wild kiwifruit, the kiwifruit industry is directly contributing to the spread of these pests. The beneficiary base is broad, although the exacerbators are mostly limited to the kiwifruit industry, except where existing wild kiwifruit is not controlled and allowed to continue to spread.

Programme	Beneficiaries	Exacerbators
Progressive containment (kiwifruit)	Kiwifruit growers for the long-term protection of economic values. Land-based industry sectors (e.g. horticulture, forestry) for whom the spread of wild kiwifruit would be a pest problem and a cost. The regional community through protection of biodiversity and public values and management of spread through containment. This could be a significant issue where wild kiwifruit infests native bush areas or pristine landscapes.	Kiwifruit industry that in some cases provides a source of seed through unpicked fruit or poorly managed orchards. Packhouses also provide reject fruit as stockfeed that pose a risk of bird spread. Owners and occupiers who do not undertake management of this pest.

Allocation of costs

Direct and indirect costs, and who bears them

The significant costs associated with the preferred option, are the annual cost of monitoring and compliance, and the cost of removal and/or destruction of pests imposed on all occupiers. The general community absorbs the indirect costs associated with impact on the regions biodiversity.

Description Cost

Cost Type	Description	Cost
Direct costs	Surveillance, ongoing monitoring and compliance (Council).	$75,000 (Current direct costs to Council).
Indirect costs	Cost of managing incursions should they arise (Council and kiwifruit industry).	

Most effective agents

Management of wild kiwifruit is currently managed by Kiwifruit Vine Health and Council. This partnership reflects the most effective agencies to undertake control.

Council can undertake surveillance for wild kiwifruit using provisions of the Biosecurity Act to enter properties often while undertaking surveillance of other properties. Council has powers to complete cost recovery component from landowners. Kiwifruit Vine Health has no powers available to recover costs of controlling wild kiwifruit.

Sharing direct and indirect costs between beneficiaries and exacerbators

Council costs represent the regional beneficiaries.

Industry costs are through contributions to manage kiwifruit in the region and occupier costs are through rule compliance.

The kiwifruit industry exacerbates the problem in eastern parts of region and through provision of stockfeed to farmers but public also contribute by discarding partially eaten fruit in public places (Redwoods)

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is efficient and practical to fund Council compliance costs from rates. The funding of the programme is secure by way of the Local Government Long Term Plan (LTP) processes and does not rely on the funding decisions of external agencies.

Fair and reasonable

For the main exacerbators (commercial kiwifruit growers/kiwifruit industry) it would be fair and reasonable to expect them to pay for most of the programme. It would seem unfair for landowners without crops to have to pay when there is potentially continual recruitment of new infestations from neighbouring orchardists.

Cost imposition mechanisms

Levies could be a cost mechanism in the future but at the time the RPMP was developed, Council did not have processes in place to administer levies. Council will look for stronger support from industry (voluntary mechanisms).

Conclusion

Council may seek a formal funding with KVH.

Sustained control

Wild ginger, woolly nightshade, gorse, blackberry, ragwort, lantana, old man's beard, climbing spindle berry

Grouping for cost allocation

These pests tend to be fairly well established. Based on the infestation curve (NPD Guidance) the species that make up this group are assessed as lying between Level 6 (toward the end of the "explosion" phase) and Level 8 ("widespread"). The level of infestation varies across the region with places that are largely free of these pests, and some areas prone to invasion. Council's objective is to manage the impact of these pest's spread to other properties.

The Biosecurity Act 1993 is the only legislation that regulates these pests.

These pests impact on environment and on production values. There are also some biodiversity and amenity benefits that accrue from the management of these species.

This group of pests have a similar exacerbator/beneficiary profile, and legislative responsibility. While the infestation size and location for each pest varies — and thus the cost impact on occupiers is potentially different for each pest — the cost allocation rationale is applicable to these species.

It is likely that there will be two or more of these pest species on any given property. To separate them for cost allocation would present an artificial representation of the cost of compliance.

Programme	Beneficiaries	Exacerbators
Sustained Control Pests (Boundary Control)	Rural occupiers for the long-term protection of economic values. Land-based production sectors such as farming and horticulture derive economic benefits from management. There is likely to be flow-on positive economic effects to the regional community as a result. The regional and national community indirectly benefit primarily through the protection of economic futures, but also environmental, social and cultural benefits.	Owners and occupiers of land (including the Crown) who do not manage the spread of pests from their properties.

Allocation of costs

Direct and indirect costs, and who bears them

The significant costs associated with the preferred options (sustained control of these species), are the annual cost of compliance assessments, and the cost of rules imposed on all occupiers.

In terms of Council costs, the overall programme has been designed so that the work can be undertaken under a combined budget for these species. This approach enables cost efficiencies by treating multiple pests at each site. The costs are presented as the combined annual cost of the compliance programme and the total estimated cost of the rules. The table below identifies the direct costs of the Plan, and draws from analyses against NPD clauses 7(2)(d)i to 7(2)(d)xv to indicate who should bear the costs (in brackets).

Cost type Description Cost

Cost Type	Description	Cost
Direct costs	Annual compliance monitoring programme (Council). Estimated cost of compliance with Rules (Occupiers).	$246,000. $300 - $500 per ha (infested).
Indirect costs	None identified.	Not known.

Most effective agents

The most effective agency to undertake control is the occupier as the main beneficiary and/or the main exacerbator. Council is the most effective agency to intervene when required for boundary control.

Sharing direct and indirect costs between beneficiaries and exacerbators

Landowners will make decisions about what level of pest control makes sense in relation to productivity returns or protecting their land.

Occupiers will bear the costs of controlling sustained control pests on their land and preventing them from spreading to neighbouring land.

Any compliance costs can be transferred to occupiers.

Cost allocation for Council costs

Council, as the bearer of the cost of following up complaints and undertaking some compliance assessments, represents communities of regional beneficiaries who have direct and indirect economic benefits, and indirect environmental benefits. Regional beneficiaries include urban and rural communities.

Cost allocation for Occupier costs

The occupier, as the bearer of the cost of complying with the rules, represents the direct (private) beneficiary and exacerbator share. This is approximately 97% of the cost of the Plan.

For most of these pests, the land occupiers are both the beneficiaries of the pest control and exacerbators of the pest problem. Landowners will make decisions about the levels of pest control that make sense in relation to productivity returns or protecting their land.

Efficiency, effectiveness, practicality, administrative efficiency, and funding security

It is efficient and effective to have occupiers assume responsibility for the cost of managing these pests on the land they occupy. It is efficient and practical to fund Council compliance costs from rates. The funding of the programme is secure by way of the Local Government Long Term Plan (LTP) processes and does not rely on the funding decisions of external agencies.

Fair and reasonable

Occupiers of land are the most significant direct beneficiary; therefore it is fair and reasonable to weight the share of the costs on the Plan onto this community through rule compliance costs. These occupiers also contribute towards Council compliance costs via general rating.

While not bound by good neighbour rules it is fair and reasonable, for Crown agencies to have a role in managing pests on land they occupy. This is reflected in the MOUs.

Cost imposition mechanisms

Owners or occupiers will decide the most cost effective way to comply with the rules.

Where landowners or occupiers refuse to comply with rules, Council can carry out work by default under section 128 of the Biosecurity Act and recover costs associated with this work from the landowner or occupier.

Conclusion

This section summarises the best cost imposition mechanisms after taking into account all of the factors considered above and any statutory requirements. On balance, the costs arising from the reduced spread of sustained control pests lie with the individual occupiers who directly benefit from reduction of spread or occupiers who exacerbate spread by having these pests on the boundaries of land that is clear of or being cleared of these pests.

These beneficiaries and exacerbators can be identified as those who have the pests present and a cost can be fairly assigned to them through compliance with a rule to prevent or manage spread.

Council may fund management of some of these pests through its site-led approach.

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Appendix 1:

Section 6(1) of the NPD

Determining the most suitable level of analysis of the benefits depends on criteria listed in the NPD and the interactions and weighting between them. Council has assessed these in the following way:

Assessment Criteria 1: The likely significance of the pest or the proposed measures

- **High** – Potential for significant interest, ***or*** strong opposing viewpoints in community ***or*** high total costs.
- **Medium** – Potential for moderate interest, opposing viewpoints in some groups within community, or moderate total costs.
- **Low** – Not generally likely to be an issue for community public or organisations, or low total costs.

Assessment Criteria 2: Likely costs relative to likely benefits

- **High** – Costs for the programme are likely to be similar to the benefits of the programme.
- **Medium** – Costs for the programme are likely to be lower than the benefits of the programme in most scenarios.
- **Low** – Costs for the programme are likely to be substantially lower than the benefits of the programme, even if the objectives are not fully achieved.

Assessment Criteria 3: Uncertainty of the impacts of the pest and effectiveness of measures

- **High** – Not much known about the pest's impacts. Measures are untested.
- **Medium** – Known to have impacts elsewhere in similar situations. Similar measures have been effective in other areas, or measures have only been somewhat effective.
- **Low** – Known to have significant impacts, spread risk known and the effectiveness of measures is well-known.

Assessment Criteria 4: Level and quality of data available

- **High** – Very high-quality current distribution data; costs and impacts well established
- **Medium** – Some historical information or data from other sources (outside of the region or NZ). No specific targeted monitoring data. Costs and impacts capable of being estimated from case studies.
- **Low** – Little information available.

Assessment criteria 1-3 relate to the level of analysis that should be done in responsonse to a particular situation. The fourth criterion focuses on the level of analysis that is possible.

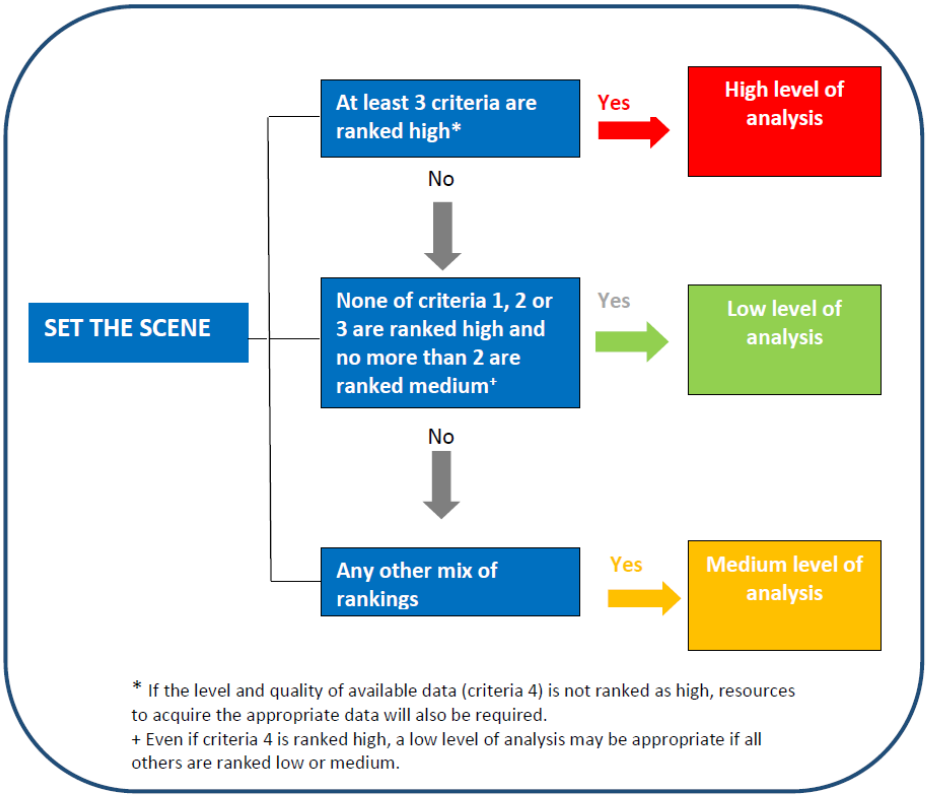

Figure 1: Determining the level of analysis to undertake

Pest		Community and stakeholder interest		Cost versus Benefits		Level of uncertainty				Level of analysis required
		6(1)(b)		*6(1)(c)*		*6(1)(a)*		*6(1)(d)*		
		Likely significance or controversy of the pest or Proposed measures or cost of measures		*Likely costs relative to likely benefits*		*Uncertainty of impacts and effectiveness of methods*		*Level and quality of data*		
		Criteria 1		*Criteria 2*		*Criteria 3*		*Criteria 4*		
Plants										
African feather grass	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Alligator weed (defined areas)*	**2**	Medium	2	Medium	2	Medium	2	Medium	2	Medium
Apple of Sodom	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Arundo donx	**1**	Low	1	Low	1	Low	1	Low	1	Low
Asiatic knotweed	**2**	Medium	1	Low	1	Low	2	Medium	1.5	Low
Batwinged passionflower	**1**	Low	1	Low	1	Low	1	Low	1	Low
Blackberry	**2**	Medium	2	Medium	2	Medium	3	High	2.3	High
Boneseed	**1**	Low	2	Medium	1	Low	3	High	1.8	Medium
Chilean flame creeper	**1**	Low	1	Low	1	Low	1	Low	1	Low
Chilean needle grass	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
Chinese knotweed	**1**	Low	1	Low	1	Low	1	Low	1	Low
Chocolate vine	**1**	Low	1	Low	1	Low	1	Low	1	Low
Climbing spindle berry	**2**	Medium	2	Medium	2	Medium	2	Medium	2	Medium
Coast tea tree	**1**	Low	1	Low	2	Medium	3	High	1.8	Medium
Creeping gloxinia	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
Darwin's barberry	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Didymo*	**2**	Medium	2	Medium	1	Low	3	High	2	Medium
Egeria	**3**	High	2	Medium	1	Low	3	High	2.3	High
Elodea	**2**	Medium	2	Medium	1	Low	3	High	2	Medium

	Community and stakeholder interest		Cost versus Benefits		Level of uncertainty				Level of analysis required
	6(1)(b)		*6(1)(c)*		*6(1)(a)*		*6(1)(d)*		
Pest	***Likely significance or controversy of the pest or Proposed measures or cost of measures***		***Likely costs relative to likely benefits***		***Uncertainty of impacts and effectiveness of methods***		***Level and quality of data***		
	Criteria 1		*Criteria 2*		*Criteria 3*		*Criteria 4*		
Field horsetail	**1** Low	1	Low	1	Low	2	Medium	1.3	Low
Giant knotweed	**1** Low	1	Low	1	Low	1	Low	1	Low
Gorse* (part only)	**2** Medium	2	Medium	1	Low	3	High	2	Medium
Hornwort	**3** High	2	Medium	1	Low	3	High	2.3	High
Horse nettle	**1** Low	1	Low	1	Low	3	High	1.5	Low
Hydrilla*	**3** High	2	Medium	1	Low	3	High	2.3	High
Italian buckthorn	**2** Medium	1	Low	1	Low	3	High	1.8	Medium
Kauri dieback*	**3** High	1	Low	2	Medium	2	Medium	2	Medium
Kudzu vine	**1** Low	1	Low	1	Low	3	High	1.5	Low
Lagarosiphon	**3** High	2	Medium	1	Low	3	High	2.3	High
Lantana (defined areas)	**1** Low	1	Low	1	Low	2	Medium	1.3	Low
Lodgepole pine	**3** High	1	Low	1	Low	3	High	2	Medium
Marram grass	**1** Low	2	Medium	2	Medium	2	Medium	1.8	Medium
Marshwort	**1** Low	1	Low	1	Low	2	Medium	1.3	Low
Nasella tussock	**1** Low	1	Low	1	Low	3	High	1.5	Low
Noogoora bur	**2** Medium	1	Low	2	Medium	2	Medium	1.8	Medium
Old man's beard (defined areas)	**2** Medium	1	Low	2	Medium	2	Medium	1.8	Medium
Privet	**3** High	3	High	1	Low	3	High	2.5	High
Purple loosestrife	**1** Low	1	Low	2	Medium	2	Medium	1.5	Low
Ragwort (defined areas)	**2** Medium	1	Low	1	Low	3	High	1.8	Medium

		Community and stakeholder interest		Cost versus Benefits		Level of uncertainty				Level of analysis required
Pest		***6(1)(b)*** ***Likely significance or controversy of the pest or Proposed measures or cost of measures*** ***Criteria 1***		***6(1)(c)*** ***Likely costs relative to likely benefits*** ***Criteria 2***		***6(1)(a)*** ***Uncertainty of impacts and effectiveness of methods*** ***Criteria 3***		***6(1)(d)*** ***Level and quality of data*** ***Criteria 4***		
Rough horsetail	**1**	Low	1	Low	2	Medium	2	Medium	1.5	Low
Royal Fern	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
Sagitarria	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
Senegal tea	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Spartina	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Spiny emex	**1**	Low	1	Low	2	Medium	3	High	1.8	Medium
Stout bamboo grass	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
Sydney golden wattle	**2**	Medium	3	High	2	Medium	2	Medium	2.3	High
Variegated thistle	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Velvetleaf	**2**	Medium	2	Medium	2	Medium	3	High	2.3	High
Water poppy	**1**	Low	1	Low	1	Low	2	Medium	1.3	Low
White edged nightshade	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Wild ginger*	**3**	High	2	Medium	2	Medium	2	Medium	2.3	High
Wild kiwifruit*	**3**	High	3	High	2	Medium	2	Medium	2.5	High
Wilding conifers (excluding Lodgepole pine)	**3**	High	2	Medium	2	Medium	1	Low	2	Medium
Woolly nightshade (defined areas)*	**3**	High	3	High	2	Medium	3	High	2.8	High
Yellow flag iris	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Animals										
Argentine ants	**1**	Low	1	Low	2	Medium	2	Medium	1.5	Low
Asian paddlecrab*	**2**	Medium	1	Low	3	High	1	Low	1.8	Medium

Pest		Community and stakeholder interest		Cost versus Benefits		Level of uncertainty				Level of analysis required
		6(1)(b)		*6(1)(c)*		*6(1)(a)*		*6(1)(d)*		
		Likely significance or controversy of the pest or Proposed measures or cost of measures		***Likely costs relative to likely benefits***		***Uncertainty of impacts and effectiveness of methods***		***Level and quality of data***		
		Criteria 1		*Criteria 2*		*Criteria 3*		*Criteria 4*		
Australian droplet tunicate*	**2**	Medium	1	Low	3	High	1	Low	1.8	Medium
Brown bullhead catfish*	**3**	High	3	High	2	Medium	2	Medium	2.5	High
Canada geese	**2**	Medium	2	Medium	1	Low	2	Medium	1.8	Medium
Clubbed tunicate*	**3**	High	2	Medium	3	High	2	Medium	2.5	Medium
Feral cats	**2**	Medium	2	Medium	2	Medium	2	Medium	2	Medium
Feral goats*	**2**	Medium	2	Medium	1	Low	3	High	2	Medium
Koi carp	**2**	Medium	1	Low	2	Medium	2	Medium	1.8	Low
Mediterranean fanworm*	**2**	Medium	1	Low	3	High	2	Medium	2	Medium
Northern pacific sea star	**2**	Medium	1	Low	3	High	1	Low	1.8	Low
Perch	**2**	Medium	1	Low	3	High	2	Medium	2	Low
Pyura*	**2**	Medium	1	Low	3	High	1	Low	1.8	Medium
Rabbits	**1**	Low	1	Low	1	Low	3	High	1.5	Low
Rainbow lorikeets	**1**	Low	2	Medium	2	Medium	1	Low	1.5	Low
Rooks	**2**	Medium	2	Medium	2	Medium	2	Medium	2	Medium
Rudd	**2**	Medium	1	Low	3	High	2	Medium	2	Medium
Tench	**2**	Medium	1	Low	3	High	2	Medium	2	Medium
Wallabies*	**3**	High	2	Medium	2	Medium	2	Medium	2.3	High
Wasps	**3**	High	3	High	3	High	3	High	3	High

Appendix 2:

Regional Pest Management Plan – Summary list of pests, their proposed programme and rationale

Catchment abbreviations:

TGA - Tauranga Harbour
KAI - Kaituna Maketū Pongakawa
TAR - Tarawera
ROT - Rotorua Lake
RAN - Rangitāiki
WHA - Whakatāne
OHI - Ōhiwa Harbour and Waiōtahe
WAI - Waioeka and Otara
EAST - East Coast

Pest Name	Programmes considered	Our proposed programme	Comments
African feathergrass	***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Positively cost beneficial.* *Very problematic pest plant that is difficult to control.*
Alligator weed	***Eradication*** *– regional* ***Eradication*** *– TGA* ***Exclusion*** *– KAI, ROT* ***Progressive Containment*** *– regional* ***Progressive Containment*** *– TAR, RAN, WHA, OHI, WAI, EAST*	***Eradication*** *– TGA* ***Exclusion*** *– KAI, ROT* ***Progressive Containment*** *– TAR, RAN, WHA, OHI, WAI, EAST*	*Cost benefit favoured a sub-regional split rather than a regional classification. This was also staff preference.* *Highly cost beneficial, particularly exclusion.*

Pest Name	Programmes considered	Our proposed programme	Comments
Argentine ants	***Sustained Control*** *– regional*	***Do not include in RPMP***	*While positively cost beneficial the cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Apple of Sodom	***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Positively cost beneficial.* *Not common or widespread in region, easily managed.*
Arundo donax	***Progressive Containment –*** *regional* ***Sustained Control –*** *regional*	***Do not include in RPMP***	*Negatively cost beneficial.* *Impacts are minor.* *Biocontrol agent currently being developed.*
Asian paddlecrab	***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Significantly cost beneficial* *Impacts of pests are significant.*
Asiatic knotweed	***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Cost benefit analysis came back negative due to model placing little value in urban environments.* *Including as recognised as a significant issue internationally and very difficult pest to control.* *Currently at low levels in the region and would have a significant impact on landowners if became widely established.*
Australian droplet tunicate	***Exclusion*** *– regional*	***Exclusion*** *– regional*	*Strongly cost beneficial* *Not currently present in the region.*
Batwinged passionflower	***Exclusion*** *– regional*	***Exclusion*** *– regional*	*Strongly cost beneficial* *Not currently present in the region.*

Pest Name	Programmes considered	Our proposed programme	Comments
Blackberry	***Sustained Control*** *– regional*	***Sustained Control*** *– regional*	*Strongly cost beneficial* *Proposed to be included as boundary rule as with the current RPMP approach.* *Too costly a programme to manage more intensively.*
Boneseed	***Progressive Containment –*** *regional*	***Progressive Containment –*** *regional*	
Canada geese	***Sustained Control –*** *regional*	***Do not include in RPMP***	*While positively cost beneficial the cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Catfish	***Exclusion*** *– Freshwater sites apart from Lake Rotoiti, Lake Rotorua and the Kaituna River* ***Progressive Containment*** *– Lake Rotoiti, Lake Rotorua and the Kaituna River*	***Exclusion*** *– Freshwater sites apart from Lake Rotoiti, Lake Rotorua and the Kaituna River* ***Progressive Containment*** *– Lake Rotoiti, Lake Rotorua and the Kaituna River*	*Exclusion strongly cost beneficial, Containment cost beneficial.* *Strong support from the public to effectively manage this species.*
Chilean flame creeper	***Exclusion*** *– regional*	***Exclusion*** *– regional*	*Cost beneficial* *Not currently present in the region.*
Chilean needle grass	***Exclusion*** *– regional*	***Exclusion*** *– regional*	*Strongly cost beneficial* *Not currently present in the region.*
Climbing spindleberry	***Progressive Containment*** *– TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST* ***Sustained Control*** *– ROT*	***Progressive Containment*** *– TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST* ***Sustained Control*** *– ROT*	*Cost beneficial.* *Relatively low incidence pest apart from Rotorua, highly visible pest at times of year.*
Chinese knotweed	***Exclusion –*** *regional*	***Do not include in RPMP***	*Negative cost benefit.* *Will be captured in general surveillance work.*

Pest Name	Programmes considered	Our proposed programme	Comments
Chocolate vine	***Progressive Containment –*** *regional*	***Do not include in RPMP***	*Negative cost benefit.* *Pest has limited impact.*
Clubbed tunicate	***Eradication –*** *regional* ***Progressive Containment*** *- regional*	***Progressive Containment*** *– regional*	*Progressive Containment a more cost beneficial option.*
Coast tea tree	***Eradication*** *– regional*	***Eradication*** *– regional*	*Cost beneficial programme.* *Very limited to small part of the region.* *Coastal environment not highly valued in the model which is the land use this pest impacts on predominantly.*
Creeping gloxinia	***Eradication*** *– regional* ***Progressive Containment*** *– regional*	***Eradication*** *– regional*	*Positive cost benefit.* *Eradication more cost beneficial compared to Progressive Containment.*
Darwin's barberry	***Exclusion*** *– TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST* ***Progressive Containment*** *– ROT*	***Exclusion*** *– TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST* ***Progressive Containment*** *– ROT*	*Slightly negative cost benefit.* *Very limited distribution and has the potential to have large impact despite what model suggests.* *Good progress has been made and will continue to be made with investment.*
Egeria densa	***Exclusion*** *– Lakes Ōkataina, Rotoehu, Rotomā, Tikitapu, Ōkaro, Rotokakahi.* ***Progressive Containment*** *– Lake Rotorua, Rotoiti, Ōkāreka, Tarawera, Rotomahana, Rerewhakaaitu.* ***Sustained Control*** *– All Rotorua Lakes.* ***Sustained Control*** *– Lake Rotorua, Rotoiti, Ōkāreka, Tarawera, Rotomahana, Rerewhakaaitu.*	***Exclusion*** *– Lakes Ōkataina, Rotoehu, Rotomā, Tikitapu, Ōkaro, Rotokakahi.* ***Progressive Containment*** *– Lake Rotorua, Rotoiti, Ōkāreka, Tarawera, Rotomahana, Rerewhakaaitu.*	*Strongly positive cost benefit.* *Proposed combination had best cost benefit result.*

Pest Name	Programmes considered	Our proposed programme	Comments
Elodea canadensis	***Exclusion*** *– Lake Rotomahana* ***Sustained Control*** *– Lakes Rotorua, Rotoiti, Ōkāreka, Tarawera, Rerewhakaaitu, Ōkataina, Rotoehu, Rotomā, Tikitapu, Ōkaro, Rotokakahi.* ***Sustained Control*** *– All Rotorua Lakes*	***Exclusion*** *– Lake Rotomahana* ***Sustained Control*** *– Lakes Rotorua, Rotoiti, Ōkāreka, Tarawera, Rerewhakaaitu, Ōkataina, Rotoehu, Rotomā, Tikitapu, Ōkaro, Rotokakahi.*	*Strong cost benefit of Exclusion meant proposed option had better cost benefit compared to Sustained Control for all the Rotorua Lakes.*
Feral cat	***Sustained Control*** *– regional* ***Site-led*** *– regional*	***Do not include in RPMP***	*While positively cost beneficial the cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Feral goat	***Eradication*** *– east of Mōtū River.* ***Progressive Containment*** *– west of Mōtū River.* ***Sustained Control*** *– west of Mōtū River.*	***Eradication*** *– east of Mōtū River.* ***Progressive Containment*** *– west of Mōtū River.*	*All options strongly cost beneficial.* *Proposed option had best combined cost benefit.*
Field horsetail	***Exclusion*** *– regional*	***Exclusion*** *– regional*	*Slightly negative cost benefit.* *Included for management as very high risk species that is extremely difficult to control. Big issue in other parts of New Zealand.*
Giant knotweed	***Exclusion*** *– regional*	***Do not include in RPMP***	*Negative cost benefit.* *Will be captured in general surveillance work.*

Pest Name	Programmes considered	Our proposed programme	Comments
Gorse	***Sustained control*** *– regional* ***Progressive Containment*** *– Lake Rotorua catchment* ***Sustained Control*** *– Lake Rotorua catchment*	***Sustained control*** *– regional*	*Cost benefit not undertaken for the proposed programme but based on results of blackberry and ragwort analysis would be strongly cost beneficial.* *Other considered programmes removed to support other RPMP as they were proposed to support the Lake Rotorua nutrient reduction programme.*
Hornwort	***Exclusion*** *– Lake Rerewhakaaitu, Ōkaro, Rotokakahi, Tikitapu, Rotomā.* ***Eradication*** *– Lakes Ōkāreka and Ōkataina.* ***Progressive Containment*** *– Lake Rotorua, Rotoiti, Rotoehu, Tarawera, Rotomahana.* ***Sustained Control*** *- Lake Rotorua, Rotoiti, Rotoehu, Tarawera, Rotomahana.* ***Sustained Control*** *– All Rotorua Lakes*	***Exclusion*** *– Lake Rerewhakaaitu, Ōkaro, Rotokakahi, Tikitapu, Rotomā.* ***Eradication*** *– Lakes Ōkāreka and Ōkataina.* ***Progressive Containment*** *– Lake Rotorua, Rotoiti, Rotoehu, Tarawera, Rotomahana.*	*All considered programmes had positive cost benefit.* *The proposed options had the best combined cost benefit.*
Horse nettle	***Eradication –*** *regional*	***Eradication –*** *regional*	*Positive cost benefit.* *Species has limited distribution.*
Hydrilla	***Exclusion –*** *regional*	***Do not include in RPMP***	*To be managed by Ministry of Primary Industries under National Interest Pest programme.*
Italian buckthorn	***Exclusion –*** *ROT, TAR, RAN, WHA, OHI, WAI, EAST.* ***Progressive Containment*** *– TGA, KAI*	***Exclusion –*** *ROT, TAR, RAN, WHA, OHI, WAI, EAST.* ***Progressive Containment*** *– TGA, KAI*	*Negative cost benefit.* *Impacts mainly Urban and Coastal environment which isn't highly valued by the AgResearch model.* *Significant progress made to date, limited distribution currently, good progress can be made with ongoing investment.*

Pest Name	Programmes considered	Our proposed programme	Comments
Kauri dieback disease	***Exclusion –*** *regional*	***Do not include in RPMP***	*To be managed by Ministry of Primary Industries under National Interest Pest programme.*
Koi carp	***Eradication –*** *regional*	***Eradication –*** *regional*	*Positive cost benefit analysis.* *Very limited distribution in region.* *Pest has potential to have significant impact, particularly on water quality.*
Kudzu vine	***Eradication –*** *regional*	***Eradication –*** *regional*	*Positive cost benefit analysis.* *Very limited distribution in region.*
Lagarosiphon major	***Exclusion –*** *Lakes Rotokakahi, Rotomahana, Ōkaro.* ***Progressive Containment*** *– Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaaitu, Ōkataina, Rotoehu.* ***Sustained Control*** *– Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaaitu, Ōkataina, Rotoehu.* ***Sustained Control*** *– All Rotorua Lakes*	***Exclusion –*** *Lakes Rotokakahi, Rotomahana, Ōkaro.* ***Progressive Containment*** *– Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaaitu, Ōkataina, Rotoehu.*	*All considered programmes had positive cost benefit.* *The proposed options had the best combined cost benefit.*
Lantana	***Eradication –*** *ROT.* ***Progressive Containment*** *– KAI, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control*** *– TGA.*	***Eradication –*** *ROT.* ***Progressive Containment*** *– KAI, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control*** *– TGA.*	*Positive cost benefit.*
Lodgepole pine	***Progressive Containment –*** *regional*	***Progressive Containment –*** *regional*	*Very strongly cost beneficial.* *Good progress can be made with investment.* *Pest of national interest.*
Marram grass	***Progressive Containment –*** *regional* ***Sustained Control –*** *regional*	***Do not include in RPMP***	*Negative costs benefit* *Will be managed under site-led programmes such as Environmental Programmes and Coast Care.*

Pest Name	Programmes considered	Our proposed programme	Comments
Marshwort	***Exclusion –*** *regional*	***Do not include in RPMP***	*Negative cost benefit.* *Captured through general surveillance programme.*
Mediterranean fanworm	***Eradication –*** *regional* ***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Both options cost beneficial.* *The preferred option had a better cost benefit.*
Nassella tussock	***Eradication –*** *regional*	***Eradication –*** *regional*	*Positive cost benefit.* *Limited distribution and significant impact.*
Noogoora bur	***Eradication –*** *regional*	***Eradication –*** *regional*	*Positive cost benefit.* *Limited distribution and significant impact.*
Old man's beard	***Progressive Containment –*** *TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control –*** *ROT.*	***Progressive Containment –*** *TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control –*** *ROT.*	*Positive cost benefit for both proposed programmes.* *Long history of management and good progress made.*
Perch	***Eradication -*** *regional*	***Eradication -*** *regional*	*Positive cost benefit.* *Only one know site in region, large impact on native fish if established.*
Purple loosestrife	***Eradication -*** *regional*	***Eradication -*** *regional*	*Positive cost benefit.* *Very limited distribution currently.*
Privet	***Sustained Control -*** *regional*	***Do not include in RPMP***	*Negative cost beneficial.* *The cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Pyura	***Exclusion -*** *regional*	***Exclusion -*** *regional*	*Strongly positive cost beneficial programme.* *Not currently in the region.*

Pest Name	Programmes considered	Our proposed programme	Comments
Rabbits	***Sustained Control -*** *regional*	***Do not include in RPMP***	*While positively cost beneficial the cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Ragwort	***Sustained Control -*** *regional*	***Sustained control*** *- regional*	*Strongly cost beneficial* *Proposed to be included as boundary rule as with the current RPMP approach.* *Too costly a programme to manage more intensively.*
Rainbow lorikeet	***Eradication -*** *regional*	***Do not include in RPMP***	*To be managed by Ministry of Primary Industries under National Interest Pest programme.*
Rooks	***Eradication -*** *regional*	***Eradication -*** *regional*	*Cost beneficial programme.* *Good progress been made to date, limited distribution in the region.*
Rough horsetail	***Eradication -*** *regional*	***Do not include in RPMP***	*Negative cost-benefit.* *Not considered to be a highly invasive species though will be monitored.*
Royal fern	***Progressive Containment –*** *ROT, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control*** *– TGA, KAI.*	***Do not include in RPMP***	*While positive cost-benefit, logistically a very challenging species to manage due to wind spread spores.* *Will be managed ay key sites via Environmental Programmes.*
Rudd	***Eradication*** *– regional* ***Progressive Containment*** *– regional*	***Progressive Containment –*** *regional*	*Proposed option is more cost beneficial.* *Logistically, from a management perspective, Progressive Containment is the preferred option.*

Pest Name	Programmes considered	Our proposed programme	Comments
Sagittaria	***Eradication*** *- regional*	***Eradication -*** *regional*	*Positive cost-benefit.* *Good progress been made to date, limited distribution in the region.*
Senegal tea	***Eradication*** *- regional*	***Eradication -*** *regional*	*Positive cost-benefit.* *Good progress been made to date, limited distribution in the region.*
Spartina	***Eradication*** *- regional*	***Eradication -*** *regional*	*Positive cost-benefit.* *Good progress been made to date, limited distribution in the region.*
Spiny emex	***Eradication*** *– regional* ***Progressive Containment*** *– regional*	***Progressive Containment –*** *regional*	*Proposed option is more cost beneficial.*
Stout bamboo grass	***Eradication*** *– regional*	***Eradication*** *– regional*	*Slightly negative cost-benefit.* *Little investment needed to manage and very limited distribution currently.*
Sydney golden wattle	***Progressive Containment*** *– regional* ***Sustained Control*** *– regional*	***Do not include in RPMP***	*Negative cost benefit.* *Will be managed through community led programmes, Coastcare and Environmental Programmes.*
Tench	***Eradication*** *– regional* ***Progressive Containment*** *– regional*	***Progressive Containment –*** *regional*	*Proposed option is cost beneficial, the other option considered is not.*
Variegated thistle	***Progressive Containment*** *– regional*	***Progressive Containment –*** *regional*	*Positive cost-benefit.* *Limited distribution in the region.*
Velvetleaf	***Eradication –*** *regional*	***Do not include in RPMP***	*To be managed under national programme led by the Ministry of Primary Industries.* *BOPRC will continue to support them within the region.*
Wallaby	***Progressive Containment*** *– regional* ***Sustained Control*** *– regional*	***Progressive Containment –*** *regional*	*More cost beneficial option.*

Pest Name	Programmes considered	Our proposed programme	Comments
Wasps	***Sustained Control*** *– regional*	***Do not include in RPMP***	*While positively cost beneficial the cost of implementing a programme is extremely large and beyond the current resourcing of the programme.* *Managing the pest is likely to have minimal impact on the pest and its ability to impact the region.*
Water poppy	***Exclusion –*** *regional*	***Exclusion -*** *regional*	*Slightly negative cost benefit.* *Very problematic plant once established, exclusion not valued by AgResearch model.*
White edged nightshade	***Eradication –*** *regional*	***Eradication*** *– regional*	*Positive cost benefit.* *Limited distribution currently in the region and easily managed with little investment.*
Wild ginger	***Progressive Containment*** *– regional* ***Sustained Control*** *– regional*	***Sustained control*** *- regional*	*Sustained control slightly more cost beneficial.* *Also the preferred management option for this species considering its relatively wide distribution.*
Wild kiwifruit	***Progressive Containment*** *– regional* ***Sustained Control*** *– regional* ***Progressive Containment*** *– ROT, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control*** *– TGA, KAI.*	***Progressive Containment*** *– ROT, TAR, RAN, WHA, OHI, WAI, EAST.* ***Sustained Control*** *– TGA, KAI.*	*Proposed option is slightly more cost beneficial.* *Well established collaborative programme.*
Wilding conifers (excluding Lodgepole pine)	***Sustained Control*** *– regional*	***Sustained control*** *- regional*	*Highly cost beneficial.* *Links well with successful national programme which BOPRC hope to gain funding from.*

Pest Name	Programmes considered	Our proposed programme	Comments
Woolly nightshade	***Progressive Containment*** *– regional* ***Sustained Control*** *– regional* ***Progressive Containment*** *– ROT, RAN, TAR, WHA.* ***Sustained Control*** *– TGA, KAI, OHI, WAI, EAST.*	***Progressive Containment*** *– ROT, RAN, TAR, WHA.* ***Sustained Control*** *– TGA, KAI, OHI, WAI, EAST.*	*Proposed option is slightly more cost beneficial.* *Part of proposed programme has negative cost benefit though species is highly concerning to the public who expect it to be managed.*
Yellow flag iris	***Progressive Containment*** *– regional*	***Progressive Containment*** *– regional*	*Positive cost benefit.* *Aligns with current management regime which works well for this species.*

Appendix 3:

Cost Benefit Analysis for Regional Pest Management using AgResearch tool

CBA type	Species	Category	Category split (ie regional or specific catchments)	Area infested (ha)	Maximum area that could become infested (ha)	Rate of spread (*r*)	Time for infestation to reach 90% of maximum (years)	Earnings (/ha)	Reduction in earnings caused by pest (%)	Net Present Value (NPV) ($)	Internal Rate of Return (IRR) (%)	INCLUDE IN RPMP
low	African feather grass	Progressive Containment	Regional	3	698776	0.19408	100	2568	1	$921,565	10.21	**YES**
high	African feather grass	Progressive Containment	Regional	3	698776	0.19408	100	3139	1.9	$2,424,400	13.37	**YES**
low	Apple of Sodom	Progressive Containment	Regional	2	357759	0.11433	125	2828	2.5	$22,245	5.69	**YES**
high	Apple of Sodom	Progressive Containment	Regional	2	357759	0.11433	125	3456	12.5	$410,377	16.6	**YES**
low	Argentine Ants	Sustained Control	Regional	44217	884336	0.05142	100	1227	1.3	$3,132,325	6.21	**MAYBE**
high	Argentine Ants	Sustained Control	Regional	44217	884336	0.05142	100	1500	3.2	$13,742,077	7.53	**MAYBE**
low	Arundo donax	Progressive Containment	Regional	3	579588	0.09579	150	747	0.8	-$102,611	0	**NO**
high	Arundo donax	Progressive Containment	Regional	3	579588	0.09579	150	913	4.1	-$77,342	0	**NO**
low	Arundo donax	Sustained Control	Regional	3	579588	0.09579	150	747	0.8	-$49,162	0	**NO**
high	Arundo donax	Sustained Control	Regional	3	579588	0.09579	150	913	4.1	-$25,245	0.42	**NO**
low	Asiatic knotweed	Progressive Containment	Regional	1	1037670	0.214	75	1877	0	-$161,664	0	**YES**

CBA type	Species	Category	Category split (ie regional or specific catchments)	Area infested (ha)	Maximum area that could become infested (ha)	Rate of spread (*r*)	Time for infestation to reach 90% of maximum (years)	Earnings (/ha)	Reduction in earnings caused by pest (%)	Net Present Value (NPV) ($)	Internal Rate of Return (IRR) (%)	INCLUDE IN RPMP
high	Asiatic knotweed	Progressive Containment	Regional	1	1037670	0.214	75	2294	0.2	$2,637	4.06	**YES**
low	Batwinged passionflower	Exclusion	Regional	1	905981	0.21219	75	1342	2.2	-$94,641	1.62	YES
high	Batwinged passionflower	Exclusion	Regional	1	905981	0.21219	75	1640	11.2	$532,868	8.52	**YES**
low	Blackberry	Sustained Control (boundary rule)	Regional	25000	1237906	0.06079	100	1787	2.5	$42,735,398	28.7537	**YES**
high	Blackberry	Sustained Control (boundary rule)	Regional	25000	1237906	0.06079	100	2185	12.5	$262,365,566	29.5944	**YES**
low	Boneseed	Progressive Containment	Regional	6	557943	0.13637	100	542	0.1	-$252,240	0	**NO**
high	Boneseed	Progressive Containment	Regional	6	557943	0.13637	100	663	0.4	-$235,765	0	**NO**
low	Canada geese	Sustained Control	Regional	11100	382971	0.06908	125	4138	2	$17,453,525	18.3	**MAYBE**
high	Canada geese	Sustained Control	Regional	11100	382971	0.06908	125	5058	8.7	$94,210,278	20.12	**MAYBE**
low	Chilean flame creeper	Exclusion	Regional	0	905981	0.21219	75	1342	2.2	-$94,642	1.6235	YES
high	Chilean flame creeper	Exclusion	Regional	0	905981	0.21219	75	1640	11.1	$526,189	8.48	**YES**
low	Chilean needle grass	Exclusion	Regional	1	385133	0.30117	50	3303	4.2	$5,709,825	14.8254	**YES**
high	Chilean needle grass	Exclusion	Regional	1	385133	0.30117	50	4037	10.1	$17,198,625	18.2983	**YES**
low	Chinese knotweed	Exclusion	Regional	1	552152	0.12335	125	535	0.2	-$107,344	0	NO
high	Chinese knotweed	Exclusion	Regional	1	552152	0.12335	125	654	0.8	-$107,086	0	NO

CBA type	Species	Category	Category split (ie regional or specific catchments)	Area infested (ha)	Maximum area that could become infested (ha)	Rate of spread (*r*)	Time for infestation to reach 90% of maximum (years)	Earnings (/ha)	Reduction in earnings caused by pest (%)	Net Present Value (NPV) ($)	Internal Rate of Return (IRR) (%)	INCLUDE IN RPMP
low	Chocolate vine	Progressive Containment	Regional	1	579526	0.12374	125	959	1.3	-$44,122	0	**NO**
high	Chocolate vine	Progressive Containment	Regional	1	579526	0.12374	125	1172	2.3	-$32,985	0	**NO**
low	Climbing spindle berry	Progressive Containment	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	19	828164	0.1288	100	1245	3.8	$716,902	11.57	**YES**
high	Climbing spindle berry	Progressive Containment	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	19	828164	0.1288	100	1522	12.5	$3,318,397	21.97	**YES**
low	Climbing spindle berry	Sustained Control	ROT	10	47748	0.10668	100	956	4.1	-$65,303	2.11	**YES**
high	Climbing spindle berry	Sustained Control	ROT	10	47748	0.10668	100	1168	12.5	$342,115	8.76	**YES**
low	Coast tea tree	Eradication	Regional	50	1029765	0.16173	75	1582	0.1	$183,911	7.21	**YES**
high	Coast tea tree	Eradication	Regional	50	1029765	0.16173	75	1933	0.2	$584,781	10.04	**YES**
low	Creeping gloxinia	Eradication	Regional	1	878545	0.15883	100	1227	1.9	$28,906	6.25	**YES**
high	Creeping gloxinia	Eradication	Regional	1	878545	0.15883	100	1500	7.5	$262,733	12.0117	**YES**
low	Creeping gloxinia	Progressive Containment	Regional	1	878545	0.15883	100	1227	1.9	$28,397	6.5918	**NO**
high	Creeping gloxinia	Progressive Containment	Regional	1	878545	0.15883	100	1500	7.5	$260,309	12.9883	**NO**
low	Darwin's barberry	Exclusion	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	1	943825	0.12764	125	1646	1.5	-$213,319	0	NO
high	Darwin's barberry	Exclusion	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	1	943825	0.12764	125	2012	4	-$209,924	0	NO
low	Darwin's barberry	Progressive Containment	ROT	2	63510	0.1005	125	2051	1.4	-$16,493	1.01	**YES**
high	Darwin's barberry	Progressive Containment	ROT	2	63510	0.1005	125	2506	3.3	$18,436	6.01	**YES**

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low	Field horsetail	Exclusion	Regional	1	393966	0.20108	75	3211	2.2	-$81,264	0	YES
high	Field horsetail	Exclusion	Regional	1	393966	0.20108	75	3924	10.3	$42,185	5.26	**YES**
low	Giant knotweed	Exclusion	Regional	1	552152	0.12335	125	535	0.2	-$107,344	0	NO
high	Giant knotweed	Exclusion	Regional	1	552152	0.12335	125	654	0.8	-$107,086	0	NO
low	Horse nettle	Eradication	Regional	1	393966	0.15081	100	3211	2.5	$104,861	6.7	**YES**
high	Horse nettle	Eradication	Regional	1	393966	0.15081	100	3924	12.5	$1,076,961	13.55	**YES**
low	Italian buckthorn	Exclusion	ROT, TAR, RAN, WHA, OHI, WAI, EAS	1	18682	0.12032	100	315	2.5	-$214,412	0	YES
high	Italian buckthorn	Exclusion	ROT, TAR, RAN, WHA, OHI, WAI, EAS	1	18682	0.12302	100	386	12.5	-$212,308	0	YES
low	Italian buckthorn	Progressive Containment	TGA, KAI	4	20385	0.10733	100	345	2.5	-$252,287	0	**YES**
high	Italian buckthorn	Progressive Containment	TGA, KAI	4	20385	0.10733	100	422	12.5	-$179,746	0	**YES**
low	Koi carp	Eradication	Regional	1	45255	0.12917	100	12830	4.1	$135,634	5.52	**YES**
high	Koi carp	Eradication	Regional	1	45255	0.12917	100	15681	9.7	$951,973	10.02	**YES**
low	Kudzu vine	Eradication	Regional	1	878545	0.15883	100	1227	2.5	$74,235	8.79	**YES**
high	Kudzu vine	Eradication	Regional	1	878545	0.10589	100	1500	12.5	$594,986	16.5	**YES**
low	Lantana	Eradication	ROT	1	50394	0.13025	100	2170	0.7	$7,305	6.64	**YES**
high	Lantana	Eradication	ROT	1	50394	0.13025	100	2718	0.2	$78,228	15.23	**YES**
low	Lantana	Progressive Containment	KAI, TAR, RAN, WHA, OHI, WAI, EAS	1	258367	0.14659	100	3013	0.5	$123,324	0	**YES**
high	Lantana	Progressive Containment	KAI, TAR, RAN, WHA, OHI, WAI, EAS	1	258367	0.14659	100	3683	2.4	$22,259	4.5	**YES**
low	Lantana	Sustained Control	TGA	1	83487	0.1325	100	3025	0.9	$1,190	4.15	**YES**

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high	Lantana	Sustained Control	TGA	1	83487	0.1325	100	3697	2.7	$90,285	9.86	**YES**
low	Lodgepole pine	Progressive Containment	Regional	7910	1216261	0.07226	100	1712	2.6	$39,041,429	>100	**YES**
high	Lodgepole pine	Progressive Containment	Regional	7910	1216261	0.07226	100	2093	7.5	$140,067,409	>100	**YES**
low	Marram grass	Progressive Containment	Regional	1	27436	0.12417	100	5016	0.2	-$43,411	0	**NO**
high	Marram grass	Progressive Containment	Regional	1	27436	0.12417	100	6130	0.7	-$17,891	2.4292	**NO**
low	Marram grass	Sustained Control	Regional	1	27436	0.12417	100	5016	0.2	-$13,695	0	**NO**
high	Marram grass	Sustained Control	Regional	1	27436	0.12417	100	6130	0.7	$11,825	6.0059	**NO**
low	Marshwort	Exclusion	Regional	1	58277	0.1317	100	7853	2.5	-$92,849	0	NO
high	Marshwort	Exclusion	Regional	1	58277	1317	100	9598	12.3	-$19,845	3.09	NO
low	Nasella tussock	Eradication	Regional	1	889868	0.21195	50	1460	1.9	$16,343,352	19.35	**YES**
high	Nasella tussock	Eradication	Regional	1	889868	0.21195	50	1785	9.7	$103,136,475	26.56	**YES**
low	Noogoora bur	Eradication	Regional	2	379342	0.1435	100	3335	2.5	$89,554	5.29	**YES**
high	Noogoora bur	Eradication	Regional	2	379342	0.1435	100	4076	12.4	$1,564,779	12.23	**YES**
low	Old man's beard	Progressive Containment	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	16	970726	0.1321	100	1502	1.2	$164,556	6.82	**YES**
high	Old man's beard	Progressive Containment	TGA, KAI, TAR, RAN, WHA, OHI, WAI, EAS	16	970726	0.1321	100	1836	6.1	$1,810,758	15.63	**YES**
low	Old man's beard	Sustained Control	ROT	68	91173	0.05833	100	1688	0.7	$75,864	6.86	**YES**
high	Old man's beard	Sustained Control	ROT	68	91173	0.05833	100	2064	3.5	$1,013,087	20.12	**YES**
low	Perch	Eradication	Regional	3	45255	0.11819	100	12830	4.1	$273,637	5.9357	**YES**

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high	Perch	Eradication	Regional	3	45255	0.11819	100	15681	9.7	$1,757,371	11.1694	**YES**
low	Purple loosestrife	Eradication	Regional	1	79922	0.10789	125	7358	1.9	$45,005	10.74	**YES**
high	Purple loosestrife	Eradication	Regional	1	79922	0.10789	125	8993	9.7	$358,347	50	**YES**
low	Rabbits	Sustained Control	Regional	70000	684152	0.03495	125	2326	1	$8,487,566	6.15	**MAYBE**
high	Rabbits	Sustained Control	Regional	70000	684152	0.03495	125	3206	2.4	$59,117,890	12.76	**MAYBE**
low	Ragwort	Sustained Control (boundary rule)	Regional	120	351968	0.08145	125	2854	2.5	$1,222,370	>100	**YES**
high	Ragwort	Sustained Control (boundary rule)	Regional	120	351968	0.06787	125	3488	12.5	$7,524,460	>100	**YES**
low	Rainbow lorikeets	Eradication	Regional	1	1216261	0.32417	50	1712	1.2	$29,376,495	23.999	**MAYBE**
high	Rainbow lorikeets	Eradication	Regional	1	1216261	0.32417	50	2093	3.7	$111,032,734	29.6875	**MAYBE**
low	Rooks	Eradication	Regional	1	1216261	0.21611	75	1712	1.4	$538,578	8.53	**YES**
high	Rooks	Eradication	Regional	1	1216261	0.21611	75	2093	6.3	$3,929,976	14.51	**YES**
low	Rough horsetail	Eradication	Regional	1	34667		125	214	2.5	-$24,151	0	NO
high	Rough horsetail	Eradication	Regional	1	34667		125	261	12.5	-$15,062	0	NO
low	Royal Fern	Progressive Containment	ROT, TAR, RAN, WHA, OHI, WAI, EAS	10	744357	0.13415	100	1539	1.6	-$1,551	3.9612	**NO**
high	Royal Fern	Progressive Containment	ROT, TAR, RAN, WHA, OHI, WAI, EAS	10	744357	0.13415	100	1881	8	$785,221	11.4868	**NO**
low	Royal Fern	Sustained Control	TGA, KAI	42	92774	0.09897	100	1146	1	$60,989	8.4473	**NO**

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high	Royal Fern	Sustained Control	TGA, KAI	42	92774	0.09897	100	1401	4.6	$541,624	19.5313	**NO**
low	Rudd	Eradication	Regional	1	45255	0.12917	100	12830	4.1	-$106,004	2.9831	NO
high	Rudd	Eradication	Regional	1	45255	0.12917	100	15681	9.7	$659,610	7.55	**NO**
low	Rudd	Progressive Containment	Regional	1	45255	0.12917	100	12830	4.1	$366,547	4.1	**YES**
high	Rudd	Progressive Containment	Regional	1	45255	0.12917	100	15681	9.7	$1,263,009	13.8428	**YES**
low	Sagittaria	Eradication	Regional	1	58277	0.1317	100	7853	2.5	$174,078	10.376	**YES**
high	Sagittaria	Eradication	Regional	1	58277	0.1317	100	9598	12.5	$1,257,063	23.4375	**YES**
low	Senegal tea	Eradication	Regional	1	58277	0.1317	100	7853	2.5	$182,189	11.7188	**YES**
high	Senegal tea	Eradication	Regional	1	58277	0.1317	100	9598	12.5	$1,265,174	30.4688	**YES**
low	Spartina	Eradication	Regional	5	27436	0.10807	100	5016	2.5	$69,786	5.19	**YES**
high	Spartina	Eradication	Regional	5	27436	0.10807	100	6130	12.5	$1,428,658	14.53	**YES**
low	Spiny emex	Eradication	Regional	1	399757	0.12077	125	3183	2.5	-$85,470	0.6	NO
high	Spiny emex	Eradication	Regional	1	399757	0.12077	125	3890	12.5	$200,096	7.29	**NO**
low	Spiny emex	Progressive Containment	Regional	1	399757	0.12077	125	3183	2.5	-$43,696	1.65	**YES**
high	Spiny emex	Progressive Containment	Regional	1	399757	0.12077	125	3890	12.5	$241,382	8.98	**YES**
low	Stout bamboo grass	Eradication	Regional	1	56312	0.10509	125	2447	0.1	-$15,204	0	YES
high	Stout bamboo grass	Eradication	Regional	1	56312	0.10509	125	2990	0.7	-$7,938	0.88	YES
low	Sydney golden wattle	Progressive Containment	Regional	5	1029762	0.19243	75	925	0.1	-$104,475	0.8698	**NO**
high	Sydney golden wattle	Progressive Containment	Regional	5	1029762	0.19243	75	1131	0.2	-$17,665	0.3656	**NO**
low	Sydney golden wattle	Sustained Control	Regional	5	1029762	0.19243	75	925	0.1	-$61,306	1.19	**YES**

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high	Sydney golden wattle	Sustained Control	Regional	5	1029762	0.19243	75	1131	0.2	$25,389	4.7	**YES**
low	Tench	Eradication	Regional	1	45255	0.12917	100	12830	4.1	-$106,004	2.9831	NO
high	Tench	Eradication	Regional	1	45255	0.12917	100	15681	9.7	$659,610	7.55	**NO**
low	Tench	Progressive Containment	Regional	1	45255	0.12917	100	12830	4.1	$366,547	9.3018	**YES**
high	Tench	Progressive Containment	Regional	1	45255	0.12917	100	15681	9.7	$1,263,909	13.8428	**YES**
low	Variegated thistle	Progressive Containment	Regional	1	357759	0.1998	75	2828	1.2	$566,072	11.1206	**YES**
high	Variegated thistle	Progressive Containment	Regional	1	357759	0.1998	75	3456	2.2	$1,368,322	13.9893	**YES**
low	Velvetleaf	Eradication	Regional	1	692985	0.20861	75	2579	1.4	$881,366	9.9	**MAYBE**
high	Velvetleaf	Eradication	Regional	1	692985	0.20861	75	3152	7.1	$6,207,929	15.95	**MAYBE**
low	Wasps	Sustained Control	Regional	122000	1216261	0.06789	100	1712	1.6	-$2,099,330	3.5	**NO**
high	Wasps	Sustained Control	Regional	122000	1216261	0.06789	100	2093	5	$50,071,787	9.8	**NO**
low	Water poppy	Exclusion	Regional	1	23610	0.12267	100	19070	2.5	-$78,248	0	YES
high	Water poppy	Exclusion	Regional	1	23610	0.12267	100	23308	12.5	$70,810	6.19	**YES**
low	White edged nightshade	Eradication	Regional	1	393966		125	3211	2.5	$38,540	8.5938	**YES**
high	White edged nightshade	Eradication	Regional	1	393966		125	3924	12.5	$325,284	19.92	**YES**
low	Wilding conifers (excluding Lodgepole pine)	Sustained Control	Regional	1250	1216261	0.09077	100	1712	1.2	$3,412,609	8.4106	**YES**
high	Wilding conifers (excluding Lodgepole pine)	Sustained Control	Regional	1250	1216261	0.09077	100	2093	5.8	$28,645,473	19.7555	**YES**
low	Yellow flag iris	Progressive Containment	Regional	1	79922	0.13486	100	7358	2	$93,529	6.5796	**YES**

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high	Yellow flag iris	Progressive Containment	Regional	1	79922	0.13486	100	8993	9.7	$967,581	13.6963	**YES**

Appendix 4:

Methods and inputs for AgResearch Cost Benefit Assessment

1 Method for cost-benefit assessment - inputs

This section outlines the CBA approach and describes the methods and sources used to generate inputs for the AgResearch tool: Cost Benefit Analysis for Regional Pest Management (CBA). The CBA tool was designed for regional councils, and is available on the AgResearch Limited website (link). A user guide is provided with the CBA tool (link) and should be read in conjunction with the following information.

Determining which pests to manage and by which management method was a two-step process. In the first step a quantitative cost-benefit analysis was carried out. In the second step the quantitative results were assessed for reasonableness. This step was necessary because a CBA utilises a limited range of numerical inputs. While an understanding the quantifiable benefits and costs is essential, the results should be considered alongside the knowledge of a biosecurity expert.

Table 1 summarises the inputs and source of information for the CBA. Many of the inputs are based on expert information provided by staff in the Biosecurity Team. For other inputs Council has used Bay of Plenty information where possible (e.g. estimating GRP) and New Zealand publications (e.g. Patterson and Cole, 2013).

Table 1 Inputs and sources for the AgResearch CBA tool

Input	Source	Notes
Management programme.	Biosecurity Team.	Tested at least two approaches, one of which was 'do nothing'.
Number of years for CBA	Wildlands (2018).	10 years and 50 years.
Initial area infested (hectares and proportion of maximum density).	Biosecurity team	Maximum density is based on habitat preference, which can be suitable or marginal. This is similar to the approach by Wildlands (2018).
Area that could become infested (hectares).	Biosecurity Team.	
Time for infestation to reach 90% of maximum.	Biosecurity Team.	
Benefits per hectare expressed in dollars (worded in the model as 'earnings').	See section on estimating benefits; also Wildlands (2018).	The benefits calculation is based on ecosystem service values, including production services. These figures were also used in Wildlands (2018) for the Bay of Plenty region.

Input	Source	Notes
Reduction in benefits caused by the pest expressed as a percentage (worded in the model as 'reduction in earnings').	Biosecurity Team.	The reduction in benefits was expressed as a percentage of benefits, and is dependent on habitat preference, which relates to suitability of habitat; and the impact on benefits.
Discount rate.	Wildlands (2018).	4%. Lower discount rates give greater weight to future benefits than higher rates. See Wildlands (2018) for more discussion on this.
Probability of success of programme.	Biosecurity Team.	
Annual costs of programme.	Biosecurity Team.	Cost differed between pest management programmes.

Quantifying benefits and reductions in benefits

A spreadsheet was set up to generate average per hectare benefits based on the ecosystem services benefits described below. The spreadsheet also enabled calculation of reductions in benefits based on the density of the pest in the environment and the level of damage expected from a pest infestation.

The density of the pest was determined by preference for the habitat, which was defined as marginal – where the pest would occupy 1-4% of the habitat, and suitable – where the pest would occupy 5-25% of the habitat. These areas were defaults in the model, and could be altered by the user if unsuitable for a particular pest.

The level of damage by a pest was defined as low – where the level of damage was 1-4% of the benefits, moderate – 5-9%, and high – 10 - 20%. These defaults could be adjusted by the user.

Reviewing CBA results for reasonableness

Following the CBA modelling the Biosecurity Team staff checked the results for reasonableness. Some of the reasons that results could be not fit for purpose include:

- The ecosystem service values (benefits) estimated by Patterson and Cole (year) provide a general valuation, but the values are not specific to the Bay of Plenty region, and in some cases are from international studies. This suggests that as well as looking at the CBA results, the user should also consider the pest in the context of the district and region in which the pest occurs. These include:
    - Pest impacts on local recreation values.
    - Location-specific tourism impacts.
    - The industry sector impacted and its importance to the district, region or nation. This might include the future prospects of an industry sector such as future growth of aquaculture in the eastern part of the region.
- Other things to consider include:
    - Urban ecosystem service values – these have not been estimated so are not quantified in the CBA. The impact of pests on urban areas should be considered if applicable. Measures could include the number of people affected, or the size of area infested, along with the impact of the pest.
    - Whether the default percentages for density (based on marginal or suitable habitat) are suitable for the pest.
    - Whether the default percentages for low, moderate and high impacts are suitable for the pest.

- Whether the discount rate used in the CBA is appropriate given the expected impact of the pest on the future generations. Applying discount rates gives greater weight to benefits and costs in the near future, and less to those further out. For pest management this means that the current costs will have greater weight than the future benefits.

1.1 Estimating benefits

Pest management planning requires councils to assess the costs of different levels of pest management against the benefits of that pest management, for each pest. In preparing Pest Management Plans, some regional councils have taken an ecosystem services approach to estimating the benefits of pest management (e.g. Auckland and Taranaki councils). This type of approach recognises the range of benefits provided by the natural environment, rather than solely focusing on production values. The ecosystem services approach has been used by the Bay of Plenty Regional Council, and is described here.

The Millennium Ecosystem Assessment (MEA) defines an ecosystem as:[4]

…a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit.

The MEA framework sets our four distinct levels of ecosystem services:

- Provisioning services are the products obtained from ecosystems, such as food, freshwater, wood and fuel
- Regulating services are the benefits obtained from the regulation of ecosystem processes, such as climate regulation and water purification
- Cultural services are the nonmaterial benefits people obtain from ecosystems such as spiritual, recreational and educational
- Supporting services are necessary for the production of all other ecosystem services, such as nutrient cycling and soil formation.

In pest management decisions, the MEA framework assists in identifying a wider range of pest impacts than has traditionally been considered. These can be quantified (albeit with the appropriate cautions) using New Zealand ecosystem service valuations by Patterson and Cole.[5] The Bay of Plenty Regional Council has used a similar ecosystem services framework for identifying and estimating benefits of pest management. This report summarises:

1 Provisioning ecosystem services

2 Supporting and regulating ecosystem services

3 Urban ecosystems

4 Passive values

1.1.1 Provisioning ecosystem services

The provisioning ecosystem services output was estimated at the industry sector level. Table 2 sets out the value-added contribution of sectors in the Bay of Plenty region and the land area occupied by those sectors.[6] Value-added is similar to GDP and enables a view of the contribution of sectors to the wider economy. Using the figures in Table 2 as a base, the costs of not acting (do nothing) can be estimated.

[4] Millennium Ecosystem Assessment (2005).
[5] Patterson and Cole (1999; 2013).
[6] Land use, output and value added estimates are BOP specific. Land use figures sourced from Statistics New Zealand (Agricultural Production Census 2012). Multipliers for industry sectors were supplied by Butcher Partners Limited, and are based industry sector structures as at 2012-13. Output and value added have been adjusted to 2016 dollars using the NZ GDP Implicit price deflator (Statistics New Zealand).

Table 2 Estimated value-added in selected land uses in the Bay of Plenty region (productive values)

	Estimated area	Output 2012 $000	Direct value added impact $000	Total value added (direct, indirect and induced) $000	Value added per ha/yr ^{2012}$	Value added per ha/yr ^{2016}$
Dairy farming	119,248	826,086	396,521	685,651	5,750	6,070
Drystock	136,402	143,344	57,338	106,075	778	821
Horticulture	33,226	453,952	172,502	381,320	10,020	10,578
Forestry	260,398	642,187	224,765	558,703	1,839	1,941
*Aqua-culture	806	4,836	2,176	2,960		3,672

*Aquaculture estimated in ^{2016}$. These figures are for full production for the 800 hectares, although production is currently well below this as the mussel lines develop. The values assume that the revenue and cost structure for oyster production is similar to mussel production, and that the multipliers used in other NZ studies are appropriate for this estimate. Given the relatively small area of the oyster farming, changes either way are unlikely to make a significant difference to these estimates.

A key assumption is that total value added can be divided by the number of hectares to provide an estimate of per hectare value-added. This is probably a reasonable assumption for marginal changes as would occur with most pest incursions. If losses of productive land became greater as a result of a major pest infestation, the structure of sectors might change in response, making estimates invalid.

Aquaculture

Aquaculture is seen as a potential area of growth for the Bay of Plenty.[7] At the time of writing, 800 hectares are in mussels, and six hectares in oysters. Shellfish farming in Ōpōtiki is relatively low density compared with other areas in New Zealand, with one longline per 3.85 hectares of water space. The typical industry spacing can be 2-3 longlines per hectare.

Table 3 Aquaculture: Estimated area, production and revenue.

	Mussels (Ōpōtiki)[8]	**Oysters**
Tonnes per hectare per year when fully developed	8.2T/ha [based on 31.5 T/longline]	5.25-7.66T/ha
Average revenue per hectare	$6000/ha	-
Hectares – current	800	6

Source: Ministry of Primary Industries.

Resource consents are held for 3,800 hectares for mussels and other shellfish. When fully developed the Ōpōtiki farm is expected to produce around 14,000 tonnes of mussels per year.

Tourism

Tourism is an important part of the Bay of Plenty economy, adding about $667m to the region's economy in 2014, and employing about 12,000 people. The Rotorua-Taupō area tends to be the focus of international tourists, while that area and the Western Bay of Plenty are attract relatively similar (and high) spending by domestic tourists. For the purposes of GDP, the tourism sector is made up parts of many sectors including accommodation and retail, and does not readily add up to a concise number in the way that other sectors in Table 1.

[7] Toi Moana Bay of Plenty Growth Study.
[8]

Recreation and tourism are important contributors to the Bay of Plenty region, and particularly the Rotorua district, and the sector benefits probably deserves additional attention when considering the CBA – such as whether the value to the region or district is adequately represented by the ecosystem services figures.

Pests that may be important in to tourism and recreation include:

- Weeds in Lake Rotorua
- Wasps in the native bush areas or in parks

Limitations

- The figures in Table 2 include backward linkages in value added, but do not include forward linkages, such as the processing and manufacturing of produced goods. In this way the costs of losses in production due to pests may be understated. For regions, the level of understatement would depend on how much processing was done within the region versus outside the region.
- The value of inputs and outputs in the economy is shown in Table 2 at a point in time. Although the figures have been adjusted for inflation, they are not necessarily the same as in any other year.

Supporting and regulating ecosystem services

Patterson and Cole (2013) provide per hectare values for supporting, regulating, provisioning and cultural per hectare values for a single year. The provisioning values are split into those covered by GDP and those not. Table 2 (above) provides the per hectare values for GDP for the Bay of Plenty region. It is assumed that the remainder of the values are suitable for the Bay of Plenty region.

Native and plantation forest

Patterson and Cole (2013) present the ecosystem service values for native and plantation forests as a single 'forest'. The Auckland Council approach is to ascribe the same ecosystem service values for each, with additional provisioning values for plantation forest (Basset, 2016). That approach is considered to generate a conservative value for native forests as many non-provisioning ecosystem services are likely to be of a higher quality than plantation forests which are typically mono-cultural and regularly harvested. Where native bush is also a national park or similar, passive values (Table 4) also apply.

Marine ecosystems

Recent research by van den Belt and Cole (2014) assessed the economic value marine ecosystems using benefit transfer. The biomes within the marine ecosystem were open sea, continental shelf, estuary/lagoon/intertidal, salt marshes/wetland, seagrass/algae beds, reefs, mangroves and sand, beach and sand dunes. The total range of values for this diverse ecosystem was ^{2010}$91,836-$348,338 (including supporting services). This included:

- Mangroves: A per hectare/year value for mangroves of ^{2010}$26,964-$44,494 (exclusive of supporting values). The majority of the mangrove value is from regulating services.
- Estuaries: A per hectare/year value for estuaries was ^{2010}$1,943-$5,498. In 2016 dollars this is $2,172-$6,147, mean = $4,160. It is similar and slightly less than the estuaries figure in the Patterson and Cole report. The estuaries figure in Table 4 is sourced from Patterson and Cole (2013).
- Beaches and dunes: van den Belt and Cole (2014) provided no per hectare/year values for sand, beach and dunes. The Auckland Council CBA for pest management, in view of the scarcity of valuations for this type of coastal ecosystem, used the recreation value component for lakes and wetlands from Patterson and Cole (2013). That value is ^{2016}$1,386 per hectare/year. In the absence of a better proxy, this figure is used in Table 3.

- Marine: Marine ecosystem services were assessed by Auckland Council CBA as the ocean. Based on this, Wildlands previously used a value of [2010]$1-$170 (for Auckland Council and Taranaki Regional Council CBAs). This figure is about $1-$179 in 2016 values, and does not include the value of aquaculture. We have used the mid-point of this value of $90, plus the figure for the current area of aquaculture in the Bay of Plenty in full production.

Urban ecosystem services

The Auckland Council pest CBA valued of urban ecosystems by identifying the types of land use, for example hectares in parks and reserves, residential housing (by type) and town centres and setting out values for each based on existing literature (Wilson, 2016). In this way, the value of reserves and public space is set at a minimum of $1,982 (Patterson and Cole, 2013) to a maximum of $9,340 (Brander and Koetse, 2011). The value attributed to the ecosystem value for residential land is from $500/ha (Wildlands) to $5,000/ha based on an arbitrary 1% of the value of the land plus the cost of lawn mowing.[9]

If BOPRC has an inventory of the urban land in the region then a similar approach could be used. In the absence of reliable information, urban ecosystem values have not been included.

Passive values

Passive values, also known as non-use values, include the value that people hold for the existence of an ecosystem (for example, we might be willing to contribute financially to ensure that Little Barrier Island remains a sanctuary for the tuatara, although we may not ever visit the island). Other passive values are bequest values, such as preserving an ecosystem for future generations, and option values, which is preserving it to ensure we can make use of it at a future time.

Summary of ecosystem service benefits

Table 4provides the final ecosystem service benefits. In the CBA the total benefits per hectare were input as a range of plus and minus 10% on the point estimate. This was also the approach used by Wildlands (2018).

Table 4 Estimated per hectare ecosystem services benefits (2016).

Ecosystem type	Regulating values	Cultural values	Provisioning value (other)	Provisioning value (Table 2)	Passive values	Total benefits per ha [2016]$
Horticulture	11		7	10,578	-	10,596
Agriculture- dairy	333	11	8	6,070	-	6,422
Agriculture - drystock	333	11	8	821	-	1,173
Forest -plantation	510	108	-	1,941	-	2559
Forest – native	510	108	-	-	-	618
Estuaries	3,304	1,161	-	-	2,228	6,693
Lakes	1,889	653	15,573	-	3,074	21,189
Rivers	1,889	655	15,577	-	6,706	24,827
Coastal*	-	-	1,386	-	-	1,386
Marine*	90			3,672		3,762

*The marine ecosystems value is from the van den Belt and Cole (2014) report, with regional figures for aquaculture production. The coastal value is a proxy based on recreational value of lakes and wetlands. All other values are from Patterson and Cole (2013) or from BOPRC production information (provided in Table 2).

[9] The cost of lawn mowing is an indicator of the value people have for lawn area.

In addition to the above, Patterson and Cole (2013) estimate ecosystem service values for scrub, wetlands, mangrove and marine areas, and passive values for national parks ($2455 per hectare) and forest parks ($326 per hectare).[10]

Acknowledgements

Thank you to staff the Auckland Council for sharing ideas, reports and figures, and encouraging discussion between councils on an ecosystem services approach to pest management decision making.

[10] Patterson and Cole provide a total ecosystem value for land reserves of $1,218m. Land reserves are not defined and so it is not possible to convert this into a per hectare value.

Appendix 5:

Risk analysis

Programme	Objectives	Options considered to achieve the objective (One in bold is proposed programme)	Risk that option will not achieve objectives with consideration of: – **Technical and operational risks of the option.** – **Implementation and compliance risks.** – **Compliance with other legislation adversely affecting implementation.** – **Public or political concerns which may adversely affect implementation.** – **Any other material risk**	Programme mitigation	Likelihood	Impact	Residual risk score	Residual risk[11]
Exclusion	Over the duration of the Plan, prevent the establishment of exclusion pests in the Bay of Plenty region to avoid adverse effects on production, environmental and public values.	No regional management	If there is no surveillance for new pests and people are not aware of them or the risk they pose, by the time their presence is impacting values it might be too late.	None	4	5	20	High
		Include in the RPMP as exclusion pests	Pests may still enter the region, but no or limited tools to manage them mean the pest manages to establish	Effective surveillance will mean early detection which will allow the widest range of tools to be used to control	2	5	10	Medium
			Public might not fully understand enough about these pests and therefore not notify Council or take appropriate action.	Education and awareness programmes will increase general public awareness of what to look for and what action to take.				

11 Note: Benefits that may be impacted are provided in depth in the Cost Benefit Assessments.

Programme	Objectives	Options considered to achieve the objective (One in bold is proposed programme)	Risk that option will not achieve objectives with consideration of: – Technical and operational risks of the option. – Implementation and compliance risks. – Compliance with other legislation adversely affecting implementation. – Public or political concerns which may adversely affect implementation. – Any other material risk	Programme mitigation	Likelihood	Impact	Residual risk score	Residual risk[11]
Eradication	Over the duration of this Plan, eradicate pests in the Bay of Plenty region and eliminate adverse effects they have on production, environmental and public values.	No regional management	These pests are difficult to identify and the low levels of infestations may result in many pests not being removed in a timely manner.	None	4	5	20	High
			Public may not be able to identify pest or know appropriate control methods allowing new populations to establish and/or increase.					
		Include in RPMP as eradication pests	Council might not fully be aware of extent of some pests and therefore eradication might not be achievable.	Implement surveillance into all risk areas	2	5	10	Medium
			Surveillance and control programmes may not be effective.	Connect with science providers and other councils to ensure best practice is implemented				
Progressive containment	Over the duration of this Plan, reduce impacts to production, environmental and public values by containing and, where practicable, reducing the geographic distribution of these pests in the Bay of Plenty region.	No regional management	Pest that have established in the Bay of Plenty will extend their distribute resulting in increasing level of impact on the regions environment, economy and culture	None	5	4	20	High
		Include as Progressive containment pests	Landowners do not comply with RPMP because they do not know they are required to take action or they do not know how to manage pest	Provide advisory service while undertaking monitoring activities	2	4	8	Low
			Landowners refuse to comply with RPMP	Carry out enforcement action				

Programme	Objectives	Options considered to achieve the objective (One in bold is proposed programme)	Risk that option will not achieve objectives with consideration of: – **Technical and operational risks of the option.** – **Implementation and compliance risks.** – **Compliance with other legislation adversely affecting implementation.** – **Public or political concerns which may adversely affect implementation.** – **Any other material risk**	Programme mitigation	Likelihood	Impact	Residual risk score	Residual risk[11]
Sustained control	Over the duration of the RPMP, reduce impacts to production, environmental and public values by controlling sustained control pests in the Bay of Plenty and preventing unreasonable impacts from these pests spreading across property boundaries whereby neighbouring occupiers are actively managing the pest.	No regional management	Impacts of well-established pests increase and the actions of landowners undertaking control work are compromised by the inaction of their neighbours	None	4	3	12	Medium
		Include as sustained control pests	Landowners do not manage pests along their boundaries to minimise impact on neighbours	Carry out enforcement action	1	3	3	Low

Appendix 6:

Cost Benefit Assessment undertaken by Wildlands (including assumptions and methodology)

COST-BENEFIT ANALYSES FOR THE PROPOSED BAY OF PLENTY REGIONAL PEST MANAGEMENT PLAN

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R4299

COST-BENEFIT ANALYSES FOR THE PROPOSED BAY OF PLENTY REGIONAL PEST MANAGEMENT PLAN

Contract Report No. 4299

August 2018

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1. INTRODUCTION

Background

Under Sections 70 and 71 of the *New Zealand Biosecurity Act (1993)*, a regional council is required to be cognisant of, and evaluate and document the benefits, costs, funding arrangements and adverse effects associated with the management of pests prior to the notification of a proposed Regional Pest Management Plan (RPMP) (see Appendix 1). Amendments to the Biosecurity Act in 2012 reformed the law relating to the exclusion, eradication, and effective management of pests and unwanted organisms, including:

- New policy instruments such as the *National Policy Direction for Pest Management* (NPD, finalised in August 2015) and pathway management plans;
- 'Good Neighbour Rules' and a requirement that the Crown comply with such rules in a regional management plan;
- Changes to the development and review process for pest management plans.

The NPD contains directions on programme objectives and terminology and specifies the requirements for analysing costs and benefits (Appendix 2).

Scope

This report assesses the impacts of pest plants and animals being considered for inclusion in a proposed RPMP for Bay of Plenty, and provides a quantitative assessment of the detrimental effects and any known beneficial effects of each pest, and a cost-benefit analysis (CBA) comparing "no regional management" to one or more proposed regional pest management programmes. The results of these assessments provide an indication of whether the benefits of the proposed regional investment in managing a pest are likely to be greater than the costs and whether the inclusion of the pest in the RPMP is justified. This assessment is required to satisfy parts of Sections 70 and 71 of the Biosecurity Act. It also satisfies the requirements of Section 6(1) of the NPD (by undertaking the cost-benefit analyses at an appropriate level in relation to the level and quality of data available and the cost of the proposed programme) and parts 2(a)-(f) (see Appendix 2). In the CBA, estimates are made of the expected 'best-case' and 'worst-case' outcomes of each proposed pest management programme (i.e. the effectiveness of the programme in reducing the pest's impacts on the region) - these estimates take into account the risk that each proposed option will not achieve its objective (as per part 2(g) of the NPD).

Management Options

A number of different management options are potentially available for managing pest plants and animals in the Region:

- Exclusion.
- Eradication.
- Sustained control.
- Progressive containment.
- Site-led.

2. METHODS

2.1 Overview of cost-benefit analyses

Cost-benefit analyses (CBAs) are an economic tool to estimate all relevant costs and benefits in the same currency, usually in current dollars (termed the net present value, or NPV). In this report, the cost-benefit analysis ascertains whether the benefit of each proposed pest management programme outweighs the cost.

The cost-benefit analyses are, with some modifications, based upon similar CBA exercises undertaken by other regional councils. The CBAs undertaken in this report allow for the inclusion of a range of ecological values where a precise numerical value is unknown (e.g. potential rate of pest spread) and for the inclusion of non-production costs (Appendix 3).

The CBA provides a monetary assessment of the benefits and costs, based upon:

- The extent of the pest infestation.
- Its preferred (and less preferred) habitats.
- Values (benefits) received from the land that the pest is having impacts on.
- Cost of control.

This report provides a monetary estimate of all relevant programme costs and benefits in the same currency: all future costs and benefits are 'discounted' by the amount a dollar could earn if invested now rather than spent. This is the foundation of the CBA approach: current investment made to avoid future pest impacts is considered uneconomical if the same money invested now would be worth more than the impact cost when those impacts occur.

A discount rate of 8% was used in previous cost-benefit analyses for RPMS reviews (e.g. Severinsen 2003, Auckland Regional Council 2006, Sullivan and Hutchison 2010), however we have used a 4% discount rate for the CBAs in this report, as recommended by Auckland Council, following their review of discount rates for RPMPs (Imogen Bassett, Auckland Council, pers. comm.). With an annual compounding interest rate of 8%, $1 invested today will have grown to $46.90 in 50 years. For this reason, for it to be economically sensible to spend $10,000 today on pest control to prevent impacts in 50 years' time, those impacts would need to be worth at least $469,000. By comparison, using a discount rate of 4% (compounded annually), $1 today equals $7.11 in 50 years, so the decision to invest would depend on the pest impacts being at least $71,067. A lower discount rate gives greater weight to future costs and benefits than a higher discount rate.

Cost-benefit analysis results can give the illusion of being precise, and providing robust estimates of future costs and benefits. However, there are significant data limitations in terms of how much we know about the impacts and spread of pests and the costs of their control over future decades. Because of this, there is an unknown but undoubtedly large amount of uncertainty around any CBA estimates applied to pest management.

Cost-benefit estimates are monetarised. There are, however, non-monetarised values that are relevant, such as pest impacts on biodiversity, amenity and other environmental, social

and cultural values. Accordingly, for environmental pests, the monetarised net benefit of regional intervention (or otherwise) is likely to be an underestimate.

For each pest species, we assessed its impacts in the Region and undertook a cost-benefit analysis, comparing no coordinated regional management with one or more options under the proposed Bay of Plenty RPMP, i.e. Exclusion, Eradication, Progressive Containment, Sustained Control, or Site-led. We used data from Council staff and published information to summarise the known impacts of pest plants and animals on production values as well as environmental, social, and cultural values.

We used a modified version of the 'Harris Model' for the CBAs (see Appendix 3 for more information on the methods used and assumptions of the model)[1]. Our modifications to the Harris Model are designed to make it more flexible and less precise in its data requirements, and more capable of incorporating the diverse range of pest impacts in the Bay of Plenty Region, while retaining its robust economic foundations.

2.2 General assumptions for cost-benefit analyses

Cost-benefit analyses for pest control programmes require the adoption of a number of assumptions. These assumptions, which were generally applied to all of the proposed pest management programmes, are described below:

- When dealing with newly-established and or expanding pest populations, early action is by far the most cost-effective approach, even when there is inadequate knowledge of impacts (Harris and Timmins 2009).

- The impacts of pests (economic and environmental costs) scale linearly with the area of infestation e.g. twice as much area of weeds means twice as much impact on the region.

- Costs and obligations to undertake pest control through the RPMP will only be imposed on landowners and the community in circumstances where effective control is dependent upon the Council utilising the regulatory powers [Part 6] of the Act.

2.3 Management of pests in 'defined areas'

Some proposed pest management programmes only apply to a subset of the Region. Depending on the pest, this means they will only be controlled in particular defined areas, or they will be controlled everywhere except for particular areas. For example, one of the proposed programmes assessed for feral goats (*Capra hircus*) was Progressive Containment in an area west of the Motu River. For such programmes, the cost-benefit calculations are restricted to the current and potential extent of the pest within the defined area (i.e. costs and benefits outside this area were not considered).

2.4 CBA duration

Ten years is the standard CBA duration for a Regional Pest Management Plan. We have also included a 50 year assessment because pests typically take many decades to reach

[1] Developed in 2000 by economist Simon Harris for RPMS reviews.

their full extent in a region, therefore pests at early stages of their invasion will incur most of their impacts well beyond the standard 10-year assessment duration.

2.5 Pest attributes and distribution

A brief description of the biological characteristics of each pest species is provided, followed by a table identifying the land use/habitat types that the pest currently occupies in the Region (or defined area) and those it could potentially invade if allowed to spread.

2.5.1 Relevant biology

The form, preferred habitats, competitive ability, reproductive ability, resistance to control, and dispersal methods (plants only) of each pest were determined from the literature. Information on the current regional distribution of each pest was provided by Bay of Plenty Regional Council.

2.5.2 Land use/habitat types

Bay of Plenty Region was categorised into 11 different land use/habitat types for the cost-benefit analyses (Table 1).

Table 1: Land use/habitat types used in the cost-benefit analyses. 'Production' land use/habitat types are highlighted in orange, 'non-production' types are highlighted in green.

Land Use/Habitat Type	Description
Dairy	Dairy farms
SheepBeefDeer	Sheep, beef, deer, and goat farms
Horticulture	Arable cropping and orchards
Forestry	Timber producing plantations and woodlots
Aquaculture	Marine aquaculture
Urban	Cities, towns, industrial land
Native terrestrial	Native forest, shrubland, wetland vegetation, grassland
Coastal land	Beaches, sand dunes, coastal cliffs (land within *c.*50 m of coastline)
Estuarine	Harbours and estuaries (saltwater)
Freshwater	Waterways, lakes, and ponds
Marine	The ocean (within Bay of Plenty Region)

The total area of each land use/habitat type in the Region (or defined area) was calculated by Bay of Plenty Regional Council. The New Zealand Land Cover Database Version 4.1 (LCDB4, Ministry for the Environment 2015) was used to estimate the area of each of the nine terrestrial land use types by assigning the relevant LCDB land cover classes to the different CBA land use types (Table 2)[1].

The total area of coastal land was estimated from the area of Sand and Gravel in LCDB4, however this is likely to be an underestimate, as we defined the coastal land use type as land within 50 metres of the coastline, including coastal cliffs. The total area of freshwater in the Region is likely to be an underestimate, as small waterways (less than 20 metres wide) and lakes (less than one hectare) were not identified in LCDB4 (due to the resolution of the satellite imagery).

[1] Several of the LCDB4 classes were not assigned to our CBA land use types because they did not correspond clearly to one land use type (i.e. Gorse and/or Broom, Gravel and Rock, Landslide, Major Shelterbelts, Mixed Exotic Shrubland, Surface Mines and Dumps). These classes cover a relatively small proportion of the Region (*c.*1%).

Table 2: Total area of each CBA land use/habitat type in Bay of Plenty Region[1] and the land cover classes (from the New Zealand Land Cover Database Version 4.1, LCDB4) assigned to the nine terrestrial land use/habitat types. 'Production' land use types are highlighted in orange, 'non-production' types are highlighted in green.

Land Use/ Habitat Type	Area in Bay of Plenty Region (ha)	Land Cover Class (from LCDB4)
Dairy	159,125	High Producing Exotic Grassland
SheepBeefDeer	172,800	Low Producing Grassland
Horticulture	27,374	Orchard Vineyard and Other Perennial Crops Short-rotation Cropland
Forestry	299,019	Deciduous Hardwoods Exotic Forest Forest - Harvested
Aquaculture	806	*
Urban	14,624	Built-up Area (settlement) Urban Parkland/Open Space
Native terrestrial	517,485	Alpine Grass/Herbfield Broadleaved Indigenous Hardwoods Depleted grassland Fernland Flaxland Indigenous Forest Manuka and/or Kanuka Matagouri or Grey Scrub Tall Tussock Grassland
Coastal land	5,791	Sand and Gravel
Estuarine	21,645	Estuarine Open Water Herbaceous Saline Vegetation Mangrove
Freshwater	23,610	Herbaceous Freshwater Vegetation Lake and Pond River
Marine	934,668	*

* Area estimated using Bay of Plenty Regional Council data.

2.5.3 Current and potential land use types occupied by each pest

Current Land Use Types Occupied

Land use/habitat types currently occupied by each pest were identified and each land use type in the Region (or defined area) was categorised as:

- Primary habitat for the pest (most infested currently), or
- Secondary habitat for the pest (less infested currently), or
- Not currently occupied by the pest (N.B. some land use types may be potentially suitable for the pest but have not yet been invaded).

Land use types currently occupied by each pest were determined by Bay of Plenty Regional Council.

[1] The model assumes that the area of each land use/habitat type in the region (or defined area) does not change over the duration of the CBA (i.e. the next 10-50 years).

Potential Land Use Types Occupied

Land use types potentially occupied by each pest were identified and categorised as:

- Primary habitat for the pest (most suitable/preferred), or
- Secondary habitat for the pest (less suitable/preferred), or
- Unsuitable for the pest.

Land use/habitat types potentially occupied by each pest were determined by Bay of Plenty Regional Council and reviewed by Wildland Consultants, based on information in the literature and expert opinion. If a land use type is categorised as a current primary habitat for a pest, then it is categorised as primary habitat for the pest in future.

An example for alligator weed (*Alternanthera philoxeroides*) in the Bay of Plenty Region is provided in Table 3.

Table 3: Current and potential land use types occupied by alligator weed in the Bay of Plenty Region. High = land use is a primary habitat for the pest (i.e. most infested/ preferred), Low = land use is a secondary habitat for the pest (i.e. less infested/ preferred), - = the pest is not currently present in that land use/habitat or the land use/habitat is unsuitable for the pest.

Land Use/Habitat Type	Current Infestation	Potential Infestation
Dairy	Low	High
SheepBeefDeer	Low	High
Horticulture	Low	High
Forestry	Low	High
Aquaculture	-	-
Urban	Low	High
Native terrestrial	Low	High
Coastal land	Low	Low
Estuarine	-	-
Freshwater	Low	Low
Marine	-	-

2.5.4 Current area infested

The total area (number of hectares) in the Region (or defined area) currently infested by each pest was determined by Bay of Plenty Regional Council.

In general, data for the current area infested are considered to be reasonably accurate for Eradication pests, as the distributions of these species are relatively limited and reasonably well known, whereas accurate distribution information is often not available for the more widespread Progressive Containment, Sustained Control, and Site-led pests, in which case the current area infested had to be estimated.

For Exclusion programmes, the current area infested is always zero, as it is assumed that the pest species is not currently present in the Region (or if the proposed programme is Exclusion from a defined area, then the pest species may be present in the Region but is not present within the defined area in which the Exclusion programme applies).

For some widespread animal pests, their overall distribution/extent in the Region (or defined area) may be known but this is not an accurate measure of the number of hectares

they actually impact upon as they are mobile and their densities vary. In order to estimate the current area infested by such pests, we used the following two parameters:

- Current area infested: current extent/distribution of the pest in the Region (or defined area) (i.e. total number of hectares).
- Proportion of maximum density: current proportion of the maximum density that the pest may be able to reach if uncontrolled, averaged across its entire distribution in the Region (or defined area).

Current area impacted by the pest =Current area infested (in ha) × Proportion of maximum density

For example, feral cats (*Felis catus*) are estimated to occupy 1,000,000 hectares in the Bay of Plenty at present, but are estimated to be at only 27% of the maximum density they could potentially reach, therefore the current area impacted is estimated as follows:

Current area impacted by feral cats = 1,000,000 ha × 0.27 = 270,000 hectares

2.5.5 Potential area infested

In order to estimate potential impacts of the pest in future we need to estimate the maximum extent (number of hectares) a pest would be capable of occupying in the Region (or defined area) in the absence of regional control.

To calculate the number of hectares potentially infested by each pest we used information on the potential land use types occupied (see Section 2.5.3). If a land use/habitat type is a primary habitat for a pest, we assume that the pest could potentially infest **5-25% of the total area of that land use type in the Region** (or defined area). If a land use type is a secondary habitat for a pest, then we assume that the pest could potentially infest **1-4% of the total regional area** of that land use type.

In each CBA, the area of each land use potentially infested by each pest (in the Region or defined area) was estimated by multiplying the area of each land use type by its habitat suitability for that pest, i.e.

Potential area infested = Area of each land use type in the Region (or defined area) × Habitat suitability (primary, secondary, or unsuitable)

For some pest animals that are already (or have the potential to be) widespread in the Region (e.g. possums - *Trichosurus vulpecula*, wallabies - *Macropus eugenii*), we assume that the pest could potentially occupy a higher proportion of their primary habitats in the Region (or defined area). If a land use/habitat type is a primary habitat for a pest, we assumed that the pest could potentially infest **5-50% of the total area of that land use type in the Region** (or defined area). For secondary habitats we maintain our assumption that the pest could potentially infest 1-4% of the regional area of land use type.

2.5.6 Exclusion programmes

For pests not currently in the Region (or defined area), in order to carry out the CBA we assumed that the pest arrives in the Region in the first year of the RPMP, i.e. one hectare

is infested in year one. The future spread of the pest is then modelled in the same way as for pests that are already present in the Region.

2.5.7 Estimating pest spread rates

A key part of the CBA is estimating the number of years a pest will take to reach its maximum extent in the Region (or defined area). To do this, pest life forms are matched to average times to reach maximum extent from the year they are first discovered in the wild (Table 4), based on information available in the scientific literature. For pest animals, the default value was 50 years (i.e. the model assumes that it will take 50 years for a pest animal to spread into suitable habitats in the Region).

For pest plants, each species was categorised using one of four life forms:

- Short-lived (annual and biennial) herb.
- Long-lived (perennial) herb.
- Short-lived woody plant (woody vines and shrubs).
- Long-lived woody plant (trees).

A potential spread rate (time to reach maximum extent in the Region) was then assigned to each pest according to their life form (based on data for the entire naturalised flora of New Zealand, from Gatehouse 2008). Potential spread rate was then adjusted according to the dispersal ability of the species (Table 5). An uncertainty rating has not been assigned to these estimated spread rates, but uncertainty is captured in the maximum potential area a pest is expected to infest within these timeframes.

Table 4: Estimated times for pests of different life forms to reach their maximum extent in the Bay of Plenty Region from the year first found wild.

LifeForm	Time to Reach Maximum Extent in the Region
Pest animals	50 years
Short-lived herb	75 years
Long-lived herb	100 years
Short-lived woody	125 years
Long-lived woody	150 years

Table 5: Adjustment to the anticipated spread time for pest plants of different life forms based on their dispersal capabilities.

Dispersal Rate	Adjustment
Low	+25 years
Moderate	+0 years
High	-25 years

2.6 Estimating the outcome of the proposed pest management programme

Calculation of the costs and benefits of the proposed regional management requires both estimation of costs of the proposed management and the likely effect of this management in reducing the impacts of the pest. Estimation of the likely effectiveness of the proposed management is inherently more difficult that anticipating the costs of the programme.

We followed the Harris Model in assuming that each proposed management option (i.e. Exclusion, Eradication, Progressive Containment, Sustained Control, or Site-led) will result in a linear change in the pest extent. For most programmes, the expected outcome is a reduction in the pest over the duration of the RPMP, however for some programmes (e.g. Site-led programmes) there may still be an increase in pest extent or density, but this will be a lesser increase than would have happened without regional management.

The expected outcome of each pest management programme (i.e. proportional rate of change in the area impacted by the pest) was estimated by Bay of Plenty Regional Council staff, based on the area to be controlled each year and their experience undertaking control of these pests. A minimum and maximum value was estimated, to allow for uncertainty in the expected outcome, i.e. a best-case and worse-case outcome. The model uses the average of the minimum and maximum rate of change.

2.7 Impact assessment

2.7.1 Qualitative impact assessment

Firstly, a qualitative assessment of the impacts of each pest in the Bay of Plenty Region was completed using the available literature and information provided by Bay of Plenty Regional Council. The assessments follow the general structure of impact assessments in other previous RPMP reviews, e.g. Severinsen 2003; Auckland Regional Council 2006. For each species a broad assessment was made of their current and potential impacts on the following aspects of the Bay of Plenty Region:

- **Production**: impacts on dairy, sheep/beef/deer farming, forestry, horticulture, viticulture, aquaculture, international trade, or other production.
- **Soil resources**: causes soil loss or erosion, alters soil fertility or moisture levels.
- **Water quality**: increases siltation or sedimentation, reduces oxygenation of water, or reduces water supply.
- **Native species diversity**: impacts on the diversity, abundance, or composition of indigenous species.
- **Threatened species**: impacts on Threatened or At Risk indigenous species (according to the New Zealand Threat Classification System, Townsend *et al.* 2008).
- **Human health**: species that are poisonous or known to sting or bite.
- **Recreation**: impacts on recreation or amenity values (prevents or restricts recreational use, causes toxic algal blooms in water ways etc.).
- **Māori culture**: impacts on food gathering, hunting, tourism, or recreation, or impacts on important cultural sites (e.g. marae, urupa) or water purity (life force, mauri).

These impacts are based upon those identified in Section 71 of the Biosecurity Act and are detrimental in nature. For each pest species, the impacts were summarised and a "Low", "Moderate", or "High" impact value was assigned to each type of impact[1]. The sources of this information are referenced for each pest.

Then the different types of impacts were assigned to different land use types (Table 6). For example, if a pest has a High impact on dairy production and occurs on Dairy land, then it is assumed that the pest has a High impact on the Dairy land use/habitat type; if a pest has a Low impact on water quality and occurs in Freshwater, then it is assumed to have a Low impact on the Freshwater land use/habitat type.

Table 6: Types of impacts associated with different land use/habitat types in the Bay of Plenty Region. 'Production' land uses are highlighted in orange, 'non-production' land uses are highlighted in green.

Land Use/ Habitat Type	Impact Type (from Qualitative Impact Assessment)
Dairy	Dairy
SheepBeefDeer	Sheep/Beef/Deer
Horticulture	Horticulture
Forestry	Forestry
Aquaculture	Marine aquaculture
Urban	Human health
Native terrestrial	Species diversity
Coastal land	Soil resources + Water quality + Recreation + Species diversity
Estuarine	Soil resources + Water quality + Species diversity
Freshwater	Water quality + Recreation + Species diversity
Marine	Species diversity

2.7.2 Economic values of different land use/habitat types

Annual economic values (minimum and maximum) per hectare were estimated for each of the land use/habitat types in the Bay of Plenty Region (see Table 7). All values were provided by Bay of Plenty Regional Council.

Production land use/habitat types

Economic values (benefits) for the productive sectors (i.e. Dairy, Sheep and Beef, Forestry, Horticulture and Aquaculture) were provided by Bay of Plenty Regional Council. The values were based on the direct, indirect and induced contribution of each sector to regional gross domestic product (GDP) in the Bay of Plenty Region. The minimum and maximum values for each land use/habitat type were defined as plus/minus 10% of the point estimate.

Non-production land use/habitat types

Non-market valuations of the other land use/habitat types (i.e. Native terrestrial, Coastal land, Estuarine, Freshwater, Marine, and Urban) are inherently more difficult to quantify, however this is essential for evaluating the economic impacts of pest species that occur primarily in non-production lands/habitats (and the potential economic benefits for the Region in managing them).

[1] Note that current impacts may be categorised as 'Low' when impacts have not actually been documented in the Bay of Plenty but published information from elsewhere suggests that impacts are likely.

Table 7: Estimated annual economic value per hectare of different land use/habitat types in the Bay of Plenty Region. All values were provided by Bay of Plenty Regional Council. 'Production' land use/habitat types are highlighted in orange, 'non-production' types are highlighted in green.

Land Use/ Habitat Type	Economic Value ($) Per ha Per Annum		Explanation
	Min	Max	
Dairy	5,463	6,677	Bay of Plenty average per hectare contribution to regional gross domestic product (GDP), including direct, indirect and induced effects. [1, 2]
SheepBeefDeer	739	903	Bay of Plenty average per hectare contribution to regional GDP, including direct, indirect and induced effects. [1, 2]
Horticulture	9,520	11,636	Bay of Plenty average per hectare contribution to regional GDP, including direct, indirect and induced effects. [1, 2]
Forestry	1,747	2,135	Bay of Plenty average per hectare contribution to regional GDP, including direct, indirect and induced effects. [1, 2]
Aquaculture	3,305	4,039	Bay of Plenty average per hectare contribution to regional GDP, including direct, indirect and induced effects. The estimate is based on full production of the current area in production. [1, 2]
Urban	NA	NA	Economic values for urban areas in the Bay of Plenty Region were not quantified by Bay of Plenty Regional Council.
Native terrestrial	556	680	Economic values for native terrestrial ecosystems were based on estimated ecosystem service values in Patterson and Cole (2013). The estimate was based on the value for 'forest' minus the value of 'raw materials' (i.e. assuming no extractive use of native forests).
Coastal land	1,247	1,525	Economic values were based on estimated values in Patterson and Cole (2013). Assuming that the main economic value of sand dunes is recreation, we used the recreational values from similar ecosystems: the minimum value came from the recreational value of 'lakes' and the maximum came from the recreational value of 'rivers'. [2]
Estuarine	6,024	7,362	Based on ecosystem service values for estuaries in Patterson and Cole (2013). [2]
Freshwater	19,070	27,310	Based on ecosystem service values for freshwater ecosystems in Patterson and Cole (2013). The minimum and maximum values reflect the range around a point estimate.
Marine	81	99	Based on cultural and biodiversity values estimated for New Zealand continental shelf areas by van den Belt and Cole (2014). [2]

[1] Values for Production land use/habitat types do not include ecosystem service values.
[2] The minimum and maximum values for each land use/habitat type were defined as plus/minus 10% of the point estimate.

In the CBAs carried out for previous RPMP reviews, relatively conservative estimates of economic values were used for non-production lands, based on the relatively small number of relevant studies listed in Geoff Kerr's New Zealand non-market valuation database (www2.lincoln.ac.nz/nonmarketvaluation). For example, Coastal land was assigned an economic value of $10-$200/hectare per year in the CBAs carried out for the

Bay of Plenty RPMS review in 2010 (Sullivan and Hutchison 2010). These non-market values were based on New Zealand studies of recreation and existence values, and ecosystem services of natural areas. Coastal land and Estuarine values were based on recreation and amenity values, which have additional economic contributions to fisheries and water purification. Freshwater values were based primarily on recreation (including tourism) but also existence values for high water quality.

Two recent publications on the economic values of New Zealand land-based (Patterson and Cole 2013) and marine (van den Belt and Cole 2014) ecosystems have quantified the total economic value of the ecosystem services they provide, i.e. supporting services, regulating services, provisioning services, cultural services, and passive values. Data in these publications were used by Bay of Plenty Regional Council to estimate the economic values of non-production land use/habitat types in the Bay of Plenty.

Non-market valuations used for RPMP CBAs would benefit from further development. We are not aware of any studies that have attempted to estimate economic values of 'non-production' habitat types specifically for the Bay of Plenty.

2.7.3 Estimating quantitative impacts

Quantitative impacts of each pest (current and potential) were estimated from the proportional impact of the pest on the economic value of each land use/habitat type in the region (or defined area) (see Appendix 3, Section C3.8). For example, a *low* impact on a particular land use type was calculated as a 1-4% reduction in the annual economic value per hectare of that land use type (see Table 8). Assumptions used in the CBAs were:

- **Low** impact = 1-4% reduction in annual economic value per hectare.
- **Moderate** impact = 5-9% reduction in annual economic value per hectare.
- **High** impact = 10-50% reduction in annual economic value per hectare.

For most pests, there is relatively little information on their economic impacts on different land use or habitat types. The standardised percentages we have used to quantify pest impacts are based on the limited information that is available, as well as the technical opinion of the report authors and Regional Council staff. For example, giant buttercup (*Ranunculus acris*), which is considered to have a high impact on dairy farming, was estimated to reduce overall farm profit on a typical Golden Bay dairy farm by up to 36% (AgPest website http://agpest.co.nz/? pesttypes=giant-buttercup).

In order to quantify the total impact of each pest on the Bay of Plenty Region we need to know how many hectares of each land use/habitat type are infested by the pest and what level of impact the pest in having on each land use. Although it is possible for Regional Council staff to estimate the overall area currently infested by each pest in the Region (or defined area), it is much more difficult to estimate how much of the current area infested occurs in each land use/habitat type, as this requires much more accurate distributional data for each species.

Instead, data on the current and potential land use types occupied (i.e. whether a land use is a primary, secondary or unsuitable habitat for each pest) were used to estimate pest impacts on each land use type. This is not ideal but the true value is still likely to lie within the minimum and maximum range.

From the estimated impacts per land use/habitat type (Table 8), the total annual per hectare impact of a pest in the Region was calculated by weighting the impact on each land use by its relative proportion of the pest's total infestation area (across all land use/habitat types), using the following equation:

Weighted impact on each land use type = Economic value of land use × Impact level × Extent in each land use

Table 8: Reduction in the annual economic value (in dollars) per hectare of land use/habitat types in the Bay of Plenty in relation to the level of pest impact.

Land Use/ Habitat Type	Reduction in Annual Economic Value ($) per Hectare In relation to the Level of Pest Impact					
	Low Impact (1-4%)		Moderate Impact (5-9%)		High Impact (10-50%)	
	Min	Max	Min	Max	Min	Max
Dairy	54.63	267.08	273.15	600.93	546.30	3,338.50
SheepBeefDeer	7.39	36.12	36.95	81.27	73.90	451.50
Horticulture	95.20	465.44	476.00	1,047.24	952.00	5,818.00
Forestry	17.47	85.40	87.35	192.15	174.70	1,067.50
Aquaculture	33.05	161.56	165.25	363.51	330.50	2,019.50
Urban [1]	NA		NA		NA	
Native terrestrial	5.56	27.20	27.80	61.20	55.60	340.00
Coastal land	12.47	61.00	62.35	137.25	124.70	762.50
Estuarine	60.24	294.48	301.20	662.58	602.40	3,681.00
Freshwater	190.70	1,092.40	953.50	2,457.90	1,907.00	13,655.00
Marine	0.81	3.96	4.05	8.91	8.10	49.50

[1] Pest impacts on Urban land were not quantified in the Bay of Plenty CBAs as economic values for urban land were not estimated by Bay of Plenty Regional Council.

2.8 Estimating costs and benefits

Costs of implementing each pest management programme were divided into three categories:

- Regional Council costs.
- Agency compliance costs.
- Landowner (private) compliance costs.

2.8.1 Regional Council costs

These are costs borne directly by Bay of Plenty Regional Council in managing the proposed programme and include costs incurred to support, undertake or provide pest control, surveillance, monitoring, research, advice and information, as well as administration and governance. The expected annual expenditure by the Council on each of the proposed programmes was provided by Bay of Plenty Regional Council.

In the CBAs, if the proposed management programme results in eradication of the pest from the Region or defined area (within 50 years or less), Council costs are assumed to be $1,000 per year over the subsequent 20 years after the pest has been eradicated, as ongoing monitoring and surveillance will be required (if Council costs in year one are less

than $1,000, then the cost stays the same as in year one), then after this Council costs are assumed to be zero.

2.8.2 Agency compliance costs

These are costs borne by agencies such as the Department of Conservation (DOC) and Land Information New Zealand (LINZ) who manage state-owned land within Bay of Plenty Region. Agency compliance costs are additional costs that are incurred by agencies in order to comply with the requirements of the proposed RPMP. Total annual agency compliance costs for each pest management programme (where relevant) were estimated by Bay of Plenty Regional Council staff.

In the CBAs, agency compliance costs were included in the calculations for the first 10 years, but were not estimated for subsequent years as compliance costs are difficult to estimate beyond this period and are likely to decrease over time.

2.8.3 Landowner compliance costs

One of the important but difficult to quantify aspects of each CBA is estimating the cost of pest control carried out by private landowners in order to comply with the requirements of the proposed RPMP. Some pest management programmes do not incur private landowner costs; for example the costs of Exclusion and Eradication pest management programmes are normally entirely met by the Regional Council (sometimes in conjunction with agencies). Landowner compliance costs for each pest management programme were estimated by Bay of Plenty Regional Council staff.

2.8.4 Benefits provided by pests

Potential economic benefits arising from each pest were identified (see the Relevant Biology table in the outputs for each pest), however the annual economic value provided by a pest to the Region was unknown for most species. Benefits were quantified only for pests for which the benefit to the Region was considered to be of moderate or greater economic value (i.e. at least $0.50/hectare per year). The annual benefit per hectare was estimated using available literature. For example, a report on the possum fur industry in Taranaki stated that the income for possum control contractors from possum fur was estimated at $3-5 per hectare (Warburton 2008).

3. COST-BENEFIT ANALYSIS RESULTS FOR EACH PEST SPECIES

3.1 Asian paddle crab (*Charybdis japonica*)

Relevant biology

Attribute	Description
Form	Carapace wider than long, colour varies between pale green, dark green, brown and purple. Reaches 110 mm carapace width. Can have pilose (furry) carapace.
Habitat	Intertidal and subtidal to 15 m. Sandy, muddy or stony bottom. Appears primarily estuarine rather than coastal.
Regional distribution	Not currently present in Bay of Plenty. Elsewhere found in Waitemata Harbour, Mahurangi Harbour, Tamaki Estuary, Whangārei Harbour, Whangaparaoa Peninsula, Weiti River, Whitford Estuary, and Whangapoua.
Competitive ability	Aggressive - defends immediate space and excludes competitors through behavioural interactions.
Reproductive ability	Spawns twice-yearly when water temperature is between 20 and 28 degrees C. Average of 85,000 eggs per brood.
Resistance to control	No current human control methods. Predation by native fishes is highly likely. Range expansion southwards may be restricted by cool water temperatures.
Benefits	Target of commercial fishery for human consumption throughout its native range.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	-	High
Marine	-	High

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1
Horticulture	-	-		
Aquaculture	-	L	As a benthic predator, Asian paddle crab may influence populations of commercially-important soft-sediment bivalves and flatfish.	
Other	-	-		
International trade	-	L	Exported seafood from New Zealand is highly unlikely to transport Asian paddle crab. Foreign vessels may unknowingly take on ballast water containing larval individuals.	
Environment				
Soil resources	-	-		
Water quality	-	L	Predation on filter-feeding bivalves and other benthic filter feeders may result in increased sedimentation and decreased stability of substrate. However, data surrounding this is not explicitly related to New Zealand organisms, and water quality may beAttributed to other factors.	2, 3, 4
Species diversity	-	M	Generalist predator of benthic bivalves, fishes, crustaceans and cephalopods. Asian paddle crab could have a significant impact on small bivalves in NZ estuaries, including cockles, pipi, scallops and mussels, all of which have commercial, recreational and cultural	1, 5, 6, 7

Category	Current	Potential	Comment	Source
			importance. Asian paddle crab may also impact other native benthic organisms through direct predation or trophic cascades. The potential distribution of Asian paddle crab may not impact native portunid crab as (*Ovalipes catharus*) populations, as they occupy slightly different habitats. Direct competition may be minimal. May also prey on flounder and other flatfishes, which have commercial, recreational and cultural value.	
Threatened species	-	L	There are few threatened marine invertebrates, although it is possible that Asian paddle crab may predate on juvenile toheroa if the species distributions overlap.	1, 5, 6, 7
Social/Cultural				
Human health	-	L	May transmit toxic shellfish poisoning through human consumption during periods of high algal blooms.	8
Recreation	-	L	May nip recreational swimmers with claws (aggressive behaviour).	
Māori culture	-	L	See Human Health and Recreation	

L = low, M = moderate, H = high
source 1: Sudo et al. (2008), 2: Newell & Koch (2004), 3: Doering & Oviatt (1986), 4: Newell (2004), 5: Invasive Species Compendium (2008), 6: Fowler et al. (2011), 7: Gust & Inglis (2006), 8: Oikawa et al. (2004)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	33.05-161.56
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	0	301.20-662.58
- Marine	0	4.05-8.91

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Asian paddle crab**
Proposed management programme: **Exclusion (region)**
Area of Programme: **12,071 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	3,311 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$784	$0		$0	$0	$0	
	min: 237						
	max: 3,855						
Exclusion (region)	$0	$0	$784	$843,533	$0	$0	$-842,749
	min: 0		min: 237				min: -843,296
	max: 0		max: 3,855				max: -839,678

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$537,519	$0		$0	$0	$0	
	min: 120,189						
	max: 2,643,160						
Exclusion (region)	$0	$0	$537,519	$2,234,147	$0	$0	$-1,696,628
	min: 0		min: 120,189				min: -2,113,958
	max: 0		max: 2,643,160				max: 409,013

3.2 Australian droplet tunicate (*Eudistoma elongatum*)

Relevant biology

Attribute	Description
Form	Long cylindrical pendulous colonies tapering to a smooth stalk, sometimes with short wart-like side processes. Smooth and gelatinous to touch, firm overall. Cream coloured with light brown specks, specks becoming orange when reproductive. Colonies regress over winter (to approx. 10 mm) and regrow in spring (approx. 20 mm diameter and 300 mm long).
Habitat	Intertidal and subtidal (0-2m depth). Found attached to hard structures in sheltered bays i.e. oyster racks, mangrove roots, rocks and shells in mud.
Regional distribution	Not currently present in Bay of Plenty. Elsewhere found in Houhora Harbour, Parengarenga Harbour, Raungaunu, Bay of Islands, Whangārei Harbour, Kawau Island, and Nelson.
Competitive ability	Rapid growth and densely populates benthic habitats. Could smother and overwhelm other organisms.
Reproductive ability	Populations are reproductive for nine months (Oct to June). Appears to reproduce and establish rapidly.
Resistance to control	Multiple chemical controls have been attempted, only acetic acid has been successful thus far. Dispersal southwards may be restricted by water temperature (growth and reproduction is restricted at less than 14 degrees C).
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	-	High
Marine	-	High

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1, 2
Horticulture	-	-		
Aquaculture	-	H	Severely impacts intertidal aquaculture structures, e.g. smothering oyster racks in Northland New Zealand.	
Other	-	-		
International trade	-	L	May impact volume and quality of exported seafood, e.g. oysters.	
Environment				
Soil resources	-	-		
Water quality	-	L	As a filter feeder, Australian droplet tunicate may have a positive impact on water quality. However, there may be negative impacts from displacement of other, more effective filter feeders.	
Species diversity	-	H	Smothers benthic hard substrate habitats and associated organisms. Will displace other resident and native marine species.	2
Threatened species	-	L	Unknown if *E. elongatum* will impact threatened species (little is known about threatened species within the same habitat).	2
Social/Cultural				
Human health	-	L	Is not consumed by humans.	
Recreation	-	L	May have an impact as a fouling organism on recreational	

Category	Current	Potential	Comment	Source
			vessels and through displacement of recreationally caught seafood e.g. oysters.	
Māori culture	-	M	See Human Health and Recreation, particularly regarding seafood collection from traditional areas.	

L = low, M = moderate, H = high
source 1: Page et al. (2011), 2: Smith et al. (2007)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	0	602.40-3,681.00
- Marine	0	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Australian droplet tunicate**
Proposed management programme: **Exclusion (region)**
Area of Programme: **22,568.6 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	1,639 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$14,356	$0		$0	$0	$0	
	min: 3,438 max: 45,263						
Exclusion (region)	$0	$0	$14,356	$843,533	$0	$0	$-829,177
	min: 0 max: 0		min: 3,438 max: 45,263				min: -840,095 max: -798,270

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$6,328,374	$0		$0	$0	$0	
	min: 1,096,928 max: 31,047,349						
Exclusion (region)	$0	$0	$6,328,374	$2,234,147	$0	$0	$4,094,227
	min: 0 max: 0		min: 1,096,928 max: 31,047,349				min: -1,137,219 max: 28,813,202

3.3 Catfish (Exclusion) (*Ameiurus nebulosus*)

Relevant biology

Attribute	Description
Form	Large-headed fish with 8 long whisker-like barbels around the mouth. Dark brown to olive green colour with paler sides and belly. Relatively small eyes and a smooth skin. Commonly 200-300 mm in length but can grow to 500 mm and 3 kg.
Habitat	Lakes, ponds and rivers.
Regional distribution	Only present in Lake Rotoiti.
Competitive ability	Extremely robust, can survive for very long periods out of water. A scavenger and predator, eating many native species of fish and invertebrates. Could affect trout and whitebait fisheries by predation on juveniles.
Reproductive ability	Can reproduce quickly and successfully, as it has done in other regions in New Zealand.
Resistance to control	Control can be achieved within small, enclosed bodies of water e.g. ponds. Limited control may be possible in larger bodies of water.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-		
International trade	-	L	Reduced trout population could affect tourism (fishing).	1
Environment				
Soil resources	-	-		
Water quality	-	L	High numbers increase turbidity by stirring up sediment in water.	1, 2, 3
Species diversity	-	M	Can build up to large numbers. Is a scavenger and predator of small native fish, trout, fish eggs, koura and invertebrates.	1, 2
Threatened species	-	H	Predator of threatened native fish such as koaro, inanga and shortjaw kōkopu. Koaro have been recorded in Lake Rotoiti.	1, 2
Social/Cultural				
Human health	-	L	Leading edges on their dorsal and pectoral fins have a sharp toxic spine, which needs to be avoided while handling to prevent being spiked.	2
Recreation	-	M	Impact on fishing through reduced native fish and trout populations.	1, 2
Māori culture	-	M	Impact on fishing through reduced native fish populations.	1, 2

L = low, M = moderate, H = high
source 1: Department of Conservation (2007), 2: McDowall (2001), 3: Rowe (2007)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	953.50-2,457.90
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Catfish**
Proposed management programme: **Exclusion (defined area)**
Area of Programme: **12,018.3 ha**
Proposed annual expenditure by Council: **$50,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	3,385 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$28,695	$0		$0	$0	$0	
	min: 13,177 max: 124,048						
Exclusion (defined area)	$0	$0	$28,695	$421,767	$0	$0	$-393,072
	min: 0 max: 0		min: 13,177 max: 124,048				min: -408,590 max: -297,719

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$19,682,678	$0		$0	$0	$0	
	min: 6,803,133 max: 85,087,740						
Exclusion (defined area)	$0	$0	$19,682,678	$1,117,074	$0	$0	$18,565,604
	min: 0 max: 0		min: 6,803,133 max: 85,087,740				min: 5,686,059 max: 83,970,666

3.4 Catfish (Progressive Containment) (*Ameiurus nebulosus*)

Relevant biology

Attribute	Description
Form	Large-headed fish with 8 long whisker-like barbels around the mouth. Dark brown to olive green colour with paler sides and belly. Relatively small eyes and a smooth skin. Commonly 200-300 mm in length but can grow to 500 mm and 3 kg.
Habitat	Lakes, ponds and rivers.
Regional distribution	Present in Lakes Rotoiti, Rotorua, Kaituna.
Competitive ability	Extremely robust, can survive for very long periods out of water. A scavenger and predator, eating many native species of fish and invertebrates. Could affect trout and whitebait fisheries by predation on juveniles.
Reproductive ability	Can reproduce quickly and successfully, as it has done in other regions in New Zealand.
Resistance to control	Control can be achieved within small, enclosed bodies of water e.g. ponds. Limited control may be possible in larger bodies of water.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-		
International trade	-	L	Reduced trout population could affect tourism (fishing).	1
Environment				
Soil resources	-	-		
Water quality	L	L	High numbers increase turbidity by stirring up sediment in water.	1, 2, 3
Species diversity	L	M	Can build up to large numbers. Is a scavenger and predator of small native fish, trout, fish eggs, koura and invertebrates.	1, 2
Threatened species	-	H	Predator of threatened native fish such as koaro, inanga and shortjaw kōkopu. Koaro have been recorded in Lake Rotoiti.	1, 2
Social/Cultural				
Human health	L	L	Leading edges on their dorsal and pectoral fins have a sharp toxic spine, which needs to be avoided while handling to prevent being spiked.	2
Recreation	L	M	Impact on fishing through reduced native fish and trout populations.	1, 2
Māori culture	L	M	Impact on fishing through reduced native fish and trout populations.	1, 2

L = low, M = moderate, H = high
source 1: Department of Conservation (2007), 2: McDowall (2001), 3: Rowe (2007)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	190.70-1,092.40	953.50-2,457.90
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Catfish**
Proposed management programme: **Progressive Containment (Lakes Rotoiti, Rotorua, Kaituna)**
Area of Programme: **11,591 ha**
Proposed annual expenditure by Council: **$300,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	303.21 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$641.55/ha	Potential extent in the region°	1,739 ha
	$190.7-1,092.4/ha		579.55-2,897.75 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,797,496 min: 681,622 max: 6,868,017	$0		$0	$0	$0	
Progressive Containment	$1,475,978	$0	$1,321,518	$2,530,599	$0	$0	$-1,209,081
	min: 392,039 max: 2,780,703		min: 289,583 max: 4,087,314				min: -2,241,016 max: 1,556,715

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$10,461,463 min: 2,097,851 max: 42,705,876	$0		$0	$0	$0	
Progressive Containment	$2,237,189	$0	$8,224,274	$5,747,488	$0	$0	$2,476,786
	min: 465,500 max: 5,954,347		min: 1,632,351 max: 36,751,529				min: -4,115,137 max: 31,004,041

3.5 Clubbed tunicate (Eradication) (*Styela clava*)

Relevant biology

Attribute	Description
Form	Club-shaped body on a tough stalk; can reach 200 mm length. Leathery and conical, warty swellings at the top near the siphons. Short siphons are close together at the top of the body. Posterior half creased longitudinally. Colour brownish-white, yellowish-brown or reddish-brown.
Habitat	Low-tidal and sub-tidal, down to approximately 25 m. Attaches to hard substrates (e.g. rocks, boats, wharf pilings, pontoons). Found in relatively sheltered environments with near-normal marine salinity.
Regional distribution	Only present in Bay of Plenty at a few sites in Tauranga Harbour and some outer islands. Widespread elsewhere in Auckland, Lyttelton, Nelson, Opua, Otago, Picton, Wellington, and Whangārei.
Competitive ability	Multiplies rapidly in suitable sites and competes strongly with other filter feeders for food and space. At overseas sites *S. clava* reaches densities of 500-1500 individuals per square metre.
Reproductive ability	Hermaphroditic. Reproductive for most of the year, not reproducing when water temperature is less than 15 degrees C. Larvae are mobile in the water column for approximately 24 hours before settling on a surface.
Resistance to control	Manual removal is most effective, albeit time-consuming and laborious. Desiccation and extreme temperature is also used. Chemical methods have also been attempted (high salinity, hydrated lime and acetic acid). The chemical medetomidine inhibits larval mobility.
Benefits	Consumed by humans in Korea in a dish called mideodok-chim.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	Low	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	Low	High
Marine	Low	High

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1
Horticulture	-	-		
Aquaculture	L	H	Densities are not yet high enough in Tauranga harbour to have a significant impact on aquaculture or fisheries. However, clubbed tunicate is a major fouling organism on aquaculture gear and stock (e.g. oysters, mussels). This increases handling times, maintenance costs, cost of control efforts, and diminishes financial returns. May also influence the abundance and distribution of recreational fisheries. Also may alter aesthetics of local dive sites, potentially impacting tourism activities.	
Other	-	-		
International trade	L	L	May impact volume and quality of exported seafood, e.g. oysters, mussels	
Environment				
Soil resources	-	-		
Water quality	L	L	As a filter feeder, clubbed tunicate may have a positive impact	

Category	Current	Potential	Comment	Source
			on water quality. However, there may be negative impacts from displacement of other more effective filter feeders.	
Species diversity	L	H	Clubbed tunicate has so far been detected in Tauranga Harbour in small numbers on vessel hulls. Has potential to form monospecific stands that out-compete native organisms for space, severely reducing biodiversity.	1
Threatened species	L	L	Unknown if clubbed tunicate will impact threatened species (little is known about threatened species within the same habitat).	1
Social/Cultural				
Human health	L	L	Appears to be safe to consume. However, caution is advisable during periods of toxic algae blooms as clubbed tunicate is a filter feeder that will probably uptake toxins into tissues.	2
Recreation	L	M	Will likely impact recreational seafood collection (e.g. mussels, oysters). May have aesthetic impact on recreational diving. May also impact recreational vessels (increased cost of managing biofouling).	1, 2
Māori culture	L	M	See Human Health and Recreation, particularly regarding seafood collection from traditional areas.	

L = low, M = moderate, H = high
source 1: Grayling (2015), 2: NIWA (2016)

Estimated quantitative impacts

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	33.05-161.56	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	60.24-294.48	602.40-3,681.00
- Marine	0.81-3.96	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Clubbed tunicate**
Proposed management programme: **Eradication (region)**
Area of Programme: **22,568.6 ha**
Proposed annual expenditure by Council: **$250,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0.01 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$147.82/ha	Potential extent in the region°	4,885 ha
Current benefits	$50.21-245.43/ha $0/ha	Discount rate	1,628.43-8,142.15 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$531,062 min: 77,480 max: 2,798,971	$0		$0	$0	$0	
Eradication (region)	$10 min: 2 max: 21	$0	$531,052 min: 77,478 max: 2,798,950	$2,108,833	$487 min: 246 max: 808	$0	$-1,578,268 min: -2,032,163 max: 689,871

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$565,130,049 min: 94,078,484 max: 2,920,387,868	$0		$0	$0	$0	
Eradication (region)	$11 min: 2 max: 44	$0	$565,130,038 min: 94,078,482 max: 2,920,387,824	$3,421,308	$494 min: 246 max: 808	$0	$561,708,236 min: 90,656,366 max: 2,916,966,270

3.6 Clubbed tunicate (Progressive Containment) (*Styela clava*)

Relevant biology

Attribute	Description
Form	Club-shaped body on a tough stalk; can reach 200 mm length. Leathery and conical, warty swellings at the top near the siphons. Short siphons are close together at the top of the body. Posterior half creased longitudinally. Colour brownish-white, yellowish-brown or reddish-brown.
Habitat	Low-tidal and sub-tidal, down to approximately 25 m. Attaches to hard substrates (e.g. rocks, boats, wharf pilings, pontoons). Found in relatively sheltered environments with near-normal marine salinity.
Regional distribution	Only present in Bay of Plenty at a few sites in Tauranga Harbour and some outer islands. Widespread elsewhere in Auckland, Lyttelton, Nelson, Opua, Otago, Picton, Wellington, and Whangārei.
Competitive ability	Multiplies rapidly in suitable sites and competes strongly with other filter feeders for food and space. At overseas sites *S. clava* reaches densities of 500-1500 individuals per square metre.
Reproductive ability	Hermaphroditic. Reproductive for most of the year, not reproducing when water temperature is less than 15 degrees C. Larvae are mobile in the water column for approximately 24 hours before settling on a surface.
Resistance to control	Manual removal is most effective, albeit time-consuming and laborious. Desiccation and extreme temperature is also used. Chemical methods have also been attempted (high salinity, hydrated lime and acetic acid). The chemical medetomidine inhibits larval mobility.
Benefits	Consumed by humans in Korea in a dish called mideodok-chim.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	Low	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	Low	High
Marine	Low	High

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1
Horticulture	-	-		
Aquaculture	L	H	Densities are not yet high enough in Tauranga harbour to have a significant impact on aquaculture or fisheries. However, clubbed tunicate is a major fouling organism on aquaculture gear and stock (e.g. oysters, mussels). This increases handling times, maintenance costs, cost of control efforts, and diminishes financial returns. May also influence the abundance and distribution of recreational fisheries. Also may alter aesthetics of local dive sites, potentially impacting tourism activities.	
Other	-	-		
International trade	L	L	May impact volume and quality of exported seafood, e.g. oysters, mussels	
Environment				
Soil resources	-	-		
Water quality	L	L	As a filter feeder, clubbed tunicate may have a positive impact	

Category	Current	Potential	Comment	Source
			on water quality. However, there may be negative impacts from displacement of other more effective filter feeders.	
Species diversity	L	H	Clubbed tunicate has so far been detected in Tauranga Harbour in small numbers on vessel hulls. Has potential to form monospecific stands that out-compete native organisms for space, severely reducing biodiversity.	1
Threatened species	L	L	Unknown if clubbed tunicate will impact threatened species (little is known about threatened species within the same habitat).	1
Social/Cultural				
Human health	L	L	Appears to be safe to consume. However, caution is advisable during periods of toxic algae blooms as clubbed tunicate is a filter feeder that will likely uptake toxins into tissues.	2
Recreation	L	M	Will likely impact recreational seafood collection (e.g. mussels, oysters). May have aesthetic impact on recreational diving. May also impact recreational vessels (increased cost of managing biofouling).	1, 2
Māori culture	L	M	See Human Health and Recreation, particularly regarding seafood collection from traditional areas.	

L = low, M = moderate, H = high
source 1: Grayling (2015), 2: NIWA (2016)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	33.05-161.56	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	60.24-294.48	602.40-3,681.00
- Marine	0.81-3.96	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Clubbed tunicate**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **22,568.6 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0.01 ha	Time to reach maximum extent†	50 yrs
Current impacts★	$147.82/ha	Potential extent in the region°	4,885 ha
	$50.21-245.43/ha		1,628.43-8,142.15 ha
Current benefits	$0/ha	Discount rate	4%

★ Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region with the assumptions made.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$531,062 min: 77,480 max: 2,798,971	$0		$0	$0	$0	
Progressive Containment (region)	$13	$0	$531,049	$843,533	$626	$0	$-313,110
	min: 4 max: 22		min: 77,476 max: 2,798,949		min: 413 max: 844		min: -766,901 max: 1,955,003

★ Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$565,130,049 min: 94,078,484 max: 2,920,387,868	$0		$0	$0	$0	
Progressive Containment (region)	$31	$0	$565,130,018	$2,234,147	$626	$0	$562,895,245
	min: 10 max: 53		min: 94,078,474 max: 2,920,387,815		min: 413 max: 844		min: 91,843,483 max: 2,918,153,255

3.7 Feral cat (Site-led) (*Felis catus*)

Relevant biology

Attribute	Description
Form	Resemble domestic cats in both size and colouration. Females average about 75% of the weight of males.
Habitat	Inhabits a wide range of urban, rural and forest habitats. Found from sea level to alpine habitats.
Regional distribution	Scattered throughout the region.
Competitive ability	Diet is wide-ranging and includes small mammals, fish, birds and invertebrates.
Reproductive ability	2-3 litters per year with an average of 4 young in each.
Resistance to control	Controlled by poisons, trapping and shooting. No natural predators.
Benefits	Control rodents and to some degree mustelids (young stoats and weasels).

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	High	High
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Can transmit bovine Tb which can be transferred to cattle. In an area with Tb-infected cattle, a study found 1 in 50 cats had gross lesions typical of Tb.	
Sheep and beef	L	M	Carry many parasites and both feral and farm cats can transmit *Toxoplasma gondii* to sheep, causing toxoplasmosis. Sheep become infected from eating contaminated pasture, concentrate feeds and hay. Once ingested, the toxoplasma spreads to the sheep's muscles and brain, and also into the placenta.	
Forestry	-	-		1, 2, 3, 4
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Eats native birds, lizards and invertebrates.	1, 2
Threatened species	M	H	Predator of eggs and chicks of threatened native birds and lizards (e.g. brown teal, NZ dotterel).	1
Social/Cultural				
Human health	L	L	Can bite and scratch. Can transmit *Toxoplasma gondii* and cause toxoplasmosis to humans.	1
Recreation	-	-		
Māori culture	-	-		

L = low, M = moderate, H = high

source 1: King (2005), 2: Auckland Regional Council (2004), 3: Environment Bay of Plenty (2003), 4: Taranaki Regional Council (2013)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Feral cat**
Proposed management programme: **Site-led (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$200,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	299,367.6 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$44.73/ha	Potential extent in the region°	299,368 ha
	$20.87-68.59/ha		299,367.6-299,367.6 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$121,996,310 min: 56,914,331 max: 187,078,289	$0		$0	$0	$0	
Site-led (region)	$101,599,456 min: 42,354,093 max: 172,381,887	$0	$20,396,854 min: 14,560,238 max: 14,696,402	$1,687,066	$0	$0	$18,709,788 min: 12,873,172 max: 13,009,336

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$301,039,945 min: 140,442,667 max: 461,637,222	$0		$0	$0	$0	
Site-led (region)	$153,997,715 min: 50,290,541 max: 369,123,135	$0	$147,042,230 min: 90,152,126 max: 92,514,087	$3,832,723	$0	$0	$143,209,507 min: 86,319,403 max: 88,681,364

3.8 Feral cat (Sustained Control) (*Felis catus*)

Relevant biology

Attribute	Description
Form	Resemble domestic cats in both size and colouration. Females average about 75% of the weight of males.
Habitat	Inhabits a wide range of urban, rural and forest habitats. Found from sea level to alpine habitats.
Regional distribution	Scattered throughout the region.
Competitive ability	Diet is wide-ranging and includes small mammals, fish, birds and invertebrates.
Reproductive ability	2-3 litters per year with an average of 4 young in each.
Resistance to control	Controlled by poisons, trapping and shooting. No natural predators.
Benefits	Control rodents and to some degree mustelids (young stoats and weasels).

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	High	High
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Can transmit bovine Tb which can be transferred to cattle. In an area with Tb-infected cattle, a study found 1 in 50 cats had gross lesions typical of Tb.	
Sheep and beef	L	M	Carry many parasites and both feral and farm cats can transmit *Toxoplasma gondii* to sheep.	
Forestry	-	-		1, 2, 3, 4
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Eats native birds, lizards and invertebrates.	1, 2
Threatened species	M	H	Predator of eggs and chicks of threatened native birds and lizards (e.g. brown teal, NZ dotterel).	1
Social/Cultural				
Human health	L	L	Can bite and scratch.	1
Recreation	-	-		
Māori culture	-	-		

L = low, M = moderate, H = high

source 1: King (2005), 2: Auckland Regional Council (2004), 3: Environment Bay of Plenty (2003), 4: Taranaki Regional Council (2013)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Feral cat**
Proposed management programme: **Sustained Control (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$400,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	299,367.6 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$44.73/ha	Potential extent in the region°	299,368 ha
	$20.87-68.59/ha		299,367.6-299,367.6 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$121,996,310	$0		$0	$0	$0	
	min: 56,914,331 max: 187,078,289						
Sustained Control (region)	$82,676,480	$0	$39,319,830	$3,374,133	$0	$0	$35,945,697
	min: 34,787,200 max: 139,218,560		min: 22,127,131 max: 47,859,729				min: 18,752,998 max: 44,485,596

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$301,039,945	$0		$0	$0	$0	
	min: 140,442,667 max: 461,637,222						
Sustained Control (region)	$91,478,189	$0	$209,561,756	$4,854,648	$0	$0	$204,707,108
	min: 36,452,154 max: 165,305,786		min: 103,990,513 max: 296,331,436				min: 99,135,865 max: 291,476,788

3.9 Feral goat (Eradication) (*Capra hircus*)

Relevant biology

Attribute	Description
Form	Feral goats vary in size and colour. Can be white, black, brown or a combination of colours. Both sexes have horns. Adult males stand approximately 70 cm high and weigh 50-60 kg. Females are smaller.
Habitat	Inhabits a wide range of rural and forest habitats. Favours steep, dry, sunny faces.
Regional distribution	Primarily in Eastern Bay of Plenty (Waioeka Gorge to Motu River). Also small areas in Kaimai Ranges and near Rotorua.
Competitive ability	Diet is wide-ranging. Able to exploit a wide variety of habitats.
Reproductive ability	Females begin breeding at 6 months and can breed twice a year. Twins are common. Males can mate from 6 months but are usually excluded by other males until 3-4 years of age.
Resistance to control	No natural predators in New Zealand. Controlled by shooting and high-quality fencing.
Benefits	Some value as feral meat. Some farmers muster out goats infrequently and sell them off.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	Low
Sheep and beef	High	High
Forestry	High	High
Horticulture	Low	Low
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Competes with stock for pasture and reduces pasture productivity. May spread livestock diseases.	
Sheep and beef	L	M	Removal of vegetation through browsing and trampling can cause soil erosion, particularly in the eastern hill country.	
Forestry	L	M	Can cause severe damage to young trees in plantation forests by trampling seedlings, browsing young trees and stripping bark from older trees.	1, 2, 3, 4
Horticulture	L	M	Can cause damage to fruit trees and crops.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	L	M	Removal of vegetation through browsing and trampling can cause erosion.	4
Water quality	L	M	Erosion of soil can lead to increased sedimentation in waterways.	2
Species diversity	M	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	3, 4, 5, 6
Threatened species	L	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	5, 6
Social/Cultural				
Human health	-	-		

Category	Current	Potential	Comment	Source
Recreation	L	L	Damages and eliminates palatable native plant species and alters structure of native forest, which can affect recreational experiences. Viewed as a recreational resource by some hunters.	2, 4
Māori culture	L	M	Destroys native forests and eats culturally important plants (e.g. koromiko).	2, 4

L = low, M = moderate, H = high
source 1: King (2005), 2: Severinsen (2003), 3: Auckland Regional Council (2004), 4: Invasive Species Specialist Group (2010), 5: Husheer (2006), 6: Clements (2004).

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Feral goat**
Proposed management programme: **Eradication (E of Motu)**
Area of Programme: **121,006.4 ha**
Proposed annual expenditure by Council: **$150,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	15,042.54 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$43.53/ha	Potential extent in the region°	36,664 ha
Current benefits	$25.48-61.57/ha $0.5/ha	Discount rate	15,042.54-58,286.07 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$7,154,185 min: 3,492,186 max: 14,306,385	$75,133 min: 63,444 max: 103,213		$0	$0	$0	
Eradication (E of Motu)	$3,778,353 min: 1,824,966 max: 6,279,770	$43,568 min: 36,942 max: 50,193	$3,344,267 min: 1,614,200 max: 8,000,113	$1,265,300	$0	$421,767	$1,657,200 min: -72,867 max: 6,313,046

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$20,584,455 min: 8,617,372 max: 57,989,958	$234,763 min: 168,036 max: 466,761		$0	$0	$0	
Eradication (E of Motu)	$4,043,587 min: 1,824,966 max: 7,456,493	$48,007 min: 36,942 max: 62,672	$16,354,112 min: 6,388,317 max: 50,402,371	$1,655,735	$0	$421,767	$14,276,610 min: 4,310,815 max: 48,324,869

3.10 Feral goat (Progressive Containment) (*Capra hircus*)

Relevant biology

Attribute	Description
Form	Feral goats vary in size and colour. Can be white, black, brown or a combination of colours. Both sexes have horns. Adult males stand approximately 70 cm high and weigh 50-60 kg. Females are smaller.
Habitat	Inhabits a wide range of rural and forest habitats. Favours steep, dry, sunny faces.
Regional distribution	Primarily in Eastern Bay of Plenty (Waioeka Gorge to Motu River). Also small areas in Kaimai Ranges and near Rotorua.
Competitive ability	Diet is wide-ranging. Able to exploit a wide variety of habitats.
Reproductive ability	Females begin breeding at 6 months and can breed twice a year. Twins are common. Males can mate from 6 months but are usually excluded by other males until 3-4 years of age.
Resistance to control	No natural predators in New Zealand. Controlled by shooting and high-quality fencing.
Benefits	Some value as feral meat. Some farmers muster out goats infrequently and sell them off.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	Low
Sheep and beef	High	High
Forestry	High	High
Horticulture	Low	Low
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Competes with stock for pasture and reduces pasture productivity. May spread livestock diseases.	
Sheep and beef	L	M	Removal of vegetation through browsing and trampling can cause soil erosion, particularly in the eastern hill country.	
Forestry	L	M	Can cause severe damage to young trees in plantation forests by trampling seedlings, browsing young trees and stripping bark from older trees.	1, 2, 3, 4
Horticulture	L	M	Can cause damage to fruit trees and crops.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	L	M	Removal of vegetation through browsing and trampling can cause erosion.	4
Water quality	L	M	Erosion of soil can lead to increased sedimentation in waterways.	2
Species diversity	M	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	3, 4, 5, 6
Threatened species	L	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	5, 6
Social/Cultural				
Human health	-	-		

Category	Current	Potential	Comment	Source
Recreation	L	L	Damages and eliminates palatable native plant species and alters structure of native forest, which can affect recreational experiences. Viewed as a recreational resource by some hunters.	2, 4
Māori culture	L	M	Destroys native forests and eats culturally important plants (e.g. koromiko).	2, 4

L = low, M = moderate, H = high
source 1: King (2005), 2: Severinsen (2003), 3: Auckland Regional Council (2004), 4: Invasive Species Specialist Group (2010), 5: Husheer (2006), 6: Clements (2004)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Feral goat**
Proposed management programme: **Progressive Containment (W of Motu)**
Area of Programme: **1,135,756 ha**
Proposed annual expenditure by Council: **$130,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	158,731.3 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$45.23/ha	Potential extent in the region°	300,899 ha
	$22.13-68.34/ha		158,731.3-443,066.3 ha
Current benefits	$0.5/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$76,020,056	$770,009		$0	$0	$0	
	min: 31,999,228	min: 669,475					
	max: 148,319,345	max: 974,822					
Progressive Containment (W of Motu)	$59,549,652	$634,518	$16,334,913	$1,096,593	$0	$3,374,133	$11,864,187
	min: 28,067,325	min: 613,544	min: 3,612,574				min: -858,152
	max: 93,253,204	max: 655,493	max: 55,010,210				max: 50,539,484

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$213,062,701	$2,338,802		$0	$0	$0	
	min: 78,961,781	min: 1,773,145					
	max: 525,329,469	max: 3,812,526					
Progressive Containment (W of Motu)	$122,462,171	$1,400,513	$89,662,241	$2,904,391	$0	$3,374,133	$83,383,717
	min: 50,215,126	min: 1,176,934	min: 26,558,221				min: 20,279,697
	max: 214,949,682	max: 1,624,092	max: 309,783,576				max: 303,505,052

3.11 Feral goat (Sustained Control) (*Capra hircus*)

Relevant biology

Attribute	Description
Form	Feral goats vary in size and colour. Can be white, black, brown or a combination of colours. Both sexes have horns. Adult males stand approximately 70 cm high and weigh 50-60 kg. Females are smaller.
Habitat	Inhabits a wide range of rural and forest habitats. Favours steep, dry, sunny faces.
Regional distribution	Primarily in Eastern Bay of Plenty (Waioeka Gorge to Motu River). Also small areas in Kaimai Ranges and near Rotorua.
Competitive ability	Diet is wide-ranging. Able to exploit a wide variety of habitats.
Reproductive ability	Females begin breeding at 6 months and can breed twice a year. Twins are common. Males can mate from 6 months but are usually excluded by other males until 3-4 years of age.
Resistance to control	No natural predators in New Zealand. Controlled by shooting and high-quality fencing.
Benefits	Some value as feral meat. Some farmers muster out goats infrequently and sell them off.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	Low
Sheep and beef	High	High
Forestry	High	High
Horticulture	Low	Low
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Competes with stock for pasture and reduces pasture productivity. May spread livestock diseases.	
Sheep and beef	L	M	Removal of vegetation through browsing and trampling can cause soil erosion, particularly in the eastern hill country.	
Forestry	L	M	Can cause severe damage to young trees in plantation forests by trampling seedlings, browsing young trees and stripping bark from older trees.	1, 2, 3, 4
Horticulture	L	M	Can cause damage to fruit trees and crops.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	L	M	Removal of vegetation through browsing and trampling can cause erosion.	4
Water quality	L	M	Erosion of soil can lead to increased sedimentation in waterways.	2
Species diversity	M	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	3, 4, 5, 6
Threatened species	L	H	Eats a wide variety of plant species and can eliminate preferred (palatable) species, leading to changes in plant species composition, and preventing forest regeneration and succession.	5, 6
Social/Cultural				
Human health	-	-		

Category	Current	Potential	Comment	Source
Recreation	L	L	Damages and eliminates palatable native plant species and alters structure of native forest, which can affect recreational experiences. Viewed as a recreational resource by some hunters.	2, 4
Māori culture	L	M	Destroys native forests and eats culturally important plants (e.g. koromiko).	2, 4

L = low, M = moderate, H = high
source 1: King (2005), 2: Severinsen (2003), 3: Auckland Regional Council (2004), 4: Invasive Species Specialist Group (2010), 5: Husheer (2006), 6: Clements (2004)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Feral goat**
Proposed management programme: **Sustained Control (W of Motu)**
Area of Programme: **1,135,756 ha**
Proposed annual expenditure by Council: **$80,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	158,731.3 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$45.23/ha	Potential extent in the region°	300,899 ha
	$22.13-68.34/ha		158,731.3-443,066.3 ha
Current benefits	$0.5/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$76,020,056	$770,009		$0	$0	$0	
	min: 31,999,228	min: 669,475					
	max: 148,319,345	max: 974,822					
Sustained Control (W of Motu)	$63,173,328	$669,475	$12,746,194	$674,827	$0	$3,374,133	$8,697,234
	min: 30,761,761	min: 666,679	min: 934,917				min: -3,114,043
	max: 95,881,058	max: 672,272	max: 52,435,491				max: 48,386,531

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$213,062,701	$2,338,802		$0	$0	$0	
	min: 78,961,781	min: 1,773,145					
	max: 525,329,469	max: 3,812,526					
Sustained Control (W of Motu)	$155,482,193	$1,773,145	$57,014,851	$1,787,318	$0	$3,374,133	$51,853,400
	min: 74,767,636	min: 1,743,335	min: 2,184,575				min: -2,976,876
	max: 238,895,480	max: 1,802,956	max: 286,404,179				max: 281,242,728

3.12 Mediterranean fanworm (Eradication) (*Sabella spallanzanii*)

Relevant biology

Attribute	Description
Form	Builds conspicuous leathery tubes (normally 100-500 mm, up to 1000 mm long) projecting from subtidal hard structures. From the tube it extends a spiral crown of delicate, flexible radioles (the fan), which varies in colour - most often brown/cream with black and/or white bands
Habitat	Subtidal, found attached to hard structures (e.g. rocks, boats, wharf pilings, pontoons) to approx. 30 m depth. Usually in estuaries or sheltered sites. Density decreases with depth. Demonstrates clear preference for sheltered, nutrient-rich waters.
Regional distribution	In Bay of Plenty only present in southern Tauranga Harbour. Widespread elsewhere - Auckland, Lyttelton, Nelson, Wellington, Whangārei, Gisborne, Coromandel, Bay of Islands, and Picton.
Competitive ability	Very competitive - forms dense monospecific groups that competes with and excludes native species. Can reach approx. 1000 individuals per square metre.
Reproductive ability	Highly robust organisms, can regenerate from fragments (caused naturally or by trauma), resulting in reproduction by fission. Sexual maturity is at approximately 50 mm body length. Highly fecund – approx. 50,000 eggs can be produced by a female of approx. 300 mm body length. Appears to have an annual spawning cycle, gametes released in midwinter in Melbourne, Australia. Larvae can remain in the water column for 14 days.
Resistance to control	Highly resistant to control. Chemical control is difficult as *S. spallanzanii* is found subtidally. Manual search and removal is difficult as small individuals are challenging to locate amongst other fouling organisms. Despite a large search and cull effort in Lyttelton and Waitemata harbours, elimination efforts were abandoned two years after first detection.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	Low	High
Marine	Low	Low

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	H	Dense beds of Mediterranean fanworm clog recreational and commercial fishing gear. Also has negative impacts on aquaculture due to dense fouling on structures and on farmed shellfish.	
Other	-	-		
International trade	L	M	May impact volume and quality of exported seafood, e.g. oysters, mussels.	
Environment				
Soil resources	-	-		
Water quality	L	L	Mediterranean fanworm prefers waters with high nutrient levels. Thus the presence of this organism may also be an indicator of poor water quality. May displace other more effective filter feeders, resulting in a negative impact on water	3, 4

Category	Current	Potential	Comment	Source
			quality. Mediterranean fanworm excretes nitrogen in the form of ammonia, further increasing nutrient loads in the surrounding water. Also has high potential to disrupt established nutrient pathways.	
Species diversity	L	H	Although not currently present in high numbers in Tauranga, there is high potential for Mediterranean fanworm to smother and out-compete other organisms.	1, 2, 3
Threatened species	L	L	Unknown if Mediterranean fanworm will impact threatened species (little is known about threatened species within the same habitat).	1, 2, 3
Social/Cultural				
Human health	L	L	Not consumed by humans.	
Recreation	L	M	Will likely impact recreational seafood collection (e.g. mussels, oysters). Can also clog recreational scallop dredges. Will rapidly settle on and foul the hulls of recreational vessels.	1, 3
Māori culture	L	M	See Recreation, particularly regarding seafood collection from traditional areas.	

L = low, M = moderate, H = high
source 1: Read et al. (2011), 2: Ministry for Primary Industries (2016), 3: Currie et al. (2000), 4: Ministry for Primary Industries (2013)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	60.24-294.48	602.40-3,681.00
- Marine	0.81-3.96	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Mediterranean fanworm**
Proposed management programme: **Eradication (region)**
Area of Programme: **46,481.6 ha**
Proposed annual expenditure by Council: **$250,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0.01 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$83.86/ha	Potential extent in the region°	5,368 ha
	$28.48-139.24/ha		1,830.6-8,904.63 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$681,545	$0		$0	$0	$0	
	min: 104,542 max: 3,488,271						
Eradication (region)	$7	$0	$681,538	$2,108,833	$613	$0	$-1,427,908
	min: 2 max: 12		min: 104,540 max: 3,488,259		min: 404 max: 826		min: -2,005,119 max: 1,379,022

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$595,006,714	$0		$0	$0	$0	
	min: 97,815,089 max: 3,013,507,455						
Eradication (region)	$16	$0	$595,006,698	$5,585,368	$613	$0	$589,420,717
	min: 5 max: 28		min: 97,815,084 max: 3,013,507,427		min: 404 max: 826		min: 92,228,890 max: 3,007,921,655

3.13 Mediterranean fanworm (Progressive Containment) (*Sabella spallanzanii*)

Relevant biology

Attribute	Description
Form	Builds conspicuous leathery tubes (normally 100-500 mm, up to 1000 mm long) projecting from subtidal hard structures. From the tube it extends a spiral crown of delicate, flexible radioles (the fan), which varies in colour - most often brown/cream with black and/or white bands
Habitat	Subtidal, found attached to hard structures (e.g. rocks, boats, wharf pilings, pontoons) to approx.30 m depth. Usually in estuaries or sheltered sites. Density decreases with depth. Demonstrates clear preference for sheltered, nutrient-rich waters.
Regional distribution	In Bay of Plenty only present in southern Tauranga Harbour. Widespread elsewhere - Auckland, Lyttelton, Nelson, Wellington, Whangārei, Gisborne, Coromandel, Bay of Islands, and Picton.
Competitive ability	Very competitive - forms dense monospecific groups that competes with and excludes native species. Can reach approx. 1000 individuals per square metre.
Reproductive ability	Highly robust organisms, can regenerate from fragments (caused naturally or by trauma), resulting in reproduction by fission. Sexual maturity is at approx.50 mm body length. Highly fecund - approx.50,000 eggs can be produced by a female of approx.300 mm body length. Appears to have an annual spawning cycle, gametes released in midwinter in Melbourne, Australia. Larvae can remain in the water column for 14 days.
Resistance to control	Highly resistant to control. Chemical control is difficult as *S. spallanzanii* is found subtidally. Manual search and removal is difficult as small individuals are challenging to locate amongst other fouling organisms. Despite a large search and cull effort in Lyttelton and Waitemata harbours, elimination efforts were abandoned two years after first detection.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	Low	High
Marine	Low	Low

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	H	Dense beds of Mediterranean fanworm clog recreational and commercial fishing gear. Also has negative impacts on aquaculture due to dense fouling on structures and on farmed shellfish.	
Other	-	-		
International trade	L	M	May impact volume and quality of exported seafood, e.g. oysters, mussels.	
Environment				
Soil resources	-	-		
Water quality	L	L	Mediterranean fanworm prefers waters with high nutrient levels. Thus the presence of this organism may also be an indicator of poor water quality. May displace other more effective filter feeders, resulting in a negative impact on water	3, 4

Category	Current	Potential	Comment	Source
			quality. Mediterranean fanworm excretes nitrogen in the form of ammonia, further increasing nutrient loads in the surrounding water. Also has high potential to disrupt established nutrient pathways.	
Species diversity	L	H	Although not currently present in high numbers in Tauranga, there is high potential for Mediterranean fanworm to smother and out-compete other organisms.	1, 2, 3
Threatened species	L	L	Unknown if Mediterranean fanworm will impact threatened species (little is known about threatened species within the same habitat).	1, 2, 3
Social/Cultural				
Human health	L	L	Not consumed by humans.	
Recreation	L	M	Will likely impact recreational seafood collection (e.g. mussels, oysters). Can also clog recreational scallop dredges. Will rapidly settle on and foul the hulls of recreational vessels.	1, 3
Māori culture	L	M	See Recreation, particularly regarding seafood collection from traditional areas.	

L = low, M = moderate, H = high
source 1: Read et al. (2011), 2: Ministry for Primary Industries (2016), 3: Currie et al. (2000), 4: Ministry for Primary Industries (2013)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	60.24-294.48	602.40-3,681.00
- Marine	0.81-3.96	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Mediterranean fanworm**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **46,481.6 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0.01 ha	Time to reach maximum extent†	50 yrs
Current impacts★	$83.86/ha	Potential extent in the region°	5,368 ha
	$28.48-139.24/ha		1,830.6-8,904.63 ha
Current benefits	$0/ha	Discount rate	4%

★ Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region with the assumptions made.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$681,545 min: 104,542 max: 3,488,271	$0		$0	$0	$0	
Progressive Containment (region)	$7	$0	$681,538	$843,533	$626	$0	$-162,621
	min: 2 max: 12		min: 104,540 max: 3,488,259		min: 413 max: 844		min: -739,837 max: 2,644,313

★ Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$595,006,714 min: 97,815,089 max: 3,013,507,455	$0		$0	$0	$0	
Progressive Containment (region)	$17	$0	$595,006,697	$2,234,147	$626	$0	$592,771,924
	min: 6 max: 30		min: 97,815,083 max: 3,013,507,425		min: 413 max: 844		min: 95,580,092 max: 3,011,272,865

3.14 Pyura (*Pyura doppelgangera*)

Relevant biology

Attribute	Description
Form	Part of a species complex that may be mistaken for other *Pyura* species. Solitary, stumpy, when out of water two large mounds represent siphons set in the depressed upper surface of the body. Exterior body wall (test) is tough, thick, covered with sand and algal filaments, appears green and sandy in texture. When submerged, siphons are visible and are bright reddish-orange. Up to 60 mm in length, 30-50 mm in diameter.
Habitat	Intertidal on hard platforms (rocks and wharf piles). Appears to prefer exposed coastlines.
Regional distribution	Not currently present in the Bay of Plenty. Elsewhere found in Goughs Bay, Nelson, Paihia, Kaimaumau, Pukenui, and along the Northland coastline.
Competitive ability	High potential to smother native species, reach 100% cover, and exclude all other species.
Reproductive ability	Information is scarce, however, larvae have a very short pelagic phase (less than 24 hours).
Resistance to control	Manual removal, although this has not been utilised extensively. No current chemical controls.
Benefits	Used as bait for land-based fishing from rocks in Australia.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	High
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	-
Estuarine	-	High
Marine	-	High

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	-		1, 2
Horticulture	-	-		
Aquaculture	-	H	Has high potential for smothering aquaculture structures, particularly oyster and mussel farms.	
Other	-	-		
International trade	-	L	May impact volume and quality of exported seafood, e.g. oysters, mussels.	
Environment				
Soil resources	-	-		
Water quality	-	L	As a filter feeder, *P. doppelgangera* may have a positive impact on water quality. However, there may be negative impacts from displacement of other, more effective filter feeders.	2, 3
Species diversity	-	H	Forms dense mats, smothering other organisms.	2, 3
Threatened species	-	L	Unknown if *P. doppelgangera* will impact threatened species (little is known about threatened species within the same habitat).	2, 3
Social/Cultural				
Human health	-	L	Not consumed by humans.	
Recreation	-	M	Will likely impact recreational coastal shellfish fisheries (e.g. mussels). *P. doppelgangera* can potentially smother rocks and exclude shellfish.	1, 2
Māori culture	-	M	See Recreation	

L = low, M = moderate, H = high
source 1: Hayward & Morley (2009), 2: Ministry for Primary Industries (2015), 3: Teske et al. (2015)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	330.50-2,019.50
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	0
- Estuarine	0	602.40-3,681.00
- Marine	0	8.10-49.50

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Pyura**
Proposed management programme: **Exclusion (region)**
Area of Programme: **22,568.6 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	4,885 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$8,779	$0		$0	$0	$0	
	min: 1,617 max: 45,265						
Exclusion (region)	$0	$0	$8,779	$843,533	$0	$0	$-834,754
	min: 0 max: 0		min: 1,617 max: 45,265				min: -841,916 max: -798,268

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$6,021,401	$0		$0	$0	$0	
	min: 1,026,246 max: 31,047,359						
Exclusion (region)	$0	$0	$6,021,401	$2,234,147	$0	$0	$3,787,254
	min: 0 max: 0		min: 1,026,246 max: 31,047,359				min: -1,207,901 max: 28,813,212

3.15 Wallaby (Progressive Containment) (*Macropus eugenii*)

Relevant biology

Attribute	Description
Form	Dama wallaby (*Macropus eugenii*) stands 0.5 m high and weigh approximately 4-7 kg. Grey-brown in colour with reddish shoulders. Nocturnal.
Habitat	Prefers forested or scrubby habitat with access to pasture (bush-pasture margins), using dense vegetation for shelter and cover during the day.
Regional distribution	Have expanded their range from Lake Ōkataina catchment to occupy approx. 200,000 ha east of Lake Rotorua to near Rangitāiki river, and north to Matatā. Also south into the Waikato.
Competitive ability	Impacts on native vegetation by selectively browsing palatable plant species. Competes with other pastoral grazers and damages young tree crops.
Reproductive ability	Female are mature after 1 year and can produce one offspring per year (twins are rare).
Resistance to control	Controlled with poisons, trapping and shooting. No predators in New Zealand.
Benefits	Export trade in joeys and adults as pets. Some species are endangered in their native range in Australia.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	Low
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	L	Grazing of pasture by wallabies can lower food availability for livestock. Potential reservoir host of bovine Tb, but no reported cases.	
Sheep and beef	L	L	Grazing of pasture by wallabies can lower food availability for livestock. Potential reservoir host of bovine Tb, but no reported cases.	
Forestry	L	M	Causes damage to newly planted radiata pine plantations.	1, 2, 3
Horticulture	-	L	May browse crops that are close to suitable cover.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-	Could cause a problem if they become a reservoir host for bovine Tb.	
Environment				
Soil resources	L	M	Removal of vegetation through browsing and trampling causes erosion.	1, 2, 4
Water quality	L	M	Erosion of soil can lead to increased sedimentation in waterways.	1
Species diversity	M	H	Browses native forest seedlings and destroys understorey. Favoured species include kamahi and māhoe, also hangehange, pigeonwood, mānuka, kānuka and ferns.	2, 4
Threatened species	L	M		1, 5
Social/Cultural				
Human health	-	L	Direct transmission of bovine Tb to humans is highly unlikely, however wallaby-cattle-human transmission route is a very slight possibility.	

Category	Current	Potential	Comment	Source
Recreation	-	-		
Māori culture	L	M	Can destroy ground vegetation at culturally important sites (e.g. wāhi tapu, urupa) and eat culturally important plants (e.g. koromiko).	

L = low, M = moderate, H = high
source 1: Severinsen (2003), 2: Auckland Regional Council (2004), 3: Environment Canterbury (2015), 4: Department of Conservation (2015), 5: Ritchie (2014)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wallaby**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$300,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	126,115.9 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$40.76/ha	Potential extent in the region°	320,818 ha
	$19.91-61.6/ha		126,115.9-515,520.5 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$56,408,772 min: 22,879,526 max: 122,312,609	$0		$0	$0	$0	
Progressive Containment (region)	$44,188,333	$0	$12,220,439	$2,530,599	$0	$84,353	$9,605,487
	min: 21,082,167 max: 68,355,898		min: 1,797,359 max: 53,956,711				min: -817,593 max: 51,341,759

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$162,900,656 min: 56,457,864 max: 507,290,014	$0		$0	$0	$0	
Progressive Containment (region)	$101,854,603	$0	$61,046,053	$6,702,442	$0	$84,353	$54,259,258
	min: 45,143,465 max: 168,237,536		min: 11,314,399 max: 339,052,478				min: 4,527,604 max: 332,265,683

3.16 Wallaby (Sustained Control) (*Macropus eugenii*)

Relevant biology

Attribute	Description
Form	Dama wallaby (*Macropus eugenii*) stands 0.5 m high and weigh approximately 4-7 kg. Grey-brown in colour with reddish shoulders. Nocturnal.
Habitat	Prefers forested or scrubby habitat with access to pasture (bush-pasture margins), using dense vegetation for shelter and cover during the day.
Regional distribution	Have expanded their range from Lake Ōkataina catchment to occupy approx. 200,000 ha east of Lake Rotorua to near Rangitāiki river, and north to Matatā. Also south into the Waikato.
Competitive ability	Impacts on native vegetation by selectively browsing palatable plant species. Competes with other pastoral grazers and damages young tree crops.
Reproductive ability	Female are mature after 1 year and can produce one offspring per year (twins are rare).
Resistance to control	Controlled with poisons, trapping and shooting. No predators in New Zealand.
Benefits	Export trade in joeys and adults as pets. Some species are endangered in their native range in Australia.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	Low
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	Low	Low
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	L		
Sheep and beef	L	L	Grazing of pasture by wallabies can lower food availability for livestock. Potential reservoir host of bovine Tb, but no reported cases.	
Forestry	L	M	Causes damage to newly planted radiata pine plantations.	1, 2, 3
Horticulture	-	L	May browse crops that are close to suitable cover.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-	Could cause a problem if they become a reservoir host for bovine Tb.	
Environment				
Soil resources	L	M	Removal of vegetation through browsing and trampling causes erosion.	1, 2, 4
Water quality	L	M	Erosion of soil can lead to increased sedimentation in waterways.	1
Species diversity	M	H	Browses native forest seedlings and destroys understorey. Favoured species include kamahi and māhoe, also hangehange, pigeonwood, mānuka, kānuka and ferns.	2, 4
Threatened species	L	M		1, 5
Social/Cultural				
Human health	-	L	Direct transmission of bovine Tb to humans is highly unlikely, however wallaby-cattle-human transmission route is a very slight possibility.	
Recreation	-	-		
Māori culture	L	M	Can destroy ground vegetation at culturally important sites	

Category	Current	Potential	Comment	Source
			(e.g. wāhi tapu, urupa) and eat culturally important plants (e.g. koromiko).	

L = low, M = moderate, H = high
source 1: Severinsen (2003), 2: Auckland Regional Council (2004), 3: Environment Canterbury (2015), 4: Department of Conservation (2015), 5: Ritchie (2014)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wallaby**
Proposed management programme: **Sustained Control (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$200,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	126,115.9 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$40.76/ha	Potential extent in the region°	320,818 ha
Current benefits	$19.91-61.6/ha $0/ha	Discount rate	126,115.9-515,520.5 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$56,408,772 min: 22,879,526 max: 122,312,609	$0		$0	$0	$0	
Sustained Control (region)	$50,414,418 min: 22,096,129 max: 84,039,706	$0	$5,994,354 min: 783,397 max: 38,272,903	$1,687,066	$0	$84,353	$4,222,935 min: -988,022 max: 36,501,484

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$162,900,656 min: 56,457,864 max: 507,290,014	$0		$0	$0	$0	
Sustained Control (region)	$158,588,572 min: 54,382,994 max: 311,153,124	$0	$4,312,084 min: 2,074,870 max: 196,136,890	$4,468,294	$0	$84,353	$-240,563 min: -2,477,777 max: 191,584,243

3.17 Didymo (*Didymosphenia geminata*)

Relevant biology

Attribute	Description
Form	Single celled, stalked dinoflagellate algae. Forms blooms of dense mats on stream, lake and river beds, approximately 10-30mm thick. Mat is brown on the surface (cellular layer) and white underneath (stalk layer).
Habitat	Freshwater stream, river and lake beds. Attaches to hard substrates (e.g. rocks), particularly in nutrient-poor waters.
Regional distribution	Not currently present in the Bay of Plenty. Widespread in South Island, particularly lower South Island. Main foci and centres of spread are the Mararoa, Waiau and Buller Rivers.
Competitive ability	During a bloom, didymo smothers rocks and plants. Very competitive, excludes all other organisms.
Reproductive ability	Although sexual reproduction has been documented, it is not often observed in blooms. Vegetative cell division (mitotic cell division) increases mat size but individual cells are smaller. Restoration of maximum cell size is achieved through formation and distribution of auxospores.
Resistance to control	Highly resistant. Doses of chelated copper (Gemex, 1 hr pulse dose of 20 mg Cu/L) have been shown to be effective on early-stage infestations. Controlling the movement of didymo via human vectors with the 'Check, Clean, Dry' campaign appears to have been largely successful in preventing movement into the North Island.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	L	Didymo may impact dairy through fouling of irrigation water intakes.	
Sheep and beef	-	L	Didymo may impact sheep and beef farming through fouling of irrigation water intakes.	
Forestry	-	-		1, 2
Horticulture	-	L	Didymo may impact horticulture through fouling of irrigation water intakes.	
Aquaculture	-	-		
Other	-	-		
International trade	-	L	May impact trout fishing tourism through restrictions on types of equipment allowed into NZ.	
Environment				
Soil resources	-	-		
Water quality	-	L	Appears to have little impact on sedimentation or water clarity, and nutrient levels appear to govern didymo growth rather than didymo affecting water chemistry. However, there are significant recreational impacts (see Recreation).	2
Species diversity	-	H	During blooms didymo can completely cover hard substrates in streams and rivers (100% cover), excluding other algae. Can increase invertebrate densities and causes shifts in	1

Category	Current	Potential	Comment	Source
			invertebrate community composition.	
Threatened species	-	M	Although ecosystem effects of didymo on native aquatic plants and algae are largely negative, it is unknown how this may affect native fishes (e.g. kōkopu).	1
Social/Cultural				
Human health	-	L	Has been reported to cause eye irritation to swimmers in affected areas.	2
Recreation	-	M	Will predominantly impact rivers of specific water chemistry (i.e. low phosphorus). Blooms of didymo will have significant impact on recreational swimmers (see Human Health) and on recreational fishermen, as it fouls fishing gear.	1, 2
Māori culture	-	M	The perceived loss of a waterway's health could be culturally devastating, particularly if it is a waterway of importance to Māori. See also Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Kilroy et al. (2009), 2: Root & O'Reilly (2012)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	54.63-267.08
- Sheep and beef	0	7.39-36.12
- Forestry	0	0
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Didymo**
Proposed management programme: **Exclusion (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$12,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	3,542 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$136,940 min: 27,581 max: 720,952	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$136,940 min: 27,581 max: 720,952	$101,224	$0	$0	$35,716 min: -73,643 max: 619,728

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$93,931,371 min: 14,283,063 max: 494,524,938	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$93,931,371 min: 14,283,063 max: 494,524,938	$268,098	$0	$0	$93,663,273 min: 14,014,965 max: 494,256,840

3.18 Kauri dieback disease (*Phytophthora agathidicida*)

Relevant biology

Attribute	Description
Form	Fungus-like disease specific to kauri (*Agathus australis*).
Habitat	Lives in the soil and infects trees through their roots.
Regional distribution	Not currently present in the Bay of Plenty.
Competitive ability	
Reproductive ability	Short-lived swimming spores and long-lived resistant spores.
Resistance to control	Potentially contaminated equipment and machinery can be cleaned and dried or treated with a disinfectant such as Trigene. There is no known tree or soil treatment currently available.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	High
Native terrestrial	-	High
Coastal land	-	-
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	-	L	Kauri are not commonly used in production forestry, but a few plots have been planted and there is future forestry potential.	1
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-		
International trade	-	L	Unlikely to affect international trade, unless wood or plant importing is carried out (but they could be fumigated).	
Environment				
Soil resources	-	L	Soil erosion could occur if major treefalls occur.	
Water quality	-	L	Possible impacts if significant treefalls occur, leading to erosion.	
Species diversity	-	M	Infection will kill kauri trees, but it is species-specific. Death of kauri trees could have a major impact on the whole ecosystem and any organisms dependant on kauri.	2, 3, 4
Threatened species	-	M	Kauri is classified as Threatened-Nationally Vulnerable (de Lange et al. 2018). Other species that depend on kauri and its associated forest ecosystem may be negatively affected.	
Social/Cultural				
Human health	-	-	Kauri is not consumed by humans. *Phytophthora agathidicida* (PTA) spores do not infect humans.	
Recreation	-	L	Sick trees, loss of kauri, and reduction in forest quality could negatively impact the recreational experience.	
Māori culture	-	M	Kauri is considered a taonga species: valued as a connection to the spiritual beliefs of Māori and way of life of their ancestors.	2

L = low, M = moderate, H = high
source 1: Steward et al. (2014), 2: Anon. (2017), 3: Belgard (2014), 4: NatureSpace (2017)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	17.47-85.40
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	27.80-61.20
- Coastal	0	0
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Kauri dieback disease**
Proposed management programme: **Exclusion (region)**
Area of Programme: **400 ha**
Proposed annual expenditure by Council: **$40,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	110 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$195 min: 95 max: 493	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$195 min: 95 max: 493	$337,413	$0	$0	$-337,218 min: -337,318 max: -336,920

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will still not be of net benefit to the region with the assumptions made. However, additional non-monetised benefits associated with the protection of biodiversity values are anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$10,726 min: 3,578 max: 82,665	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$10,726 min: 3,578 max: 82,665	$893,659	$0	$0	$-882,933 min: -890,081 max: -810,994

3.19 Alligator weed (Eradication-Tauranga) (*Alternanthera philoxeroides*)

Relevant biology

Attribute	Description
Form	A floating aquatic, but sometimes terrestrial, perennial herb. Stems are green-brown, hollow and rooting at nodes. Leaves are obovate to narrow-elliptical.
Habitat	Still water to 1.5 m deep, or flowing fresh water. Tolerates up to 30% sea water. Will grow on moist banks, swampy places, damp pasture and cropping land.
Regional distribution	17 scattered sites in the Bay of Plenty, from a kiwifruit orchard near Ōpōtiki, the Rangitāiki Plains, and west to Tauranga and Katikati. Very low levels and small sites in western part of region. More widespread and some larger sites in eastern Bay of Plenty. Worst infestations along 30 km of Rangitāiki River.
Competitive ability	Floating mats shade out other plants. Biomass doubles in 50 days. Will out-compete pasture species.
Reproductive ability	No viable seeds are produced.
Dispersal methods	Fragments dispersed by cultivation machinery, as weeds or contaminants of aquatic plant trade.
Resistance to control	Effective control is difficult, even in small waterways, swampy pastures and cropping land. Use of herbicide in and beside waterways makes control difficult.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	High
Sheep and beef	-	High
Forestry	-	High
Horticulture	Low	High
Aquaculture	-	-
Urban	-	High
Native terrestrial	-	High
Coastal land	Low	Low
Freshwater	Low	Low
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	H	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Sheep and beef	L	M	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Forestry	-	-		1, 2, 3
Horticulture	L	M	Can spread through wetlands and waterways on farms. Can spread through wetlands and waterways onto cropping land, out-competing other species.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	L	L	Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Species diversity	L	H	Replaces most other herbaceous species on water and dry land. Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1

Category	Current	Potential	Comment	Source
Threatened species	L	M		1
Social/Cultural				
Human health	-	-		
Recreation	L	M	Obstructs access to waterways for fishing, swimming, kayaking etc.	4
Māori culture	L	H	Could degrade waterways and invade culturally important sites (e.g. wāhi tapu, urupa).	4

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Roy et al. (2004), 3: Environment Bay of Plenty (2004), 4: Severinsen (2003)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	546.30-3,338.50
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	55.60-340.00
- Coastal	12.47-61.00	124.70-762.50
- Freshwater	190.70-1,092.40	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Alligator weed**
Proposed management programme: **Eradication (Tauranga Harbour catchment)**
Area of Programme: **150,551.9 ha**
Proposed annual expenditure by Council: **$22,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0.546 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$191.53/ha $64.91-318.14/ha	Potential extent in the region°	18,204 ha 6,072.08-30,336.29 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$48,891 min: 9,937 max: 243,231	$0		$0	$0	$0	
Eradication (Tauranga Harbour catchment)	$519 min: 169 max: 897	$0	$48,372 min: 9,768 max: 242,334	$185,577	$0	$0	$-137,205 min: -175,809 max: 56,757

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$27,361,513 min: 5,544,747 max: 136,358,487	$0		$0	$0	$0	
Eradication (Tauranga Harbour catchment)	$536 min: 169 max: 953	$0	$27,360,977 min: 5,544,578 max: 136,357,534	$209,313	$0	$0	$27,151,664 min: 5,335,265 max: 136,148,221

3.20 Alligator weed (Eradication) (*Alternanthera philoxeroides*)

Relevant biology

Attribute	Description
Form	A floating aquatic, but sometimes terrestrial, perennial herb. Stems are green-brown, hollow and rooting at nodes. Leaves are obovate to narrow-elliptical.
Habitat	Still water to 1.5 m deep, or flowing fresh water. Tolerates up to 30% sea water. Will grow on moist banks, swampy places, damp pasture and cropping land.
Regional distribution	17 scattered sites in the Bay of Plenty, from a kiwifruit orchard near Ōpōtiki, the Rangitāiki Plains, and west to Tauranga and Katikati. Very low levels and small sites in western part of region. More widespread and some larger sites in eastern Bay of Plenty. Worst infestations along 30 km of Rangitāiki River.
Competitive ability	Floating mats shade out other plants. Biomass doubles in 50 days. Will out-compete pasture species.
Reproductive ability	No viable seeds are produced.
Dispersal methods	Fragments dispersed by cultivation machinery, as weeds or contaminants of aquatic plant trade.
Resistance to control	Effective control is difficult, even in small waterways, swampy pastures and cropping land. Use of herbicide in and beside waterways makes control difficult.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	High
Sheep and beef	Low	High
Forestry	Low	High
Horticulture	Low	High
Aquaculture	-	-
Urban	Low	High
Native terrestrial	Low	High
Coastal land	Low	Low
Freshwater	Low	Low
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	H	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Sheep and beef	L	M	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Forestry	-	-		1, 2, 3
Horticulture	L	M	Can spread through wetlands and waterways on farms. Can spread through wetlands and waterways onto cropping land, out-competing other species.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	L	L	Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Species diversity	L	H	Replaces most other herbaceous species on water and dry land. Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1

Category	Current	Potential	Comment	Source
Threatened species	L	M		1
Social/Cultural				
Human health	-	-		
Recreation	L	M	Obstructs access to waterways for fishing, swimming, kayaking etc.	4
Māori culture	L	H	Could degrade waterways and invade culturally important sites (e.g. wāhi tapu, urupa).	4

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Roy et al. (2004), 3: Environment Bay of Plenty (2004), 4: Severinsen (2003)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	546.30-3,338.50
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	5.56-27.20	55.60-340.00
- Coastal	12.47-61.00	124.70-762.50
- Freshwater	190.70-1,092.40	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Alligator weed**
Proposed management programme: **Eradication (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$200,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	3.369 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$49.9/ha	Potential extent in the region°	179,299 ha
Current benefits	$16.42-83.37/ha $0/ha	Discount rate	59,815.34-298,782.7 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$106,191 min: 20,460 max: 533,978	$0		$0	$0	$0	
Eradication (region)	$834 min: 263 max: 1,451	$0	$105,357 min: 20,197 max: 532,527	$1,687,066	$0	$0	$-1,581,709 min: -1,666,869 max: -1,154,539

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$39,307,860 min: 7,247,639 max: 199,450,933	$0		$0	$0	$0	
Eradication (region)	$862 min: 263 max: 1,541	$0	$39,306,998 min: 7,247,376 max: 199,449,392	$1,831,052	$0	$0	$37,475,946 min: 5,416,324 max: 197,618,340

3.21 Alligator weed (Exclusion) (*Alternanthera philoxeroides*)

Relevant biology

Attribute	Description
Form	A floating aquatic, but sometimes terrestrial, perennial herb. Stems are green-brown, hollow and rooting at nodes. Leaves are obovate to narrow-elliptical.
Habitat	Still water to 1.5 m deep, or flowing fresh water. Tolerates up to 30% sea water. Will grow on moist banks, swampy places, damp pasture and cropping land.
Regional distribution	17 scattered sites in the Bay of Plenty, from a kiwifruit orchard near Ōpōtiki, the Rangitāiki Plains, and west to Tauranga and Katikati. Very low levels and small sites in western part of region. More widespread and some larger sites in eastern Bay of Plenty. Worst infestations along 30 km of Rangitāiki River.
Competitive ability	Floating mats shade out other plants. Biomass doubles in 50 days. Will out-compete pasture species.
Reproductive ability	No viable seeds are produced.
Dispersal methods	Fragments dispersed by cultivation machinery, as weeds or contaminants of aquatic plant trade.
Resistance to control	Effective control is difficult, even in small waterways, swampy pastures and cropping land. Use of herbicide in and beside waterways makes control difficult.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	High
Sheep and beef	-	High
Forestry	-	High
Horticulture	-	High
Aquaculture	-	-
Urban	-	High
Native terrestrial	-	High
Coastal land	-	Low
Freshwater	-	Low
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	H	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Sheep and beef	-	M	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Forestry	-	-		1, 2, 3
Horticulture	-	M		
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	L	Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Species diversity	-	H	Replaces most other herbaceous species on water and dry land. Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Threatened species	-	M		1
Social/Cultural				

Category	Current	Potential	Comment	Source
Human health	-	-		
Recreation	-	M	Obstructs access to waterways for fishing, swimming, kayaking etc.	4
Māori culture	-	H	Could degrade waterways and invade culturally important sites (e.g. wāhi tapu, urupa).	4

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Roy et al. (2004), 3: Environment Bay of Plenty (2004), 4: Severinsen (2003)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	546.30-3,338.50
- Sheep and beef	0	36.95-81.27
- Forestry	0	0
- Horticulture	0	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	55.60-340.00
- Coastal	0	124.70-762.50
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Alligator weed**
Proposed management programme: **Exclusion (areas not present)**
Area of Programme: **220,343.8 ha**
Proposed annual expenditure by Council: **$5,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$0/ha	Potential extent in the region°	29,563 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$42,241 min: 7,833 max: 213,538	$0		$0	$0	$0	
Exclusion (areas not present)	$0 min: 0 max: 0	$0	$42,241 min: 7,833 max: 213,538	$42,177	$0	$0	$64 min: -34,344 max: 171,361

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$40,861,911 min: 7,576,650 max: 206,569,115	$0		$0	$0	$0	
Exclusion (areas not present)	$0 min: 0 max: 0	$0	$40,861,911 min: 7,576,650 max: 206,569,115	$111,707	$0	$0	$40,750,204 min: 7,464,943 max: 206,457,408

3.22 Alligator weed (Progressive Containment-East) (*Alternanthera philoxeroides*)

Relevant biology

Attribute	Description
Form	A floating aquatic, but sometimes terrestrial, perennial herb. Stems are green-brown, hollow and rooting at nodes. Leaves are obovate to narrow-elliptical.
Habitat	Still water to 1.5 m deep, or flowing fresh water. Tolerates up to 30% sea water. Will grow on moist banks, swampy places, damp pasture and cropping land.
Regional distribution	17 scattered sites in the Bay of Plenty, from a kiwifruit orchard near Ōpōtiki, the Rangitāiki Plains, and west to Tauranga and Katikati. Very low levels and small sites in western part of region. More widespread and some larger sites in eastern Bay of Plenty. Worst infestations along 30 km of Rangitāiki River.
Competitive ability	Floating mats shade out other plants. Biomass doubles in 50 days. Will out-compete pasture species.
Reproductive ability	No viable seeds are produced.
Dispersal methods	Fragments dispersed by cultivation machinery, as weeds or contaminants of aquatic plant trade.
Resistance to control	Effective control is difficult, even in small waterways, swampy pastures and cropping land. Use of herbicide in and beside waterways makes control difficult.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	High
Sheep and beef	Low	High
Forestry	Low	High
Horticulture	Low	High
Aquaculture	-	-
Urban	Low	High
Native terrestrial	Low	High
Coastal land	Low	Low
Freshwater	Low	Low
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	H	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Sheep and beef	L	M	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Forestry	-	-		1, 2, 3
Horticulture	L	M		
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	L	L	Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Species diversity	L	H	Replaces most other herbaceous species on water and dry land. Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Threatened species	L	M		1
Social/Cultural				

Category	Current	Potential	Comment	Source
Human health	-	-		
Recreation	L	M	Obstructs access to waterways for fishing, swimming, kayaking etc.	4
Māori culture	L	H	Could degrade waterways and invade culturally important sites (e.g. wāhi tapu, urupa).	4

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Roy et al. (2004), 3: Environment Bay of Plenty (2004), 4: Severinsen (2003)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	546.30-3,338.50
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	5.56-27.20	55.60-340.00
- Coastal	12.47-61.00	124.70-762.50
- Freshwater	190.70-1,092.40	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Alligator weed**
Proposed management programme: **Progressive Containment (defined area)**
Area of Programme: **881,066.8 ha**
Proposed annual expenditure by Council: **$80,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	3.1053 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$31.32/ha	Potential extent in the region°	130,266 ha
Current benefits	$10.57-52.07/ha $0/ha	Discount rate	43,428.62-217,104.3 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$53,688 min: 10,331 max: 270,175	$0		$0	$0	$0	
Progressive Containment (defined area)	$738	$0	$52,950	$674,827	$54,988	$337,413	$-1,014,278
	min: 223 max: 1,358		min: 10,108 max: 268,817		min: 37,302 max: 75,300		min: -1,077,432 max: -780,725

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$23,099,934 min: 4,141,931 max: 117,872,722	$0		$0	$0	$0	
Progressive Containment (defined area)	$1,119	$0	$23,098,815	$1,535,005	$55,142	$337,413	$21,171,255
	min: 264 max: 2,907		min: 4,141,667 max: 117,869,815		min: 37,302 max: 75,300		min: 2,193,949 max: 115,960,095

3.23 Alligator weed (Progressive Containment) (*Alternanthera philoxeroides*)

Relevant biology

Attribute	Description
Form	A floating aquatic, but sometimes terrestrial, perennial herb. Stems are green-brown, hollow and rooting at nodes. Leaves are obovate to narrow-elliptical.
Habitat	Still water to 1.5 m deep, or flowing fresh water. Tolerates up to 30% sea water. Will grow on moist banks, swampy places, damp pasture and cropping land.
Regional distribution	17 scattered sites in the Bay of Plenty, from a kiwifruit orchard near Ōpōtiki, the Rangitāiki Plains, and west to Tauranga and Katikati. Very low levels and small sites in western part of region. More widespread and some larger sites in eastern Bay of Plenty. Worst infestations along 30 km of Rangitāiki River.
Competitive ability	Floating mats shade out other plants. Biomass doubles in 50 days. Will out-compete pasture species.
Reproductive ability	No viable seeds are produced.
Dispersal methods	Fragments dispersed by cultivation machinery, as weeds or contaminants of aquatic plant trade.
Resistance to control	Effective control is difficult, even in small waterways, swampy pastures and cropping land. Use of herbicide in and beside waterways makes control difficult.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	Low	High
Sheep and beef	Low	High
Forestry	Low	High
Horticulture	Low	High
Aquaculture	-	-
Urban	Low	High
Native terrestrial	Low	High
Coastal land	Low	Low
Freshwater	Low	Low
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	H	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Sheep and beef	L	M	Can spread through wetlands and waterways onto farmland, outcompeting pasture species. Causes photosensitivity in stock.	
Forestry	-	-		1, 2, 3
Horticulture	L	M		
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	L	L	Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Species diversity	L	H	Replaces most other herbaceous species on water and dry land. Causes silt accumulation, obstructs water usage, causes flooding. Rotting vegetation degrades habitat for aquatic fauna and flora.	1
Threatened species	L	M		1
Social/Cultural				

Category	Current	Potential	Comment	Source
Human health	-	-		
Recreation	L	M	Obstructs access to waterways for fishing, swimming, kayaking etc.	4
Māori culture	L	H	Could degrade waterways and invade culturally important sites (e.g. wāhi tapu, urupa).	4

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Roy et al. (2004), 3: Environment Bay of Plenty (2004), 4: Severinsen (2003)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	546.30-3,338.50
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	0	0
- Horticulture	95.20-465.44	476.00-1,047.24
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	5.56-27.20	55.60-340.00
- Coastal	12.47-61.00	124.70-762.50
- Freshwater	190.70-1,092.40	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Alligator weed**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	3.369 ha	Time to reach maximum extent†	75 yrs
Current impacts★	$49.9/ha	Potential extent in the region°	179,299 ha
Current benefits	$16.42-83.37/ha $0/ha	Discount rate	59,815.34-298,782.7 ha 4%

★ Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$106,191 min: 20,460 max: 533,978	$0		$0	$0	$0	
Progressive Containment (region)	$1,275 min: 375 max: 2,358	$0	$104,916 min: 20,085 max: 531,620	$843,533	$59,657 min: 40,469 max: 81,695	$337,413	$-1,135,687 min: -1,242,556 max: -689,795

★ Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts★	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$39,307,860 min: 7,247,639 max: 199,450,933	$0		$0	$0	$0	
Progressive Containment (region)	$1,933 min: 445 max: 5,049	$0	$39,305,927 min: 7,247,194 max: 199,445,884	$1,917,958	$59,825 min: 40,469 max: 81,695	$337,413	$36,990,731 min: 4,910,128 max: 197,150,044

3.24 Egeria (Exclusion) (*Egeria densa*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to 5 m. Stems slender, brittle, much-branched, buoyant, 3 mm diameter Leaves in whorls of 4-6 (occ. 3 near base), linear, 15-30 x 4 mm, dark green. Flowers on surface, 3-petalled, 20 mm diam, white with 9 yellow stamens, Nov-Jan.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and 10-25 degrees C.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Rotomāhana, Rerewhakaaitu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only male plants found in NZ, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Can be controlled effectively using specialist herbicide and appropriate techniques.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	-	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	-	H	Forms vast underwater meadows in freshwater up to 5 m tall, shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing other fauna and flora.	1, 2, 4
Threatened species	-	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	-	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	-	M	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the waterway.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Egeria**
Proposed management programme: **Exclusion (lakes not present)**
Area of Programme: **1,086 ha**
Proposed annual expenditure by Council: **$115,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	189 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$50,562 min: 10,256 max: 127,012	$0		$0	$0	$0	
Exclusion (lakes not present)	$0	$0	$50,562	$970,063	$0	$0	$-919,501
	min: 0 max: 0		min: 10,256 max: 127,012				min: -959,807 max: -843,051

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$5,534,086 min: 804,421 max: 28,744,054	$0		$0	$0	$0	
Exclusion (lakes not present)	$0	$0	$5,534,086	$2,569,269	$0	$0	$2,964,817
	min: 0 max: 0		min: 804,421 max: 28,744,054				min: -1,764,848 max: 26,174,785

3.25 Egeria (Progressive Containment) (*Egeria densa*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to 5 m. Stems slender, brittle, much-branched, buoyant, 3 mm diameter Leaves in whorls of 4-6 (occ. 3 near base), linear, 15-30 x 4 mm, dark green. Flowers on surface, 3-petalled, 20 mm diam, white with 9 yellow stamens, Nov-Jan.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and 10-25 degrees C.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Rotomāhana, Rerewhakaaitu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only male plants found in NZ, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Can be controlled effectively using specialist herbicide and appropriate techniques.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast underwater meadows in freshwater up to 5 m tall, shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing other fauna and flora.	1, 2, 4
Threatened species	L	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the waterway.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Egeria**
Proposed management programme: **Progressive Containment (lakes where present)**
Area of Programme: **4,739 ha**
Proposed annual expenditure by Council: **$46,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,067 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha $953.5-2,457.9/ha	Potential extent in the region°	1,083 ha 1,067-1,099.25 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$16,643,066 min: 9,269,284 max: 24,100,228	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$6,556,579 min: 2,827,667 max: 12,486,682	$0	$10,086,487 min: 6,441,617 max: 11,613,546	$289,331	$0	$2,826,157	$6,970,999 min: 3,326,129 max: 8,498,058

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$41,266,090 min: 22,873,026 max: 60,059,025	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$6,556,579 min: 2,827,667 max: 12,486,682	$0	$34,709,511 min: 20,045,359 max: 47,572,343	$297,518	$0	$2,826,157	$31,585,836 min: 16,921,684 max: 44,448,668

3.26 Egeria (Sustained Control-all Rotorua lakes) (*Egeria densa*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to 5 m. Stems slender, brittle, much-branched, buoyant, 3 mm diameter Leaves in whorls of 4-6 (occ. 3 near base), linear, 15-30 x 4 mm, dark green. Flowers on surface, 3-petalled, 20 mm diam, white with 9 yellow stamens, Nov-Jan.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and 10-25 degrees C.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Rotomāhana, Rerewhakaaitu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only male plants found in NZ, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Can be controlled effectively using specialist herbicide and appropriate techniques.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast underwater meadows in freshwater up to 5 m tall, shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing other fauna and flora.	1, 2, 4
Threatened species	L	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the waterway.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Egeria**
Proposed management programme: **Sustained Control (all Rotorua Lakes)**
Area of Programme: **5,655 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,067 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,240 ha
	$953.5-2,457.9/ha		1,067-1,413.75 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$17,369,752 min: 9,269,284 max: 26,598,168	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$14,544,194 min: 8,130,321 max: 20,958,067	$0	$2,825,558 min: 1,138,963 max: 5,640,101	$57,360	$0	$358,502	$2,409,696 min: 723,101 max: 5,224,239

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$44,737,909 min: 22,873,026 max: 71,995,262	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$26,020,953 min: 14,545,922 max: 37,495,985	$0	$18,716,956 min: 8,327,104 max: 34,499,277	$151,922	$0	$358,502	$18,206,532 min: 7,816,680 max: 33,988,853

3.27 Egeria (Sustained Control-some Rotorua lakes) (*Egeria densa*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to 5 m. Stems slender, brittle, much-branched, buoyant, 3 mm diameter Leaves in whorls of 4-6 (occ. 3 near base), linear, 15-30 x 4 mm, dark green. Flowers on surface, 3-petalled, 20 mm diam, white with 9 yellow stamens, Nov-Jan.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and 10-25 degrees C.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Rotomāhana, Rerewhakaaitu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only male plants found in NZ, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Can be controlled effectively using specialist herbicide and appropriate techniques.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast underwater meadows in freshwater up to 5 m tall, shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing other fauna and flora.	1, 2, 4
Threatened species	L	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Egeria**
Proposed management programme: **Sustained Control (Rotorua lakes where present)**
Area of Programme: **4,739 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,067 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,083 ha
	$953.5-2,457.9/ha		1,067-1,099.25 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$16,643,066 min: 9,269,284 max: 24,100,228	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$14,911,623 min: 8,130,321 max: 22,016,990	$0	$1,731,443 min: 1,138,963 max: 2,083,238	$57,360	$0	$358,502	$1,315,581 min: 723,101 max: 1,667,376

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$41,266,090 min: 22,873,026 max: 60,059,025	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$29,369,073 min: 14,545,922 max: 47,145,211	$0	$11,897,017 min: 8,327,104 max: 12,913,814	$151,922	$0	$358,502	$11,386,593 min: 7,816,680 max: 12,403,390

3.28 Elodea (Exclusion) (*Elodea canadensis*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to over 8 m. Stems slender, brittle, branched, 1 mm diameter Leaves in whorls of 3 (opposite at base), linear, 6-12 x 2 mm, translucent dark green. Male (very rare) and female flowers on separate plants. Flowers on surface, on long thread-like stalks, 5-petalled, 5 mm diameter, white, tinged purple.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and temperatures under 28 degrees C.
Regional distribution	Lakes Ōkāreka, Ōkaro, Ōkataina, Rerewhakaaitu, Rotoehu, Rotoiti, Rotokākahi, Rotomā, Rotorua, Tarawera, Tikitapu and other waterbodies.
Competitive ability	Tends to be replaced by Lagarosiphon or Egeria if these are introduced into the same waterbody.
Reproductive ability	Grows easily from broken fragments. No seed set in NZ. Deliberately spread by humans.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	-	H	Forms dense masses in freshwater up to 10 m tall (to 10 m deep), shades out native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	-	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause	5

Category	Current	Potential	Comment	Source
			'swimmers itch'.	
Recreation	-	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	-	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Elodea**
Proposed management programme: **Exclusion (Lake Rotomāhana)**
Area of Programme: **312 ha**
Proposed annual expenditure by Council: **$23,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	47 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$29,769 min: 5,747 max: 81,111	$0		$0	$0	$0	
Exclusion (Lake Rotomāhana)	$0	$0	$29,769	$194,013	$0	$0	$-164,244
	min: 0 max: 0		min: 5,747 max: 81,111				min: -188,266 max: -112,902

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$1,325,312 min: 187,636 max: 7,276,114	$0		$0	$0	$0	
Exclusion (Lake Rotomāhana)	$0	$0	$1,325,312	$513,854	$0	$0	$811,458
	min: 0 max: 0		min: 187,636 max: 7,276,114				min: -326,218 max: 6,762,260

3.29 Elodea (Sustained Control-all Rotorua lakes) (*Elodea canadensis*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to over 8 m. Stems slender, brittle, branched, 1 mm diameter Leaves in whorls of 3 (opposite at base), linear, 6-12 x 2 mm, translucent dark green. Male (very rare) and female flowers on separate plants. Flowers on surface, on long thread-like stalks, 5-petalled, 5 mm diameter, white, tinged purple.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and temperatures under 28 degrees C.
Regional distribution	Lakes Ōkāreka, Ōkaro, Ōkataina, Rerewhakaaitu, Rotoehu, Rotoiti, Rotokākahi, Rotomā, Rotorua, Tarawera, Tikitapu and other waterbodies.
Competitive ability	Tends to be replaced by Lagarosiphon or Egeria if these are introduced into the same waterbody.
Reproductive ability	Grows easily from broken fragments. No seed set in NZ. Deliberately spread by humans.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense masses in freshwater up to 10 m tall (to 10 m deep), shades out native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause	5

Category	Current	Potential	Comment	Source
			'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Elodea**
Proposed management programme: **Sustained Control (all Rotorua Lakes)**
Area of Programme: **5,655 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	500 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	957 ha
	$953.5-2,457.9/ha		500-1,413.75 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$9,046,396 min: 4,343,620 max: 16,899,243	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$6,987,640 min: 3,809,898 max: 10,317,240	$0	$2,058,756 min: 533,722 max: 6,582,003	$57,360	$0	$358,502	$1,642,894 min: 117,860 max: 6,166,141

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$25,411,789 min: 10,718,382 max: 60,281,692	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$13,762,452 min: 6,816,271 max: 22,092,414	$0	$11,649,337 min: 3,902,111 max: 38,189,278	$151,922	$0	$358,502	$11,138,913 min: 3,391,687 max: 37,678,854

3.30 Elodea (Sustained Control-some Rotorua lakes) (*Elodea canadensis*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, growing to over 8 m. Stems slender, brittle, branched, 1 mm diameter Leaves in whorls of 3 (opposite at base), linear, 6-12 x 2 mm, translucent dark green. Male (very rare) and female flowers on separate plants. Flowers on surface, on long thread-like stalks, 5-petalled, 5 mm diameter, white, tinged purple.
Habitat	Rivers, lakes, dune lakes, other waterbodies with mod-high light and temperatures under 28 degrees C.
Regional distribution	Lakes Ōkāreka, Ōkaro, Ōkataina, Rerewhakaaitu, Rotoehu, Rotoiti, Rotokākahi, Rotomā, Rotorua, Tarawera, Tikitapu and other waterbodies.
Competitive ability	Tends to be replaced by Lagarosiphon or Egeria if these are introduced into the same waterbody.
Reproductive ability	Grows easily from broken fragments. No seed set in NZ. Deliberately spread by humans.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense masses in freshwater up to 10 m tall (to 10 m deep), shades out native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	M		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause	5

Category	Current	Potential	Comment	Source
			'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Elodea**
Proposed management programme: **Sustained Control (Rotorua lakes where present)**
Area of Programme: **5,513 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	500 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	918 ha
Current benefits	$953.5-2,457.9/ha $0/ha	Discount rate	500-1,335.75 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$8,990,281 min: 4,343,620 max: 16,534,830	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$6,987,640 min: 3,809,898 max: 10,317,240	$0	$2,002,641 min: 533,722 max: 6,217,590	$57,360	$0	$358,502	$1,586,779 min: 117,860 max: 5,801,728

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$25,124,462 min: 10,718,382 max: 57,676,185	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$13,762,452 min: 6,816,271 max: 22,092,414	$0	$11,362,010 min: 3,902,111 max: 35,583,771	$151,922	$0	$358,502	$10,851,586 min: 3,391,687 max: 35,073,347

3.31 Gorse (Progressive Containment) (*Ulex europaeus*)

Relevant biology

Attribute	Description
Form	Sharply spiny perennial shrub up to 4 m tall. Leaves reduced to a spine-like tip. Spines deeply furrowed. Very deep tap root and extensive lateral roots. Flowers are pea-like, yellow, 13-20 mm long, May-Nov (sometimes all year). Seed pod hairy, turning black, 13-25 mm long, explosive.
Habitat	Grassland, shrubland, forest margins (including plantation forests), hill country, coastal habitats, sand dunes, and wastelands. Tolerant of hot to cold, high to low rainfall, wind, salt, damage, grazing, and all soil types. Optimum growth on low fertility soils.
Regional distribution	Common/abundant in suitable habitat throughout the region.
Competitive ability	Fast growth and being a nitrogen fixer means it can compete effectively with tree seedlings.
Reproductive ability	Seeds have hard coat, can be dormant for up to 30 years. Huge seed bank in soil (estimated 20,000 seeds/m^2).
Dispersal methods	Most seeds fall close to parent plant but may be ejected up to 6 m. Also spread by water, birds, road making gravel and machinery.
Resistance to control	Difficult to control on infertile and steep land, as burning and grazing not effective. Stumps re-sprout quickly after damage or fire. Reseeds profusely, especially after fire, disturbance or non-selective spraying. Best controlled by a combination of methods, including selective herbicide use, and management for native forest succession.
Benefits	Can increase soil nitrogen and act as a nursery crop to facilitate regeneration of native forest on cleared land. Important source of pollen for bees, particularly in winter.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	M	Outcompetes grass and clover, reducing pasture availability.	
Sheep and beef	M	H	Can rapidly invade pastures and out-compete grass and clover, reducing food for stock. Spines pull fleece and lower value of wool.	
Forestry	M	M	Can form dense stands and invade open, disturbed or poorly managed areas such as roadsides and stream banks.	1, 2, 3, 4
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-	Nitrogen fixer (may facilitate growth of other plants).	
Water quality	M	M	Nitrogen leaching from dense gorse stands can increase nitrate levels in waterways and lakes.	5
Species diversity	M	H	Forms dense stands, out-competes low-growing species. Increases soil nitrogen, can induce succession to forest, to the detriment of specialised plants (e.g. herbs, orchids).	1, 2, 4, 6, 7, 8

Category	Current	Potential	Comment	Source
			Native forest succession through gorse results in different composition and lower diversity than succession through kānuka. Succession may be slow in dry sites.	
Threatened species	L	H	Can invade a range of rare habitat types such as coastal sites and rock outcrops as well as disturbed ground/modified habitats, all of which support specialist indigenous species.	2
Social/Cultural				
Human health	L	L	Gorse prickles can pierce skin and become infected.	
Recreation	M	M	Dense shrubs with prickly spines obstruct access.	9
Māori culture	L	M	Can impede or restrict access to cultural sites (e.g. wāhi tapu, urupa).	

L = low, M = moderate, H = high
source 1: Williams & Karl (2002), 2: Craw (2000), 3: Roy et al. (2004), 4: Environment Bay of Plenty (2005a), 5: Magesan & Wang (2008), 6: Lee et al. (1986), 7: Hill et al. (2001), 8: Sullivan et al. (2007), 9: Popay et al. (2010)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	273.15-600.93
- Sheep and beef	36.95-81.27	73.90-451.50
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Gorse**
Proposed management programme: **Progressive Containment (Lake Rotorua catchment)**
Area of Programme: **51,329.2 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	798.936 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$407.61/ha	Potential extent in the region°	6,381 ha
	$222.57-592.65/ha		2,126.89-10,634.45 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years may be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$3,799,554 min: 1,930,114 max: 6,175,735	$0		$0	$0	$0	
Progressive Containment (Lake Rotorua catchment)	$2,470,940 min: 1,205,605 max: 3,975,046	$0	$1,328,614 min: 724,509 max: 2,200,689	$843,533	$5,894,736 min: 2,665,850 max: 9,686,658	$337,413	$-5,747,068 min: -10,143,095 max: -1,646,107

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$15,696,394 min: 6,573,406 max: 39,666,980	$0		$0	$0	$0	
Progressive Containment (Lake Rotorua catchment)	$3,745,287 min: 1,431,516 max: 8,511,808	$0	$11,951,107 min: 5,141,890 max: 31,155,172	$1,917,958	$5,911,296 min: 2,665,850 max: 9,686,658	$337,413	$3,784,440 min: -6,800,139 max: 26,233,951

3.32 Gorse (Sustained Control) (*Ulex europaeus*)

Relevant biology

Attribute	Description
Form	Sharply spiny perennial shrub up to 4 m tall. Leaves reduced to a spine-like tip. Spines deeply furrowed. Very deep tap root and extensive lateral roots. Flowers are pea-like, yellow, 13-20 mm long, May-Nov (sometimes all year). Seed pod hairy, turning black, 13-25 mm long, explosive.
Habitat	Grassland, shrubland, forest margins (including plantation forests), hill country, coastal habitats, sand dunes, and wastelands. Tolerant of hot to cold, high to low rainfall, wind, salt, damage, grazing, and all soil types. Optimum growth on low fertility soils.
Regional distribution	Common/abundant in suitable habitat throughout the region.
Competitive ability	Fast growth and being a nitrogen fixer means it can compete effectively with tree seedlings.
Reproductive ability	Seeds have hard coat, can be dormant for up to 30 years. Huge seed bank in soil (estimated 20,000 seeds/m^2).
Dispersal methods	Most seeds fall close to parent plant but may be ejected up to 6 m. Also spread by water, birds, road making gravel and machinery.
Resistance to control	Difficult to control on infertile and steep land, as burning and grazing not effective. Stumps re-sprout quickly after damage or fire. Reseeds profusely, especially after fire, disturbance or non-selective spraying. Best controlled by a combination of methods, including selective herbicide use, and management for native forest succession.
Benefits	Can increase soil nitrogen and act as a nursery crop to facilitate regeneration of native forest on cleared land. Important source of pollen for bees, particularly in winter.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	M	Outcompetes grass and clover, reducing pasture availability.	
Sheep and beef	M	H	Can rapidly invade pastures and out-compete grass and clover, reducing food for stock. Spines pull fleece and lower value of wool.	
Forestry	M	M	Can form dense stands and invade open, disturbed or poorly managed areas such as roadsides and stream banks.	1, 2, 3, 4
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-	Nitrogen fixer (may facilitate growth of other plants).	
Water quality	M	M	Nitrogen leaching from dense gorse stands can increase nitrate levels in waterways and lakes.	5
Species diversity	M	H	Forms dense stands, out-competes low-growing species. Increases soil nitrogen, can induce succession to forest, to the detriment of specialised plants (e.g. herbs, orchids).	1, 2, 4, 6, 7, 8

Category	Current	Potential	Comment	Source
			Native forest succession through gorse results in different composition and lower diversity than succession through kānuka. Succession may be slow in dry sites.	
Threatened species	L	H	Can invade a range of rare habitat types such as coastal sites and rock outcrops as well as disturbed ground/modified habitats, all of which support specialist indigenous species.	2
Social/Cultural				
Human health	L	L	Gorse prickles can pierce skin and become infected.	
Recreation	M	M	Dense shrubs with prickly spines obstruct access.	9
Māori culture	L	M	Can impede or restrict access to cultural sites (e.g. wāhi tapu, urupa).	

L = low, M = moderate, H = high
source 1: Williams & Karl (2002), 2: Craw (2000), 3: Roy et al. (2004), 4: Environment Bay of Plenty (2005a), 5: Magesan & Wang (2008), 6: Lee et al. (1986), 7: Hill et al. (2001), 8: Sullivan et al. (2007), 9: Popay et al. (2010)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	273.15-600.93
- Sheep and beef	36.95-81.27	73.90-451.50
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Gorse**
Proposed management programme: **Sustained Control (Lake Rotorua catchment)**
Area of Programme: **51,329.2 ha**
Proposed annual expenditure by Council: **$50,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	798.936 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$407.61/ha	Potential extent in the region°	6,381 ha
	$222.57-592.65/ha		2,126.89-10,634.45 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$3,799,554 min: 1,930,114 max: 6,175,735	$0		$0	$0	$0	
Sustained Control (Lake Rotorua catchment)	$2,832,537 min: 1,528,692 max: 4,166,229	$0	$967,017 min: 401,422 max: 2,009,506	$421,767	$6,668,911 min: 3,299,266 max: 10,108,935	$84,353	$-6,208,014 min: -10,213,633 max: -1,795,880

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$15,696,394 min: 6,573,406 max: 39,666,980	$0		$0	$0	$0	
Sustained Control (Lake Rotorua catchment)	$6,752,802 min: 3,523,651 max: 10,253,923	$0	$8,943,592 min: 3,049,755 max: 29,413,057	$1,117,074	$6,668,911 min: 3,299,266 max: 10,108,935	$84,353	$1,073,254 min: -8,260,607 max: 24,912,364

3.33 Hornwort (Eradication) (*Ceratophyllum demersum*)

Relevant biology

Attribute	Description
Form	Submerged, free-floating or anchored perennial in water to 16 m deep. No roots, usually lightly anchored by buried stems and leaves. Stems floating or submerged, branched, stiff and brittle, 30-150 cm long. Leaves in whorls of 7-12, densely crowded at stem apex and increasingly spaced down stem, thin, 1-4 cm long, equally forked once or twice into stiff tapering segments with teeth on the outer edge, dark green. Flowers minute, green or white.
Habitat	Rivers and lakes. Overseas, hornwort is often regarded as a weed of more nutrient-enriched waters, however, in New Zealand it can grow in less polluted water and at deeper depths.
Regional distribution	Lakes Rotorua, Rotoiti, Rotoehu, Ōkataina, Ōkāreka, Tarawera, Rotomāhana and other waterbodies.
Competitive ability	Will out-compete other lake weeds.
Reproductive ability	Grows easily from broken fragments. No fruit set in New Zealand.
Dispersal methods	Water, humans. Easily dislodged by strong currents or waves and can form large drifting weed rafts.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	Low	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		
Water quality	L	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense tall masses in freshwater (to 10 m deep), shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	M		1, 4
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the	5

Category	Current	Potential	Comment	Source
			waterborne schistosome cercariae larvae that cause 'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	L	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hornwort**
Proposed management programme: **Eradication (Lakes Ōkataina and Ōkāreka)**
Area of Programme: **406 ha**
Proposed annual expenditure by Council: **$117,400**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	4 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha $953.5-2,457.9/ha	Potential extent in the region°	61 ha 20.3-101.5 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$149,779 min: 66,301 max: 304,856	$0		$0	$0	$0	
Eradication (Lakes Ōkataina and Ōkāreka)	$16,045 min: 5,577 max: 46,810	$0	$133,734 min: 60,724 max: 258,046	$447,856	$0	$1,096,593	$-1,410,715 min: -1,483,725 max: -1,286,403

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$1,104,150 min: 323,196 max: 4,537,260	$0		$0	$0	$0	
Eradication (Lakes Ōkataina and Ōkāreka)	$16,045 min: 5,577 max: 46,810	$0	$1,088,105 min: 317,619 max: 4,490,450	$454,872	$0	$1,096,593	$-463,360 min: -1,233,846 max: 2,938,985

3.34 Hornwort (Exclusion) (*Ceratophyllum demersum*)

Relevant biology

Attribute	Description
Form	Submerged, free-floating or anchored perennial in water to 16 m deep. No roots, usually lightly anchored by buried stems and leaves. Stems floating or submerged, branched, stiff and brittle, 30-150 cm long. Leaves in whorls of 7-12, densely crowded at stem apex and increasingly spaced down stem, thin, 1-4 cm long, equally forked once or twice into stiff tapering segments with teeth on the outer edge, dark green. Flowers minute, green or white.
Habitat	Rivers and lakes. Overseas, hornwort is often regarded as a weed of more nutrient-enriched waters, however, in New Zealand it can grow in less polluted water and at deeper depths.
Regional distribution	Lakes Rotorua, Rotoiti, Rotoehu, Ōkataina, Ōkāreka, Tarawera, Rotomāhana and other waterbodies.
Competitive ability	Will out-compete other lake weeds.
Reproductive ability	Grows easily from broken fragments. No fruit set in New Zealand.
Dispersal methods	Water, humans. Easily dislodged by strong currents or waves and can form large drifting weed rafts.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	-	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		
Water quality	-	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	-	H	Forms dense tall masses in freshwater (to 10 m deep), shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	-	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the	5

Category	Current	Potential	Comment	Source
			waterborne schistosome cercariae larvae that cause 'swimmers itch'.	
Recreation	-	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	-	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hornwort**
Proposed management programme: **Exclusion (lakes not present)**
Area of Programme: **1,138 ha**
Proposed annual expenditure by Council: **$55,200**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	145 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$46,560 min: 9,410 max: 117,316	$0		$0	$0	$0	
Exclusion (lakes not present)	$0 min: 0 max: 0	$0	$46,560 min: 9,410 max: 117,316	$465,630	$0	$0	$-419,070 min: -456,220 max: -348,314

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$4,276,009 min: 620,721 max: 22,295,667	$0		$0	$0	$0	
Exclusion (lakes not present)	$0 min: 0 max: 0	$0	$4,276,009 min: 620,721 max: 22,295,667	$1,233,249	$0	$0	$3,042,760 min: -612,528 max: 21,062,418

3.35 Hornwort (Progressive Containment) (*Ceratophyllum demersum*)

Relevant biology

Attribute	Description
Form	Submerged, free-floating or anchored perennial in water to 16 m deep. No roots, usually lightly anchored by buried stems and leaves. Stems floating or submerged, branched, stiff and brittle, 30-150 cm long. Leaves in whorls of 7-12, densely crowded at stem apex and increasingly spaced down stem, thin, 1-4 cm long, equally forked once or twice into stiff tapering segments with teeth on the outer edge, dark green. Flowers minute, green or white.
Habitat	Rivers and lakes. Overseas, hornwort is often regarded as a weed of more nutrient-enriched waters, however, in New Zealand it can grow in less polluted water and at deeper depths.
Regional distribution	Lakes Rotorua, Rotoiti, Rotoehu, Ōkataina, Ōkāreka, Tarawera, Rotomāhana and other waterbodies.
Competitive ability	Will out-compete other lake weeds.
Reproductive ability	Grows easily from broken fragments. No fruit set in New Zealand.
Dispersal methods	Water, humans. Easily dislodged by strong currents or waves and can form large drifting weed rafts.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense tall masses in freshwater (to 10 m deep), shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the	5

Category	Current	Potential	Comment	Source
			waterborne schistosome cercariae larvae that cause 'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hornwort**
Proposed management programme: **Progressive Containment (lakes where present)**
Area of Programme: **4,687 ha**
Proposed annual expenditure by Council: **$46,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,213 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,213 ha
	$953.5-2,457.9/ha		1,213-1,213 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$18,850,572 min: 10,537,621 max: 27,163,523	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$7,453,731	$0	$11,396,841	$289,331	$0	$3,205,426	$7,902,084
	min: 3,214,584 max: 14,195,263		min: 7,323,037 max: 12,968,260				min: 3,828,280 max: 9,473,503

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$46,515,957 min: 26,002,794 max: 67,029,120	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$7,453,731	$0	$39,062,226	$297,518	$0	$3,205,426	$35,559,282
	min: 3,214,584 max: 14,195,263		min: 22,788,210 max: 52,833,857				min: 19,285,266 max: 49,330,913

3.36 Hornwort (Sustained Control-all Rotorua lakes) (*Ceratophyllum demersum*)

Relevant biology

Attribute	Description
Form	Submerged, free-floating or anchored perennial in water to 16 m deep. No roots, usually lightly anchored by buried stems and leaves. Stems floating or submerged, branched, stiff and brittle, 30-150 cm long. Leaves in whorls of 7-12, densely crowded at stem apex and increasingly spaced down stem, thin, 1-4 cm long, equally forked once or twice into stiff tapering segments with teeth on the outer edge, dark green. Flowers minute, green or white.
Habitat	Rivers and lakes. Overseas, hornwort is often regarded as a weed of more nutrient-enriched waters, however, in New Zealand it can grow in less polluted water and at deeper depths.
Regional distribution	Lakes Rotorua, Rotoiti, Rotoehu, Ōkataina, Ōkāreka, Tarawera, Rotomāhana and other waterbodies.
Competitive ability	Will out-compete other lake weeds.
Reproductive ability	Grows easily from broken fragments. No fruit set in New Zealand.
Dispersal methods	Water, humans. Easily dislodged by strong currents or waves and can form large drifting weed rafts.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense tall masses in freshwater (to 10 m deep), shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the	5

Category	Current	Potential	Comment	Source
			waterborne schistosome cercariae larvae that cause 'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hornwort**
Proposed management programme: **Sustained Control (all Rotorua Lakes)**
Area of Programme: **5,655 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,213 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,313 ha
Current benefits	$953.5-2,457.9/ha $0/ha	Discount rate	1,213-1,413.75 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$19,315,438 min: 10,537,621 max: 28,707,523	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$16,952,014 min: 9,242,812 max: 25,029,624	$0	$2,363,424 min: 1,294,809 max: 3,677,899	$57,360	$0	$57,360	$2,248,704 min: 1,180,089 max: 3,563,179

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$48,827,807 min: 26,002,794 max: 74,484,221	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$33,387,709 min: 16,536,273 max: 53,596,196	$0	$15,440,098 min: 9,466,521 max: 20,888,025	$151,922	$0	$57,360	$15,230,816 min: 9,257,239 max: 20,678,743

3.37 Hornwort (Sustained Control-Rotorua lakes) (*Ceratophyllum demersum*)

Relevant biology

Attribute	Description
Form	Submerged, free-floating or anchored perennial in water to 16 m deep. No roots, usually lightly anchored by buried stems and leaves. Stems floating or submerged, branched, stiff and brittle, 30-150 cm long. Leaves in whorls of 7-12, densely crowded at stem apex and increasingly spaced down stem, thin, 1-4 cm long, equally forked once or twice into stiff tapering segments with teeth on the outer edge, dark green. Flowers minute, green or white.
Habitat	Rivers and lakes. Overseas, hornwort is often regarded as a weed of more nutrient-enriched waters, however, in New Zealand it can grow in less polluted water and at deeper depths.
Regional distribution	Lakes Rotorua, Rotoiti, Rotoehu, Ōkataina, Ōkāreka, Tarawera, Rotomāhana and other waterbodies.
Competitive ability	Will out-compete other lake weeds.
Reproductive ability	Grows easily from broken fragments. No fruit set in New Zealand.
Dispersal methods	Water, humans. Easily dislodged by strong currents or waves and can form large drifting weed rafts.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms dense tall masses in freshwater (to 10 m deep), shades out smaller native species, prevents recruitment. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the	5

Category	Current	Potential	Comment	Source
			waterborne schistosome cercariae larvae that cause 'swimmers itch'.	
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	1, 2, 4
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hornwort**
Proposed management programme: **Sustained Control (Rotorua lakes where present)**
Area of Programme: **4,687 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,213 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,213 ha
	$953.5-2,457.9/ha		1,213-1,213 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$18,850,572 min: 10,537,621 max: 27,163,523	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$16,952,014	$0	$1,898,558	$57,360	$0	$358,502	$1,482,696
	min: 9,242,812 max: 25,029,624		min: 1,294,809 max: 2,133,899				min: 878,947 max: 1,718,037

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$46,515,957 min: 26,002,794 max: 67,029,120	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$33,387,709	$0	$13,128,248	$151,922	$0	$358,502	$12,617,824
	min: 16,536,273 max: 53,596,196		min: 9,466,521 max: 13,432,924				min: 8,956,097 max: 12,922,500

3.38 Hydrilla (*Hydrilla verticillata*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial growing to 9 m in length. Slender, brittle and branched stems of 1 mm diameter. Translucent, dark green leaves (approx.6-20 mm x 2-4 mm) in whorls of 3-8. Leaves have toothed margins, 11-39 teeth per cm.
Habitat	Rivers, lakes, dune lakes and waterbodies with moderate to high light levels. Grows to approx.6 m, but can be found deeper in areas of high water clarity.
Regional distribution	Not currently present in Bay of Plenty. Present in Hawkes Bay region at lakes Tutira, Waikopiro, Opouahi and Eland. Spread highly controlled through management of human vectors and isolated nature of the lakes.
Competitive ability	Very strong competitor. Has excellent ability to displace other aquatic plants via fast growth and shading (grows higher than smaller native species), but may encounter competition from some species.
Reproductive ability	Only male flowers are present in NZ, so no sexual reproduction or seed dispersal. However, plant fragments are able to re-establish.
Dispersal methods	Brittle stems break and are transported downstream by water currents or on boats and trailers, eel nets, livestock and diggers. Turions (wintering buds/shoots) can also re-establish away from the parent plant.
Resistance to control	Herbicides diquat and Endothall are registered in NZ for controlling hydrilla and other submerged plants. However, it is not effective under turbid water conditions. Hydrilla appears resistant to most chemical herbicides through the production of turions and tubers, which can lie dormant. Triploid grass carp has effectively been used to manage hydrilla in Lake Eland, reducing hydrilla abundance by 99%.
Benefits	Overseas it is used medicinally, as fish food and as manure. Provides habitat, increasing biomass of invertebrates and fish. Provides food for water birds. Improves water clarity by trapping sediments. Stabilises unstable substrates and reduces lakeshore erosion.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2
Horticulture	-	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Aquaculture	-	-		
Other	-	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	L	May impact tourism (boating and fishing ventures).	
Environment				
Soil resources	-	-		

Category	Current	Potential	Comment	Source
Water quality	-	M	Has a positive impact on water quality, stabilising sediments and compartmentalising nutrients. However large amounts of aquatic plant material is required to achieve this. There is also potential for negative impact on water quality through deoxygenation and eutrophication due to restricted water movement and decomposing plant material (as observed in Lake Tutira).	1
Species diversity	-	H	Overgrows and smothers native aquatic vegetation. This can reduce habitat diversity and as a result, invertebrate, fish and water bird diversity.	2
Threatened species	-	M	The impact of hydrilla on native aquatic plants is likely to be substantial, however the impact on native threatened and uncommon fishes (e.g. kōkopu, bullies etc.) is unknown.	2
Social/Cultural				
Human health	-	M	Hydrilla and other aquatic plants support snails that host a water-borne protozoa that causes 'swimmers itch'. Large beds of hydrilla may increase incidences of swimmers itch. There is possible risk of accidental drowning through entanglement, particularly for children.	2
Recreation	-	M	See Human Health. May also impact aesthetics through putrefying plant material washed up after storms. May reduce water quality (deoxygenation/eutrophication) making lakes unfavourable to swim in. Boating and fishing activities would also be restricted due to risk of spread.	2
Māori culture	-	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Langeland (1996), 2: Walls (1993)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	54.63-267.08
- Sheep and beef	0	7.39-36.12
- Forestry	0	0
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Hydrilla**
Proposed management programme: **Exclusion (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$10,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	3,542 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$136,940 min: 27,581 max: 720,952	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$136,940 min: 27,581 max: 720,952	$84,353	$0	$0	$52,587 min: -56,772 max: 636,599

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$93,931,371 min: 14,283,063 max: 494,524,938	$0		$0	$0	$0	
Exclusion (region)	$0 min: 0 max: 0	$0	$93,931,371 min: 14,283,063 max: 494,524,938	$223,415	$0	$0	$93,707,956 min: 14,059,648 max: 494,301,523

3.39 Lagarosiphon (Exclusion) (*Lagarosiphon major*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, reaching to 5 m. Leaves recurved backwards or downwards, arranged spirally around the stem. Leaves 16 x 2 mm, with minute marginal serrations. Flowers tiny, pinkish.
Habitat	Rivers, lakes, dune lakes and other still or slow-moving waterbodies with moderate-high light levels.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaiitu, Ōkataina, Rotoehu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only female plants found in New Zealand, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	-	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	-	-	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	-	-	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	-	H	Forms vast deep meadows in freshwater up to 4 m tall (to 6 m deep), shades out smaller native species. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	-	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	-	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	-	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	0	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Lagarosiphon**
Proposed management programme: **Exclusion (lakes not present)**
Area of Programme: **644 ha**
Proposed annual expenditure by Council: **$36,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	0 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$0/ha	Potential extent in the region°	71 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$35,647 min: 6,952 max: 93,533	$0		$0	$0	$0	
Exclusion (lakes not present)	$0 min: 0 max: 0	$0	$35,647 min: 6,952 max: 93,533	$310,420	$0	$0	$-274,773 min: -303,468 max: -216,887

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,062,156 min: 292,533 max: 11,053,865	$0		$0	$0	$0	
Exclusion (lakes not present)	$0 min: 0 max: 0	$0	$2,062,156 min: 292,533 max: 11,053,865	$822,166	$0	$0	$1,239,990 min: -529,633 max: 10,231,699

3.40 Lagarosiphon (Progressive Containment) (*Lagarosiphon major*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, reaching to 5 m. Leaves recurved backwards or downwards, arranged spirally around the stem. Leaves 16 x 2 mm, with minute marginal serrations. Flowers tiny, pinkish.
Habitat	Rivers, lakes, dune lakes and other still or slow-moving waterbodies with moderate-high light levels.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaiitu, Ōkataina, Rotoehu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only female plants found in New Zealand, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast deep meadows in freshwater up to 4 m tall (to 6 m deep), shades out smaller native species. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Lagarosiphon**
Proposed management programme: **Progressive Containment (lakes where present)**
Area of Programme: **5,181 ha**
Proposed annual expenditure by Council: **$46,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,399 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,399 ha
	$953.5-2,457.9/ha		1,399-1,399 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$21,741,096 min: 12,153,448 max: 31,328,745	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$8,596,677	$0	$13,144,419	$289,331	$0	$3,708,172	$9,146,916
	min: 3,707,504 max: 16,371,948		min: 8,445,944 max: 14,956,797				min: 4,448,441 max: 10,959,294

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$53,648,659 min: 29,990,031 max: 77,307,287	$0		$0	$0	$0	
Progressive Containment (lakes where present)	$8,596,677	$0	$45,051,982	$297,518	$0	$3,708,172	$41,046,292
	min: 3,707,504 max: 16,371,948		min: 26,282,527 max: 60,935,339				min: 22,276,837 max: 56,929,649

3.41 Lagarosiphon (Sustained Control-all Rotorua lakes) (*Lagarosiphon major*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, reaching to 5 m. Leaves recurved backwards or downwards, arranged spirally around the stem. Leaves 16 x 2 mm, with minute marginal serrations. Flowers tiny, pinkish.
Habitat	Rivers, lakes, dune lakes and other still or slow-moving waterbodies with moderate-high light levels.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaiitu, Ōkataina, Rotoehu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only female plants found in New Zealand, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast deep meadows in freshwater up to 4 m tall (to 6 m deep), shades out smaller native species. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Lagarosiphon**
Proposed management programme: **Sustained Control (all Rotorua Lakes)**
Area of Programme: **5,655 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,399 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,406 ha
	$953.5-2,457.9/ha		1,399-1,413.75 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$21,762,271 min: 12,153,448 max: 31,404,548	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$19,551,415 min: 10,660,093 max: 28,867,638	$0	$2,210,856 min: 1,493,355 max: 2,536,910	$57,360	$0	$358,502	$1,794,994 min: 1,077,493 max: 2,121,048

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$53,784,470 min: 29,990,031 max: 77,754,679	$0		$0	$0	$0	
Sustained Control (all Rotorua Lakes)	$38,507,341 min: 19,071,926 max: 61,814,574	$0	$15,277,129 min: 10,918,105 max: 15,940,105	$151,922	$0	$358,502	$14,766,705 min: 10,407,681 max: 15,429,681

3.42 Lagarosiphon (Sustained Control-some Rotorua lakes) (*Lagarosiphon major*)

Relevant biology

Attribute	Description
Form	Submerged, bottom-rooting perennial, reaching to 5 m. Leaves recurved backwards or downwards, arranged spirally around the stem. Leaves 16 x 2 mm, with minute marginal serrations. Flowers tiny, pinkish.
Habitat	Rivers, lakes, dune lakes and other still or slow-moving waterbodies with moderate-high light levels.
Regional distribution	Lakes Rotorua, Rotoiti, Rotomā, Ōkāreka, Tarawera, Tikitapu, Rerewhakaiitu, Ōkataina, Rotoehu and other waterbodies.
Competitive ability	
Reproductive ability	Grows easily from broken fragments. Only female plants found in New Zealand, no seed set.
Dispersal methods	Water, humans.
Resistance to control	Difficult to control.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	-	-
Sheep and beef	-	-
Forestry	-	-
Horticulture	-	-
Aquaculture	-	-
Urban	-	-
Native terrestrial	-	-
Coastal land	-	-
Freshwater	High	High
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Sheep and beef	L	L	May cause reductions in water flow in canals and drains, and clog irrigation pump intakes. May contribute to flooding.	
Forestry	-	-		1, 2, 3
Horticulture	-	-		
Aquaculture	-	-		
Other	L	L	May block water intakes, including hydro power infrastructure, impacting on power generation output.	
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	M	M	Large clumps dislodge, causing blockage and flooding. Rotting vegetation degrades water quality. Causes nutrient release from sediments, exacerbates eutrophication.	1, 2, 3
Species diversity	M	H	Forms vast deep meadows in freshwater up to 4 m tall (to 6 m deep), shades out smaller native species. Rotting vegetation deoxygenates water, killing fauna and flora.	1, 2, 4
Threatened species	L	H		1
Social/Cultural				
Human health	-	L	Large weed beds may support more snails which host the waterborne schistosome cercariae larvae that cause 'swimmers itch'.	5
Recreation	L	M	Dense masses block up lakes and shade water, reducing access to lakes. May reduce water quality	1, 2, 4

Category	Current	Potential	Comment	Source
			(deoxygenation/eutrophication) making lakes unfavourable to swim in. Inconvenience caused by biosecurity measures i.e. restricted access to lakes by lake cordons, cleaning and washing procedures.	
Māori culture	M	H	See Human Health and Recreation. There are likely to be cultural impacts if a waterway's health is significantly affected, reducing traditional use and cultural importance of the lake/waterbody.	

L = low, M = moderate, H = high
source 1: Craw (2000), 2: Clayton & Champion (2003), 3: Champion (2009), 4: Roy et al. (2004), 5: NIWA (2002)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	0	0
- Horticulture	0	0
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	0	0
- Coastal	0	0
- Freshwater	953.50-2,457.90	1,907.00-13,655.00
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Lagarosiphon**
Proposed management programme: **Sustained Control (Rotorua lakes where present)**
Area of Programme: **5,181 ha**
Proposed annual expenditure by Council: **$6,800**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,399 ha	Time to reach maximum extent†	50 yrs
Current impacts*	$1,705.7/ha	Potential extent in the region°	1,399 ha
	$953.5-2,457.9/ha		1,399-1,399 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will be of net benefit to the region.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$21,741,096 min: 12,153,448 max: 31,328,745	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$19,551,415 min: 10,660,093 max: 28,867,638	$0	$2,189,681 min: 1,493,355 max: 2,461,107	$57,360	$0	$358,502	$1,773,819 min: 1,077,493 max: 2,045,245

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$53,648,659 min: 29,990,031 max: 77,307,287	$0		$0	$0	$0	
Sustained Control (Rotorua lakes where present)	$38,507,341 min: 19,071,926 max: 61,814,574	$0	$15,141,318 min: 10,918,105 max: 15,492,713	$151,922	$0	$358,502	$14,630,894 min: 10,407,681 max: 14,982,289

3.43 Privet (*Ligustrum lucidum, L. sinense*)

Relevant biology

Attribute	Description
Form	Tree privet is a medium-sized evergreen tree growing up to 10 m tall. Chinese privet is an evergreen or semi-deciduous shrub or small tree up to 5 m tall.
Habitat	Widely grown as hedging plants. Occur in lowland and coastal forest, mostly remnants and shrub land. Urban areas, disturbed sites, roadside banks, waste areas.
Regional distribution	Widespread throughout the region.
Competitive ability	Tree privet is shade-tolerant and competitive on a wide range of soils. Chinese privet is also shade-tolerant (probably also shade-requiring). Fire intolerant.
Reproductive ability	Both species produce 100,000-10,000,000 seeds per bush or tree.
Dispersal methods	Seed dispersed by birds.
Resistance to control	Adequately controlled by cutting and painting with metsulfuron, but this can possibly damage surrounding vegetation.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	Low	Low
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Can form dense stands and reduce pasture cover.	
Sheep and beef	L	L	Can form dense stands and reduce pasture cover.	
Forestry	L	L	Potential to invade plantation forests, and compete with young trees.	1
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	L	M	Dense stands prevent recruitment. Displaces vulnerable shrub species. Poisonous berries may possibly impact on native fauna, esp. insects.	2
Threatened species	L	L		2
Social/Cultural				
Human health	L	M	Berries and leaves are poisonous. There is no convincing evidence that pollen affects asthma and hay fever although many people believe this.	
Recreation	L	M	Forms dense stands which obstruct access.	2
Māori culture	L	M	See Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2004), 2: Craw (2000)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	7.39-36.12
- Forestry	17.47-85.40	17.47-85.40
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	5.56-27.20	27.80-61.20
- Coastal	12.47-61.00	62.35-137.25
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Privet**
Proposed management programme: **Sustained Control (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$400,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	2,625 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$80.34/ha	Potential extent in the region°	76,646 ha
	$26.4-134.28/ha		26,919.09-126,372.5 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,801,352	$0		$0	$0	$0	
	min: 883,587 max: 5,011,652						
Sustained Control (region)	$1,834,260	$0	$967,092	$3,374,133	$21,911,505	$337,413	$-24,655,959
	min: 595,666 max: 3,101,441		min: 287,921 max: 1,910,211		min: 17,344,212 max: 26,571,295		min: -29,994,920 max: -19,145,547

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$19,816,528	$0		$0	$0	$0	
	min: 5,095,807 max: 54,136,524						
Sustained Control (region)	$4,372,899	$0	$15,443,629	$8,936,589	$21,911,505	$337,413	$-15,741,878
	min: 1,373,017 max: 7,633,267		min: 3,722,790 max: 46,503,257		min: 17,344,212 max: 26,571,295		min: -32,122,507 max: 19,885,043

3.44 Wild ginger (Progressive Containment) (*Hedychium gardnerianum*, *H. flavescens*)

Relevant biology

Attribute	Description
Form	Both gingers have large green leaves with spikes and scented flowers and can grow up to 2-3 m tall, with massive branching surface rhizomes. Flowers of kahili ginger are yellow with red stamens. Yellow ginger has creamy flowers.
Habitat	Both species thrive in warm damp areas, and are very shade tolerant.
Regional distribution	Found in most parts of the region.
Competitive ability	Both gingers spread rapidly from large rhizomes which form thick mats up to 1 m deep in the soil. Can suppress 90% of native vegetation.
Reproductive ability	Kahili ginger produces up to 100 seeds per head. Also sprouts from rhizomes. Yellow ginger does not produce seed and is spread vegetatively.
Dispersal methods	Kahili ginger produces seed which is spread by birds. Spread also by dumping garden waste.
Resistance to control	Can be controlled using herbicides. Removal by hand is difficult due to the size of the rhizomes.
Benefits	Roots are edible.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	L	M	Can establish in plantation forests and out-compete young trees.	1
Horticulture	-	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	L	L	Shallow-rooted, deep rhizome beds become heavy with rain and slip on steep sites and streambanks, causing erosion.	2
Water quality	-	-		
Species diversity	M	H	Forms dense patches and out-competes almost all native species. Prevents forest regeneration. Succeeded only by introduced vines.	1, 2
Threatened species	L	M	Dense rhizome beds replace all other species.	1, 2
Social/Cultural				
Human health	-	-		
Recreation	L	M	Forms dense patches which obstruct access.	2
Māori culture	L	M	Could obstruct access to culturally important sites (e.g. wāhi tapu, urupa).	

L = low, M = moderate, H = high
source 1: Williams et al. (2003), 2: Craw (2000).

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild ginger**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$200,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	164.538 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$32.32/ha	Potential extent in the region°	178,709 ha
Current benefits	$16.52-48.12/ha $0/ha	Discount rate	59,579.24-297,838.3 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$134,682 min: 65,658 max: 221,399	$0		$0	$0	$0	
Progressive Containment (region)	$40,351	$0	$94,331	$1,687,066	$637,350	$337,413	$-2,567,498
	min: 18,427 max: 66,476		min: 47,231 max: 154,923		min: 494,120 max: 797,973		min: -2,775,221 max: -2,363,676

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$8,544,416 min: 3,644,120 max: 17,471,561	$0		$0	$0	$0	
Progressive Containment (region)	$61,162	$0	$8,483,254	$3,832,723	$639,140	$337,413	$3,673,978
	min: 21,880 max: 142,345		min: 3,622,240 max: 17,329,216		min: 494,120 max: 797,973		min: -1,345,869 max: 12,664,960

3.45 Wild ginger (Sustained Control) (*Hedychium gardnerianum*, *H. flavescens*)

Relevant biology

Attribute	Description
Form	Both gingers have large green leaves with spikes and scented flowers and can grow up to 2-3 m tall, with massive branching surface rhizomes. Flowers of kahili ginger are yellow with red stamens. Yellow ginger has creamy flowers.
Habitat	Both species thrive in warm damp areas, and are very shade tolerant.
Regional distribution	Found in most parts of the region.
Competitive ability	Both gingers spread rapidly from large rhizomes which form thick mats up to 1 m deep in the soil. Can suppress 90% of native vegetation.
Reproductive ability	Kahili ginger produces up to 100 seeds per head. Also sprouts from rhizomes. Yellow ginger does not produce seed and is spread vegetatively.
Dispersal methods	Kahili ginger produces seed which is spread by birds. Spread also by dumping garden waste.
Resistance to control	Can be controlled using herbicides. Removal by hand is difficult due to the size of the rhizomes.
Benefits	Roots are edible.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	L	M	Can establish in plantation forests and out-compete young trees.	1
Horticulture	-	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	L	L	Shallow-rooted, deep rhizome beds become heavy with rain and slip on steep sites and streambanks, causing erosion.	2
Water quality	-	-		
Species diversity	M	H	Forms dense patches and out-competes almost all native species. Prevents forest regeneration. Succeeded only by introduced vines.	1, 2
Threatened species	L	M	Dense rhizome beds replace all other species.	1, 2
Social/Cultural				
Human health	-	-		
Recreation	L	M	Forms dense patches which obstruct access.	2
Māori culture	L	M	Could obstruct access to culturally important sites (e.g. wāhi tapu, urupa).	

L = low, M = moderate, H = high
source 1: Williams et al. (2003), 2: Craw (2000)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	0	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild ginger**
Proposed management programme: **Sustained Control (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	164.538 ha	Time to reach maximum extent†	75 yrs
Current impacts*	$32.32/ha	Potential extent in the region°	178,709 ha
Current benefits	$16.52-48.12/ha $0/ha	Discount rate	59,579.24-297,838.3 ha 4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$134,682 min: 65,658 max: 221,399	$0		$0	$0	$0	
Sustained Control (region)	$46,256 min: 23,365 max: 69,673	$0	$88,426 min: 42,293 max: 151,726	$843,533	$721,055 min: 611,525 max: 832,760	$168,707	$-1,644,869 min: -1,802,707 max: -1,472,039

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$8,544,416 min: 3,644,120 max: 17,471,561	$0		$0	$0	$0	
Sustained Control (region)	$110,276 min: 53,856 max: 171,479	$0	$8,434,140 min: 3,590,264 max: 17,300,082	$2,234,147	$721,055 min: 611,525 max: 832,760	$168,707	$5,310,231 min: 354,650 max: 14,285,703

3.46 Wild kiwifruit (Progressive Containment-defined area) (*Actinidia* spp.)

Relevant biology

Attribute	Description
Form	Perennial, climbing or scrambling vine up to 15 m. Leaves are alternate, long-petioled, deciduous, oval to nearly circular, cordate at the base and 7.5-12.5 cm long. Young leaves are coated with red hairs; mature leaves are dark-green and hairless on upper surface, downy-white with prominent, light-coloured veins beneath. Oblong fruits are up to 6.5 cm long and densely covered in short, stiff, brown hairs.
Habitat	Exotic and native forest, particularly on the margins and in light gaps, regenerating forest, riparian margins, and scrub. Usually close to kiwifruit orchards or where excess fruit has been dumped or fed to stock.
Regional distribution	Found mostly near kiwifruit orchard areas in western part of the region (e.g. Te Puke) but can also be found in isolated places, usually in native forest. A recent aerial survey of the Te Puke gullies found about 100 new sites.
Competitive ability	Can smother or strangle host plants. Very vigorous grower.
Reproductive ability	Each fruit contains numerous small seeds.
Dispersal methods	Birds and stock can spread seed. Fruit also distributed by dumping or used as stock food for cattle and deer.
Resistance to control	Can be cut and treated with herbicide or sprayed during spring and summer.
Benefits	Edible fruit, major export crop. Reject export fruit used as livestock feed.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	M	M	Smothers trees in plantation forests. Prevents access and creates safety hazard during harvest of plantation trees.	1
Horticulture	L	L	Smothers trees in orchards and obstructs access.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Dense vines smother canopy trees and other native vegetation, causes canopy collapse.	1
Threatened species	-	L		1
Social/Cultural				
Human health	-	-		
Recreation	-	L	Dense walls of vines restrict access to forest.	
Māori culture	-	L	See Recreation	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2005b)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild kiwifruit**
Proposed management programme: **Progressive Containment (defined area)**
Area of Programme: **993,114.1 ha**
Proposed annual expenditure by Council: **$40,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	49.8 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$60.9/ha	Potential extent in the region°	143,453 ha
	$37.37-84.42/ha		47,820.82-239,086.1 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$51,420 min: 30,754 max: 183,481	$0		$0	$0	$0	
Progressive Containment (defined area)	$23,010	$0	$28,410	$337,413	$900,218	$84,353	$-1,293,574
	min: 12,619 max: 35,293		min: 18,135 max: 148,188		min: 731,149 max: 1,086,836		min: -1,490,467 max: -1,004,727

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$1,948,107 min: 980,326 max: 7,527,351	$0		$0	$0	$0	
Progressive Containment (defined area)	$34,877	$0	$1,913,230	$769,100	$902,747	$84,353	$157,030
	min: 14,984 max: 75,573		min: 965,342 max: 7,451,778		min: 731,149 max: 1,086,836		min: -974,947 max: 5,867,176

3.47 Wild kiwifruit (Progressive Containment) (*Actinidia* spp.)

Relevant biology

Attribute	Description
Form	Perennial, climbing or scrambling vine up to 15 m. Leaves are alternate, long-petioled, deciduous, oval to nearly circular, cordate at the base and 7.5-12.5 cm long. Young leaves are coated with red hairs; mature leaves are dark-green and hairless on upper surface, downy-white with prominent, light-coloured veins beneath. Oblong fruits are up to 6.5 cm long and densely covered in short, stiff, brown hairs.
Habitat	Exotic and native forest, particularly on the margins and in light gaps, regenerating forest, riparian margins, and scrub. Usually close to kiwifruit orchards or where excess fruit has been dumped or fed to stock.
Regional distribution	Found mostly near kiwifruit orchard areas in western part of the region (e.g. Te Puke) but can also be found in isolated places, usually in native forest. A recent aerial survey of the Te Puke gullies found about 100 new sites.
Competitive ability	Can smother or strangle host plants. Very vigorous grower.
Reproductive ability	Each fruit contains numerous small seeds.
Dispersal methods	Birds and stock can spread seed. Fruit also distributed by dumping or used as stock food for cattle and deer.
Resistance to control	Can be cut and treated with herbicide or sprayed during spring and summer.
Benefits	Edible fruit, major export crop. Reject export fruit used as livestock feed.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	M	M	Smothers trees in plantation forests. Prevents access and creates safety hazard during harvest of plantation trees.	1
Horticulture	L	L	Smothers trees in orchards and obstructs access.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Dense vines smother canopy trees and other native vegetation, causes canopy collapse.	1
Threatened species	-	L		1
Social/Cultural				
Human health	-	-		
Recreation	-	L	Dense walls of vines restrict access to forest.	
Māori culture	-	L	See Recreation	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2005b)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild kiwifruit**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$200,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	194.244 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$60.93/ha	Potential extent in the region°	178,709 ha
	$36.24-85.61/ha		59,579.24-297,838.3 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$189,751 min: 110,114 max: 280,859	$0		$0	$0	$0	
Progressive Containment (region)	$89,797	$0	$99,954	$1,687,066	$3,511,285	$1,265,300	$-6,363,697
	min: 47,728 max: 139,609		min: 62,386 max: 141,250		min: 2,851,833 max: 4,239,182		min: -7,129,162 max: -5,662,949

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$4,903,421 min: 2,382,879 max: 10,386,801	$0		$0	$0	$0	
Progressive Containment (region)	$136,108	$0	$4,767,313	$3,832,723	$3,521,149	$1,265,300	$-3,851,859
	min: 56,672 max: 298,947		min: 2,326,207 max: 10,087,854		min: 2,851,833 max: 4,239,182		min: -7,010,998 max: 2,137,998

3.48 Wild kiwifruit (Sustained Control-defined area) (*Actinidia* spp.)

Relevant biology

Attribute	Description
Form	Perennial, climbing or scrambling vine up to 15 m. Leaves are alternate, long-petioled, deciduous, oval to nearly circular, cordate at the base and 7.5-12.5 cm long. Young leaves are coated with red hairs; mature leaves are dark-green and hairless on upper surface, downy-white with prominent, light-coloured veins beneath. Oblong fruits are up to 6.5 cm long and densely covered in short, stiff, brown hairs.
Habitat	Exotic and native forest, particularly on the margins and in light gaps, regenerating forest, riparian margins, and scrub. Usually close to kiwifruit orchards or where excess fruit has been dumped or fed to stock.
Regional distribution	Found mostly near kiwifruit orchard areas in western part of the region (e.g. Te Puke) but can also be found in isolated places, usually in native forest. A recent aerial survey of the Te Puke gullies found about 100 new sites.
Competitive ability	Can smother or strangle host plants. Very vigorous grower.
Reproductive ability	Each fruit contains numerous small seeds.
Dispersal methods	Birds and stock can spread seed. Fruit also distributed by dumping or used as stock food for cattle and deer.
Resistance to control	Can be cut and treated with herbicide or sprayed during spring and summer.
Benefits	Edible fruit, major export crop. Reject export fruit used as livestock feed.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	M	M	Smothers trees in plantation forests. Prevents access and creates safety hazard during harvest of plantation trees.	1
Horticulture	L	L	Smothers trees in orchards and obstructs access.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Dense vines smother canopy trees and other native vegetation, causes canopy collapse.	1
Threatened species	-	L		1
Social/Cultural				
Human health	-	-		
Recreation	-	L	Dense walls of vines restrict access to forest.	
Māori culture	-	L	See Recreation	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2005b)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild kiwifruit**
Proposed management programme: **Sustained Control (defined area)**
Area of Programme: **258,848.5 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	152.1598 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$59.71/ha	Potential extent in the region°	34,000 ha
	$30.54-88.87/ha		11,337.57-56,661.53 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$135,961 min: 67,709 max: 213,580	$0		$0	$0	$0	
Sustained Control (defined area)	$79,020 min: 39,952 max: 118,983	$0	$56,941 min: 27,757 max: 94,597	$843,533	$3,111,780 min: 2,764,763 max: 3,465,500	$463,943	$-4,362,315 min: -4,745,219 max: -3,977,642

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits of the proposed management programme over the next 50 years will still not be of net benefit to the region with the assumptions made

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,122,650 min: 869,072 max: 4,954,846	$0		$0	$0	$0	
Sustained Control (defined area)	$188,384 min: 92,090 max: 292,841	$0	$1,934,266 min: 776,982 max: 4,662,005	$2,234,147	$3,111,780 min: 2,764,763 max: 3,465,500	$463,943	$-3,875,604 min: -5,386,608 max: -800,848

3.49 Wild kiwifruit (Sustained Control) (*Actinidia* spp.)

Relevant biology

Attribute	Description
Form	Perennial, climbing or scrambling vine up to 15 m. Leaves are alternate, long-petioled, deciduous, oval to nearly circular, cordate at the base and 7.5-12.5 cm long. Young leaves are coated with red hairs; mature leaves are dark-green and hairless on upper surface, downy-white with prominent, light-coloured veins beneath. Oblong fruits are up to 6.5 cm long and densely covered in short, stiff, brown hairs.
Habitat	Exotic and native forest, particularly on the margins and in light gaps, regenerating forest, riparian margins, and scrub. Usually close to kiwifruit orchards or where excess fruit has been dumped or fed to stock.
Regional distribution	Found mostly near kiwifruit orchard areas in western part of the region (e.g. Te Puke) but can also be found in isolated places, usually in native forest. A recent aerial survey of the Te Puke gullies found about 100 new sites.
Competitive ability	Can smother or strangle host plants. Very vigorous grower.
Reproductive ability	Each fruit contains numerous small seeds.
Dispersal methods	Birds and stock can spread seed. Fruit also distributed by dumping or used as stock food for cattle and deer.
Resistance to control	Can be cut and treated with herbicide or sprayed during spring and summer.
Benefits	Edible fruit, major export crop. Reject export fruit used as livestock feed.

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	High	High
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	-	-		
Sheep and beef	-	-		
Forestry	M	M	Smothers trees in plantation forests. Prevents access and creates safety hazard during harvest of plantation trees.	1
Horticulture	L	L	Smothers trees in orchards and obstructs access.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Dense vines smother canopy trees and other native vegetation, causes canopy collapse.	1
Threatened species	-	L		1
Social/Cultural				
Human health	-	-		
Recreation	-	L	Dense walls of vines restrict access to forest.	
Māori culture	-	L	See Recreation	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2005b)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	0	0
- Sheep and beef	0	0
- Forestry	87.35-192.15	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Wild kiwifruit**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$115,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	194.244 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$60.93/ha	Potential extent in the region°	178,709 ha
	$36.24-85.61/ha		59,579.24-297,838.3 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$189,751 min: 110,114 max: 280,859	$0		$0	$0	$0	
Progressive Containment (region)	$102,937	$0	$86,814	$970,063	$3,972,433	$506,120	$-5,361,802
	min: 60,519 max: 146,324		min: 49,595 max: 134,535		min: 3,529,438 max: 4,423,984		min: -5,850,572 max: -4,871,086

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$4,903,421 min: 2,382,879 max: 10,386,801	$0		$0	$0	$0	
Progressive Containment (region)	$245,404	$0	$4,658,017	$2,569,269	$3,972,433	$506,120	$-2,389,805
	min: 139,497 max: 360,133		min: 2,243,382 max: 10,026,668		min: 3,529,438 max: 4,423,984		min: -5,255,991 max: 3,421,841

3.50 Woolly nightshade (Prog. Containment-defined area) (*Solanum mauritianum*)

Relevant biology

Attribute	Description
Form	Perennial shrub or small tree of up to 4 m high. Leaves are grey green, ovate and densely covered with furry hairs. Violet flowers and a dull yellow berry.
Habitat	Able to establish in a wide variety of climates and soil types. Habitat limitations not well known in New Zealand.
Regional distribution	Widespread throughout warm, coastal parts of the region. In colder, inland parts of the region (e.g. around Rotorua lakes) it is still at very low densities.
Competitive ability	Can eliminate other species in dense stands. Effects on native bush not well known. Some believe that it will be shaded out over time, while others think it will continue to dominate.
Reproductive ability	Large numbers of seeds produced with 95% viability. 3 year-old plants recorded bearing 10,000 seeds.
Dispersal methods	Most seeds fall close to parent. Some spread by birds.
Resistance to control	Control by herbicides, cut and stump treatment, ring-barking, basal treatment and hand pulling.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Thought to be toxic to stock.	
Sheep and beef	L	M	Can form dense stands on rough pasture. Displaces pasture grasses and clover, thus reducing food availability for stock. Thought to be toxic to stock.	
Forestry	L	M	Could compete with young trees in plantation forests.	1, 2
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Forms dense, often pure stands, outcompeting most other species. Inhibits and slows regeneration of native plant species.	2
Threatened species	L	M		2
Social/Cultural				
Human health	L	M	Can cause skin irritation and respiratory problems in some people.	2
Recreation	L	M	Forms dense stands which obstruct access.	2
Māori culture	L	M	See Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2004), 2: Environment Bay of Plenty (2005c)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Woolly nightshade**
Proposed management programme: **Progressive Containment (defined area)**
Area of Programme: **668,946 ha**
Proposed annual expenditure by Council: **$100,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	230.1375 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$66.64/ha	Potential extent in the region°	65,820 ha
	$23.83-109.46/ha		22,341.93-109,297.6 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$232,552 min: 81,062 max: 402,422	$0		$0	$0	$0	
Progressive Containment (defined area)	$116,374	$0	$116,178	$843,533	$1,698,008	$168,707	$-2,594,070
	min: 37,183 max: 211,479		min: 43,879 max: 190,943		min: 1,228,658 max: 2,232,232		min: -3,200,593 max: -2,049,955

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme will be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$3,999,372 min: 1,154,268 max: 10,134,607	$0		$0	$0	$0	
Progressive Containment (defined area)	$176,392	$0	$3,822,980	$1,917,958	$1,702,778	$168,707	$33,537
	min: 44,151 max: 452,842		min: 1,110,117 max: 9,681,765		min: 1,228,658 max: 2,232,232		min: -3,208,780 max: 6,366,442

3.51 Woolly nightshade (Progressive Containment) (*Solanum mauritianum*)

Relevant biology

Attribute	Description
Form	Perennial shrub or small tree of up to 4 m high. Leaves are grey green, ovate and densely covered with furry hairs. Violet flowers and a dull yellow berry.
Habitat	Able to establish in a wide variety of climates and soil types. Habitat limitations not well known in New Zealand.
Regional distribution	Widespread throughout warm, coastal parts of the region. In colder, inland parts of the region (e.g. around Rotorua lakes) it is still at very low densities.
Competitive ability	Can eliminate other species in dense stands. Effects on native bush not well known. Some believe that it will be shaded out over time, while others think it will continue to dominate.
Reproductive ability	Large numbers of seeds produced with 95% viability. 3 year-old plants recorded bearing 10,000 seeds.
Dispersal methods	Most seeds fall close to parent. Some spread by birds.
Resistance to control	Control by herbicides, cut and stump treatment, ring-barking, basal treatment and hand pulling.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Thought to be toxic to stock.	
Sheep and beef	L	M	Can form dense stands on rough pasture. Displaces pasture grasses and clover, thus reducing food availability for stock. Thought to be toxic to stock.	
Forestry	L	M	Could compete with young trees in plantation forests.	1, 2
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Forms dense, often pure stands, outcompeting most other species. Inhibits and slows regeneration of native plant species.	2
Threatened species	L	M		2
Social/Cultural				
Human health	L	M	Can cause skin irritation and respiratory problems in some people.	2
Recreation	L	M	Forms dense stands which obstruct access.	2
Māori culture	L	M	See Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2004), 2: Environment Bay of Plenty (2005c)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Woolly nightshade**
Proposed management programme: **Progressive Containment (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$800,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,973.784 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$74.28/ha	Potential extent in the region°	114,023 ha
	$26.68-121.87/ha		38,879.85-189,166.5 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,036,794 min: 707,515 max: 3,550,835	$0		$0	$0	$0	
Progressive Containment (region)	$1,112,370	$0	$924,424	$6,748,265	$14,563,039	$1,349,653	$-21,736,533
	min: 357,095 max: 2,019,358		min: 350,420 max: 1,531,477		min: 10,537,640 max: 19,144,834		min: -26,892,332 max: -17,104,081

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$18,841,609 min: 5,328,187 max: 50,162,715	$0		$0	$0	$0	
Progressive Containment (region)	$1,686,056	$0	$17,155,553	$15,321,310	$14,603,951	$1,349,653	$-14,119,361
	min: 424,008 max: 4,324,072		min: 4,904,179 max: 45,838,643		min: 10,537,640 max: 19,144,834		min: -30,911,618 max: 18,630,040

3.52 Woolly nightshade (Sustained Control-defined area) (*Solanum mauritianum*)

Relevant biology

Attribute	Description
Form	Perennial shrub or small tree of up to 4 m high. Leaves are grey green, ovate and densely covered with furry hairs. Violet flowers and a dull yellow berry.
Habitat	Able to establish in a wide variety of climates and soil types. Habitat limitations not well known in New Zealand.
Regional distribution	Widespread throughout warm, coastal parts of the region. In colder, inland parts of the region (e.g. around Rotorua lakes) it is still at very low densities.
Competitive ability	Can eliminate other species in dense stands. Effects on native bush not well known. Some believe that it will be shaded out over time, while others think it will continue to dominate.
Reproductive ability	Large numbers of seeds produced with 95% viability. 3 year-old plants recorded bearing 10,000 seeds.
Dispersal methods	Most seeds fall close to parent. Some spread by birds.
Resistance to control	Control by herbicides, cut and stump treatment, ring-barking, basal treatment and hand pulling.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Thought to be toxic to stock.	
Sheep and beef	L	M	Can form dense stands on rough pasture. Displaces pasture grasses and clover, thus reducing food availability for stock. Thought to be toxic to stock.	
Forestry	L	M	Could compete with young trees in plantation forests.	1, 2
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Forms dense, often pure stands, outcompeting most other species. Inhibits and slows regeneration of native plant species.	2
Threatened species	L	M		2
Social/Cultural				
Human health	L	M	Can cause skin irritation and respiratory problems in some people.	2
Recreation	L	M	Forms dense stands which obstruct access.	2
Māori culture	L	M	See Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2004), 2: Environment Bay of Plenty (2005c)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Woolly nightshade**
Proposed management programme: **Sustained Control (defined area)**
Area of Programme: **583,016.5 ha**
Proposed annual expenditure by Council: **$300,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,700.19 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$85.25/ha	Potential extent in the region°	47,263 ha
	$30.72-139.78/ha		16,218.09-78,308.55 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$1,915,619 min: 661,698 max: 3,370,507	$0		$0	$0	$0	
Sustained Control (defined area)	$1,260,695	$0	$654,924	$2,530,599	$14,191,897	$506,120	$-16,573,692
	min: 449,002 max: 2,091,106		min: 212,696 max: 1,279,401		min: 11,233,699 max: 17,210,003		min: -20,034,026 max: -12,991,017

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$13,183,177 min: 3,705,904 max: 35,778,041	$0		$0	$0	$0	
Sustained Control (defined area)	$3,005,513	$0	$10,177,664	$6,702,442	$14,191,897	$506,120	$-11,222,795
	min: 1,034,955 max: 5,146,630		min: 2,670,949 max: 30,631,411		min: 11,233,699 max: 17,210,003		min: -21,747,616 max: 12,189,150

3.53 Woolly nightshade (Sustained Control) (*Solanum mauritianum*)

Relevant biology

Attribute	Description
Form	Perennial shrub or small tree of up to 4 m high. Leaves are grey green, ovate and densely covered with furry hairs. Violet flowers and a dull yellow berry.
Habitat	Able to establish in a wide variety of climates and soil types. Habitat limitations not well known in New Zealand.
Regional distribution	Widespread throughout warm, coastal parts of the region. In colder, inland parts of the region (e.g. around Rotorua lakes) it is still at very low densities.
Competitive ability	Can eliminate other species in dense stands. Effects on native bush not well known. Some believe that it will be shaded out over time, while others think it will continue to dominate.
Reproductive ability	Large numbers of seeds produced with 95% viability. 3 year-old plants recorded bearing 10,000 seeds.
Dispersal methods	Most seeds fall close to parent. Some spread by birds.
Resistance to control	Control by herbicides, cut and stump treatment, ring-barking, basal treatment and hand pulling.
Benefits	None

Land use/habitats occupied in Bay of Plenty

Land use type	Current infestation	Potential infestation
Dairy	High	High
Sheep and beef	High	High
Forestry	High	High
Horticulture	High	High
Aquaculture	-	-
Urban	High	High
Native terrestrial	Low	Low
Coastal land	Low	Low
Freshwater	-	-
Estuarine	-	-
Marine	-	-

High = Most infested/preferred land use(s), Low = Less infested/preferred land use(s), - = Unsuitable land use

Qualitative impact assessment

Category	Current	Potential	Comment	Source
Production				
Dairy	L	L	Thought to be toxic to stock.	
Sheep and beef	L	M	Can form dense stands on rough pasture. Displaces pasture grasses and clover, thus reducing food availability for stock. Thought to be toxic to stock.	
Forestry	L	M	Could compete with young trees in plantation forests.	1, 2
Horticulture	L	L	Can form dense stands and invade open, disturbed or poorly managed areas.	
Aquaculture	-	-		
Other	-	-		
International trade	-	-		
Environment				
Soil resources	-	-		
Water quality	-	-		
Species diversity	M	H	Forms dense, often pure stands, outcompeting most other species. Inhibits and slows regeneration of native plant species.	2
Threatened species	L	M		2
Social/Cultural				
Human health	L	M	Can cause skin irritation and respiratory problems in some people.	2
Recreation	L	M	Forms dense stands which obstruct access.	2
Māori culture	L	M	See Human Health and Recreation.	

L = low, M = moderate, H = high
source 1: Environment Bay of Plenty (2004), 2: Environment Bay of Plenty (2005c)

Estimated quantitative impacts

Quantitative annual impacts per hectare are calculated as the current or anticipated proportional impact on land value across the region. All amounts are in net present value (NPV, $).

Calculation: **Economic value per land use/habitat type** × **Impact level**

Impact level
Low = 1-4% reduction in annual economic value per hectare
Moderate = 5-9% reduction in annual economic value per hectare
High = 10-50% reduction in annual economic value per hectare

Reduction in annual economic value ($) per hectare

Land use/habitat type	Current impact per ha	Potential impact per ha
Production		
- Dairy	54.63-267.08	54.63-267.08
- Sheep and beef	7.39-36.12	36.95-81.27
- Forestry	17.47-85.40	87.35-192.15
- Horticulture	95.20-465.44	95.20-465.44
- Aquaculture	0	0
Environment/Social/Cultural		
- Urban *	0	0
- Native terrestrial	27.80-61.20	55.60-340.00
- Coastal	62.35-137.25	124.70-762.50
- Freshwater	0	0
- Estuarine	0	0
- Marine	0	0

* Pest impacts on urban land were not quantified for Bay of Plenty due to the difficulties with estimating economic values for this land use type.

Cost-benefit analysis results

Pest species: **Woolly nightshade**
Proposed management programme: **Sustained Control (region)**
Area of Programme: **whole region ha**
Proposed annual expenditure by Council: **$400,000**

Assumptions

Assumptions	Values	Assumptions	Values
Current area infested	1,973.784 ha	Time to reach maximum extent†	125 yrs
Current impacts*	$74.28/ha	Potential extent in the region°	114,023 ha
	$26.68-121.87/ha		38,879.85-189,166.5 ha
Current benefits	$0/ha	Discount rate	4%

* Current annual impact of the pest averaged across all land uses currently occupied.

° The potential extent the pest is predicted to achieve in the absence of regional management.

† The time a pest is predicted to take between first going wild in the region and reaching its maximum extent.

10 year assessment

The cost-benefit analysis indicates that the benefits of the proposed management programme over the next 10 years will not be of net benefit to the region with the assumptions made.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$2,036,794	$0		$0	$0	$0	
	min: 707,515 max: 3,550,835						
Sustained Control (region)	$1,275,154	$0	$761,640	$3,374,133	$16,475,649	$674,827	$-19,762,969
	min: 452,791 max: 2,116,480		min: 254,724 max: 1,434,355		min: 13,041,420 max: 19,979,427		min: -23,773,663 max: -15,656,025

* Includes economic, environmental and social costs.

° The estimated economic benefit provided by the pest.

† Administration and implementation costs incurred by the Council through the programme.

‡ Costs of control imposed on landowners through the programme, over and above the costs already being paid by landowners, as estimated by the Council. They are applied for the 10 years of the Plan.

50 year assessment

The longer-term cost-benefit analysis indicates that the monetised benefits over the next 50 years of the proposed management programme may be of net benefit to the region. Additional non-monetised benefits associated with the protection of biodiversity values are also anticipated.

Scenario	Pest impacts*	Pest values°	Benefit	Council costs†	Landowner compliance costs‡	Agency compliance costs‡	Net benefit
No intervention	$18,841,609	$0		$0	$0	$0	
	min: 5,328,187 max: 50,162,715						
Sustained Control (region)	$3,039,982	$0	$15,801,627	$8,936,589	$16,475,649	$674,827	$-10,285,438
	min: 1,043,689 max: 5,209,081		min: 4,284,498 max: 44,953,634		min: 13,041,420 max: 19,979,427		min: -25,306,345 max: 22,300,798

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SECTION 71 OF THE AMENDED BIOSECURITY ACT (2012)

71 Second Step: Satisfaction On Requirements

If the council is satisfied that section 70 has been complied with, the council may take the second step in the making of a plan, which is to consider whether the council is satisfied—

(a) that the proposal is not inconsistent with—
  (i) the national policy direction; or
  (ii) any other pest management plan on the same organism; or
  (iii) any pathway management plan; or
  (iv) a regional policy statement or regional plan prepared under the Resource Management Act 1991; or
  (v) any regulations; and

(b) that, during the development of the proposal, the process requirements for a plan in the national policy direction, if there were any, were complied with; and

(c) that the proposal has merit as a means of eradicating or effectively managing the subject of the proposal, which means—
  (i) the organism proposed to be specified as a pest under the plan or the organisms proposed to be specified as pests under the plan; or
  (ii) the class or description of organism proposed to be specified as a pest under the plan or the classes or descriptions of organisms proposed to be specified as pests under the plan; and

(d) that each subject is capable of causing at some time an adverse effect on 1 or more of the following in the region:
  (i) economic wellbeing:
  (ii) the viability of threatened species of organisms:
  (iii) the survival and distribution of indigenous plants or animals:
  (iv) the sustainability of natural and developed ecosystems, ecological processes, and biological diversity:
  (v) soil resources:
  (vi) water quality:
  (vii) human health:
  (viii) social and cultural wellbeing:
  (ix) the enjoyment of the recreational value of the natural environment:
  (x) the relationship between Māori, their culture, and their traditions and their ancestral lands, waters, sites, wāhi tapu, and taonga:
  (xi) animal welfare; and

(e) that, for each subject, the benefits of the plan would outweigh the costs, after taking account of the likely consequences of inaction or other courses of action; and

(f) that, for each subject, persons who are required, as a group, to meet directly any or all of the costs of implementing the plan—
    (i) would accrue, as a group, benefits outweighing the costs; or
    (ii) contribute, as a group, to the creation, continuance, or exacerbation of the problems proposed to be resolved by the plan; and

(g) that, for each subject, there is likely to be adequate funding for the implementation of the plan for the shorter of its proposed duration and 5 years; and

(h) that each proposed rule—
    (i) would assist in achieving the plan's objectives; and
    (ii) would not trespass unduly on the rights of individuals; and

(i) that the proposal is not frivolous or vexatious; and

(j) that the proposal is clear enough to be readily understood; and

(k) that, if the council rejected a similar proposal within the last 3 years, new and material information answers the council's objection to the previous proposal.

Section 71: replaced, on 18 September 2012, by section 39 of the Biosecurity Law Reform Act 2012 (2012 No 73).

NATIONAL POLICY DIRECTION FOR PEST MANAGEMENT 2015

6. DIRECTIONS ON ANALYSING BENEFITS AND COSTS

Pest management plan and pathway management plan

1. When determining the appropriate level of analysis of the benefits and costs of the plan for each subject for the purposes of a proposal for a pest management plan or pathway management plan, a proposer must consider:
   (a) the level of uncertainty of the impacts of the subject, or an organism being spread by the subject, and of the effectiveness of measures; and
   (b) the likely significance of the subject, or an organism being spread by the subject, or of the proposed measures, in terms of stakeholder interest and contention, and total costs of the proposed plan; and
   (c) the likely costs of the programme relative to the likely benefits; and
   (d) the level of certainty and the quality of the available data.

2. In the proposal for a pest management plan, or in a pathway management plan, an analysis of the benefits and costs of the plan for each subject must:
   (a) identify, and quantify (if practicable) the impacts of the proposed subject or an organism being spread by the subject; and
   (b) identify two or more options for responding to the subject or an organism being spread by the subject (one option must be either taking no action or taking the actions that would be expected in the absence of a plan); and
   (c) identify, and quantify (if practicable), the benefits of each option; and
   (d) identify, and quantify (if practicable), the costs of each option; and
   (e) state the assumptions (if any) on which the impacts, benefits and costs are based; and
   (f) be at an appropriate level of detail as determined in accordance with sub clause (1); and
   (g) take into account any risks that each option will not achieve its objective; and
   (h) identify any realistic mitigation options for the risks identified in sub clause (2)(g); and
   (i) adjust the benefits and costs for each option as appropriate to take account of subclause (2)(g) and (h); and
   (j) clearly identify which option is preferred.

3. When taking into account any risks that each option will not achieve its objective under subclause (2)(g), a proposer must consider:
   (a) the technical and operational risks of the option; and
   (b) the extent to which the option will be implemented and complied with; and
   (c) the risk that compliance with other legislation will adversely affect implementation of the option; and
   (d) the risk that public or political concerns will adversely affect implementation of the option; and
   (e) any other material risk.

4. When taking into account any risks that each option will not achieve its objective under sub clause (2)(g), a proposer must:

(a) for analyses where the benefits are fully quantified, either:
    i. estimate the residual risks as a probability of success and calculate the expected benefits of the option by multiplying the benefits by the probability of success; or
    ii. state the residual risks to the programme and calculate what the probability of success would need to be to make the expected benefits equal the costs; and
(b) for all other analyses (where the benefits are not fully quantified):
    i. state the residual risks to the programme and, where practicable, give an indication of likelihood and impact; and
    ii. specify which of the benefits are most likely to be affected if the risk eventuated.

5. The proposer of a pest management plan or pathway management plan must document the assessments made in sub clauses (1), (3) and (4) and make them publicly available with the proposal for a pest or pathway management plan.

COST-BENEFIT ANALYSIS METHODS

COST-BENEFIT ANALYSES: USE WITH CAUTION

Cost-benefit analyses are an economic tool to estimate all relevant costs and benefits in the same currency, usually in current dollars (termed the net present value, or NPV). To make these calculations, all future costs and benefits are "discounted" by the amount a dollar could earn if invested now rather than spent. Past applications of the Harris Model for RPMS reviews have used a standard discounting rate of 8% (although other values can be used in the Model). With an annual compounding interest rate of 8%, $1 invested today will have grown to $46.90 in 50 years' time. For this reason, for it to be economically sensible to spend $10,000 today on pest control to prevent impacts in 50 years' time, those impacts would need to be worth $469,000.

CBA estimates can give the illusion of being precise, robust estimates of future costs and benefits. Models like the Harris Model (described below) require precise data estimates and provide precise cost and benefit estimates calculated down to the dollar (or lower). This hides great uncertainty in our ability to predict the impacts and spread of pests and the costs of their control in the next decades. Because of this, there is an unknown but undoubtedly large amount of uncertainty around all final Harris Model estimates costs and benefits, or any CBA estimates applied to the environment.

The scenarios evaluated in pest animal and plant cost-benefit analyses cannot be regarded as accurate predictions of the future. There is enormous ecological uncertainty surrounding future pest spread and impacts. There is also uncertainty, often large, in our current knowledge of the distribution and impacts of pest populations. Applying a cost-benefit analysis becomes a task of extrapolating into the future from the available data, and using this to make as robust conclusions as can be warranted from the data. It is therefore important that decisions made based wholly or in part on CBA results are revisited with updated data at regular intervals.

Another reason to be cautious in interpreting results from CBA methods when applied to pests is because most pests take many decades, sometimes centuries, to become widespread. While we may wish that our ancestors had acted against weeds like boneseed when they first appeared in the wild over 100-years ago, a CBA done at the time may well have concluded that they would have been better off saving their money rather than helping us out. Spending the equivalent of $10,000 (in current dollars) back in 1870 when boneseed (*Chrysanthemoides monilifera*) was first detected in the wild could well have eradicated it from the country, preventing all of the environmental impacts it is causing now. However, investing the equivalent of $10,000 in 1870 would now be worth $477,887,607 at an 8% annual compounding interest rate. A CBA at the time would therefore have required the impacts of boneseed today to cost us half a billion dollars to warrant them taking action against it. That is a big impact even for a rapidly expanding environmental weed like boneseed. The big problem with using CBA in this way is that we do not now have half a billion dollars that was invested from 1870 to deal with today's boneseed problem. Deciding not to control an incipient pest now therefore transfers a financial burden onto the next generation, who may or may not be as wealthy as us, and who will certainly be dealing with many more pest species than we are now. CBA recommendations should therefore be treated with some caution.

While CBA is undoubtedly a useful tool for making political decisions about pest control, it needs be used alongside other political, social, and environmental considerations. Like with so many environmental issues, there is always the temptation to pass costs on to future generations while we enjoy the benefits of delaying action. Future generations are likely to bear the brunt of a great many such decisions. Regardless of CBA results, decisions about whether or not to act against pests now still boil down to “is it the right thing to do?" and “can we afford it?".

THE ‘HARRIS MODEL’ FOR COST-BENEFIT ANALYSES

The ’Harris Model’ was developed in 2000 by Simon Harris for the Biosecurity Managers Group, for use in the preparation of Regional Pest Management Strategies (RPMS) (now referred to as Regional Pest Management Plans). The Harris Model is used to carry out cost-benefit analyses (CBA) for pest control under different regional pest management scenarios, including no regional control. It has been used for a number of RPMS reviews in different regions, including the 2003 Bay of Plenty RPMS (Severinsen 2003) and previous Auckland RPMS reviews (Auckland Regional Council 2006). We ran into difficulties implementing the standard Harris Model for the 2009 review of the Bay of Plenty RPMS, because the standard of data it requires is typically is difficult to obtain and unavailable to most councils. It requires unrealistically precise values for ecological parameters, ignores the costs of non-production impacts, and provides no estimate of the uncertainty around the final estimates of costs and benefits.

Our modified model attempts to improve on these areas. We are ecologists, not economists, and so have not changed the underlying economic equations in the Harris model. Instead, we have attempted to simplify the Harris Model to deal with greater uncertainty in the available data and made our modifications around these equations. For example, allowing for a range of values rather than a single value is the same as running the Harris model twice with the high and low value of a range. Adding costs of non-production impacts simply requires re-running the Harris Model with the addition of per hectare impacts on things like soil quality and biodiversity (such values are notoriously difficult to assign dollar values but excluding them altogether is at least as unrealistic - we have typically assigned these small, non-zero numbers relative to production impacts to assess their possible importance). When we do this, we are sure to also include the CBA results when only production impacts are included.

Our most fundamental modification is the use of a mathematically different “S-shaped” growth curve to the Harris Model when we predict the expansion of pests. We use a logistic growth curve widely used in ecology for weed modelling. In comparison to the Harris Model growth curve, our logistic growth curve includes a shorter “establishment-phase” (the time before a species begins to rapidly spread), a longer spread phase, and a shorter plateau. Our model has each phase occupying a third of the invasion. Long lag-phases are well documented in invasion biology, especially in the period between the introduction of a species (e.g. for forestry) and its first wild establishment (e.g. Mulvaney 2001), but most of the species listed in the RPMP are expected to be beyond this early phase. Our shorter establishment phase is more likely to reflect the behaviour of an already identified weed. Usefully, the logistic growth curve also simplifies the mathematics allowing for an easier separation to the population growth time and the time period over which the costs are calculated. This is very helpful in that it makes it easy to not run out the model for all the time required for a pest to reach its full extent. It is also flexible enough to add a lag-phase for other pests if it is considered likely. We have also been careful to identify all of our data sources which will add transparency to this process and make it simple to incorporate new information into revised cost and benefit estimates as it becomes available.

OUR CHANGES TO THE HARRIS MODEL

Our modifications to the Harris Model are described below and summarised in Table A3.1.

Table A3.1: Our key modifications to the Harris Model.

Harris Model	Our Revised Model
Production impacts only	Impacts by land use/habitat type, including non-production land
Single values	Minimum, average, maximum values
Sigmoidal curve	Logistic growth curve
CBA duration = pest growth	CBA duration ≠ pest growth
Maximum extent and spread rate calculated separately	Minimum and maximum values for extent and spread rate (when more accurate data is absent)
Current impacts only	Impacts per hectare can increase

Precise Estimates of Costs and Benefits

The Harris Model requires precise estimates of all parameters in its calculations, such as the total number of hectares a pest is expected to eventually occupy and the exact number of years it will take to reach this extent. Getting precise and ecologically realistic values for these parameters is not practical for even a large subset of the pest species typically included in an RPMS. Predicting pest spread and total potential range is complicated, requires more information than is available for most pests, and is sensitive to changes in human-assisted dispersal processes (and land use and climate change). For example, building a recent spread model in New Zealand for argentine ants, one of the world's best studied insect environmental pests, took Lincoln University PhD student Joel Pitt three years of work. While the Harris Model does not preclude being run several times with minimum and maximum estimates of different parameters, past applications of the Model have only reported single available best estimates of pests' total extent and rate of spread. Our modified model allows for direct input of coarsely estimated parameters and, when these are used, it outputs maximum and minimum estimates of costs and benefits rather than single values.

Duration

Severinsen (2003) applied the Harris Model for a 50 year duration since it required pests to reach their maximum extent. Pests that were expected to spend longer than 50 years to reach their maximum extent were capped at 50 years to deal with discounting of impacts to net present value. It is likely that most incipient pests in the Bay of Plenty will take longer than 50 years to reach their maximum extent (for example, according to Bay of Plenty Regional Council staff rabbits reached the last areas of the Bay of Plenty region only in the past 20 years or so, well over a century after their initial introduction to the region). We have revised the Harris Model to grow pest populations for much longer than 50 years (when appropriate) but still make the CBA calculations for a shorter, more economically reasonable time period (e.g. 10 or 50 years).

Population Growth Model

The Harris Model used a sigmoidal growth curve with a rapid, short growth phase in the middle of a pest's spread (Figure A3.1a). We have replaced the pest spread equations of the Harris Model with the logistic growth curve (Figure A3.1b), commonly used in ecology to model population growth. This is a mathematically useful, and simple, growth curve that allows us to easily calculate growth and associated discounted impacts over only a portion of the growth curve. We have highlighted this portion in the graphs provided with the CBA outputs i.e. where a pest is expected to be now until its maximum extent.

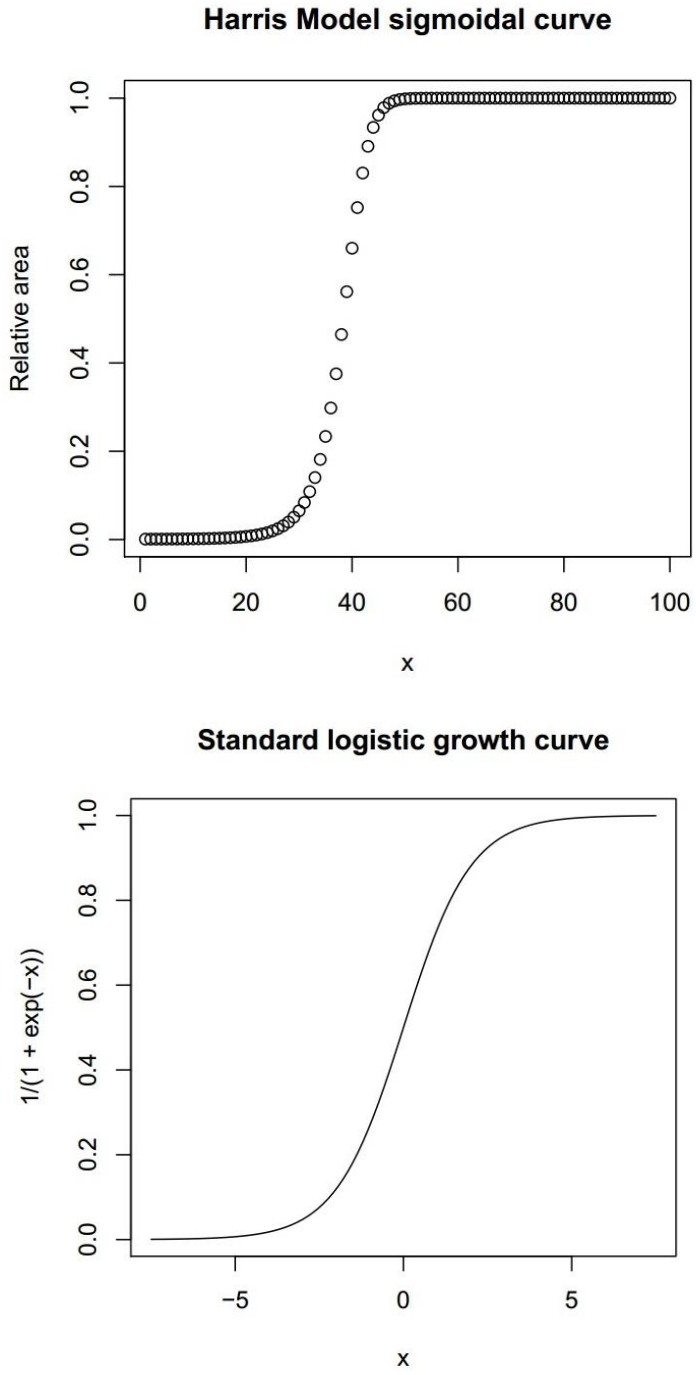

Figure A3.1: (a) The sigmoidal growth curve used to model pest spread in the Harris Model. (b) The standard logistic growth curve used to model pest spread in our CBAs.

Estimating the Potential Area Infested by Each Pest

The Harris Model requires a single estimate of the total area a pest is likely to infest in the region, given sufficient time. It is impossible to provide such a value with any useful level of certainty for almost any pest in a particular region. What is possible is to define broad land use types in each region and categorise them as primary (preferred), secondary (less preferred), or unsuitable habitat for each pest. The land use types we used were Dairy, Sheep/Beef/Deer, Horticulture, Forestry, Aquaculture, Native terrestrial, Urban, Coastal land, Estuarine, Freshwater, and Marine (see the Methods section for definitions).

We then make the assumption that if a land use/habitat type is a *primary* habitat for a pest, then it will have the potential to occur in 5-25% of the regional area of that land use type. If a land use/habitat type is a *secondary* habitat for a pest, then we assume that pest will have the potential to occur in 1-4% of the regional area of that land use type. These are the percentages a pest would be capable of reaching at its maximum regional extent in the absence of regional (RPMP) management. This approach was much quicker but also likely no less accurate than the more precise parameter required by the Harris Model.

Pest Spread

While it is prohibitively expensive and time consuming to accurately estimate a single total extent and rate of spread for a pest, what we can do with confidence is assign all listed pests into categories of current extent in each land use/habitat type, dispersal ability, and life form. These estimates can then be used to assign species to a range of likely spread rates. Our modified Harris Model uses this more coarse but realistic ecological data to estimate the range of costs and benefits within which the true value likely lies, and allows us to present maximum and minimum cost and benefit estimates around average values.

Impacts

The Harris Model bases its estimate of pest impacts on the value of production land, the proportion of this production that is lost due to a pest, and the cost of pest control and the proportion of landowners controlling the pest. The current total loss of production and total cost of control per year are combined to give a current impact per hectare per year for each pest. Getting accurate, detailed data of this kind for many pests is typically prohibitively difficult. This is especially the case for non-agricultural land, which the Harris Model avoids. We have used a simpler but habitat specific approach to estimating impacts that simply requires each pest to be identified as having a low, moderate, or major impact (or not a pest) on each land use/habitat type.

Non-Production Impacts

The Harris Model ignores the impacts, however large, on non-production values such as recreation, biodiversity, and human health. While difficult to quantify economically, the exclusion of these impacts altogether can lead to unrealistic conclusions. For example, this is the reason why the cost-benefit analysis from the 2003 Bay of Plenty RPMS concluded that there was no regional net benefit in controlling parrot's feather (*Myriophyllum aquaticum*), one of the country's worst aquatic weeds, since it caused no annual loss of production to terrestrial agriculture. To avoid these erroneous conclusions, our revised methods allow for the incorporation of non-production impacts of pests. Even if these costs are very small per hectare compared with impacts on agricultural production, they can add up to regionally important impacts for widespread and rapidly expanding pests.

Estimating Impacts

We have taken a similar approach to impacts as we have taken to estimating the potential area occupied by each pest. It is possible to accurately (and relatively quickly) categorise each pest as having a Low, Moderate, or High impact pest on each of our land use/habitat types. Using past Harris Model CBA estimates and pest literature, we assigned each of these categories to the following ranges of impacts on the per hectare value of each land use/habitat type:

- **Low impact** on a land use/habitat = 1-4% reduction in per hectare economic value
- **Moderate impact** on a land use/habitat = 5-9% reduction in per hectare economic value
- **High impact** on a land use/habitat = 10-50% reduction in per hectare economic value

These impact values can be over-written for pests where more accurate and precise values are known. In most cases, such detailed estimates of the economic impacts of pests in New Zealand regions have not been made. From these impact estimates per land use/habitat type, we calculate the total annual per hectare impact of a pest in the region by weighting each land use impact by its estimated proportion of the pest's total extent. This is illustrated below with two examples from the 2017-2018 cost-benefit analyses for the Bay of Plenty RPMP review.

Woolly nightshade (*Solanum mauritianum*) - Sustained Control programme, Bay of Plenty

- **Estimating current per hectare impacts by land use/habitat type**

The impact that woolly nightshade has on each hectare of land it occupies depends on the land use/habitat type of that land. The per hectare impact is estimated using the economic value (per hectare per year) of each land use (net present value) multiplied by the impact the pest is expected to have on production (or other) values. In the absence of a detailed economic assessment of impacts, the pest has been categorised as having a 'Low', 'Moderate', or 'High' impact on each land use/habitat type (see above). A pest having a low impact now might be regarded as able to have a moderate or high impact in the future as its infestations get denser and older. This is the case for woolly nightshade, for example on Sheep and beef land (called 'Sheep/Beef/Deer' in our CBA model). Currently it is assessed as having a low impact per hectare infested of Sheep/Beef/Deer land, but should the weed be allowed to spread extensively, it is estimated that its effects could become moderate on Sheep/Beef/Deer.

Table A3.2: Estimated per hectare impact of woolly nightshade (*Solanum mauritianum*) on different land use/habitat types in the Bay of Plenty region. These are the estimated impacts the weed has on the economic value of a hectare of land *when the weed is present*. This does not take into account what proportion of each land use/habitat type might be occupied (infested) by the weed. 'Production' land use/habitat types are highlighted in orange, 'non-production types are highlighted in green.

a. Current impacts [1]

Land Use/ Habitat Type	Economic Value ($/ha/year)		Pest Impact	Estimated Impact ($/ha occupied)	
	Min	Max		Min	Max
Dairy	5,463	6,677	Low (1-4%)	54.63	267.08
SheepBeefDeer	739	903	Low (1-4%)	7.39	36.12
Horticulture	9,520	11,636	Low (1-4%)	95.20	465.44
Forestry	1,747	2,135	Low (1-4%)	17.47	85.40
Aquaculture	3,305	4,039	Nil/negligible	0	0
Urban *	0*	0*	Low (1-4%)	0*	0*
Native	556	680	Moderate (5-9%)	27.80	61.20
Coastal	1,247	1,525	Moderate (5-9%)	62.35	137.25
Estuarine	6,024	7,362	Nil/negligible	0	0
Freshwater	19,070	27,310	Nil/negligible	0	0
Marine	81	99	Nil/negligible	0	0
TOTAL				**264.84**	**1,052.49**

* Economic values for urban areas in the Bay of Plenty Region were not quantified by Bay of Plenty Regional Council.

b. Potential impacts

Land Use/ Habitat Type	Economic Value ($/ha/year)		Pest Impact	Estimated Impact ($/ha occupied)	
	Min	Max		Min	Max
Dairy	5,463	6,677	Low (1-4%)	54.63	267.08
SheepBeefDeer	739	903	Moderate (5-9%)	36.95	81.27
Horticulture	9,520	11,636	Low (1-4%)	95.20	465.44
Forestry	1,747	2,135	Moderate (5-9%)	87.35	192.15
Aquaculture	3,305	4,039	Nil/negligible	0	0
Urban *	0*	0*	Moderate (5-9%)	0*	0*
Native	556	680	High (10-50%)	55.60	340.00
Coastal	1,247	1,525	High (10-50%)	124.7	762.50
Estuarine	6,024	7,362	Nil/negligible	0	0
Freshwater	19,070	27,310	Nil/negligible	0	0
Marine	81	99	Nil/negligible	0	0
TOTAL				**454.43**	**2,108.44**

* Economic values for urban areas in the Bay of Plenty Region were not quantified by Bay of Plenty Regional Council.

– Estimating the proportion of the pest's extent in each land use/habitat type

We need to estimate impacts across the regional extent of the pest without detailed spatial information on the pest's distribution (this is seldom available). To achieve this, we apply a weighted average per hectare impact across the total area infested by the pest (whether that is the current estimated area of the pest or the modelled area of the pest in the future after spread).

[1] The values in the "Estimated Impact" columns of Table A3.2 are also shown in Table 8 "Reduction in annual economic value ($) per hectare" (Section 2.7.3 of this report).

This weighted average per hectare impact is calculated using the modelled area of the pest in each land use/habitat type (non-marine land use/habitat types only) (see Section 2.5.5 Potential area infested). For example, Forestry is considered to be a primary habitat of woolly nightshade, now and in the future. In the absence of estimates from other studies, the model assumes that woolly nightshade could occupy 5-25% of Forestry land region-wide (without regional management). (Pests in secondary habitat are assumed to be capable of occupying 1-4% of that land use/habitat type.) These values can be replaced with pest-specific values when data are available. In the case of woolly nightshade, the default ranges were used.

The model also makes the assumption, in the absence of detailed spatial data on the pest's extent, that the pest has the potential to spread into land use/habitat types proportional to their area in the whole region. For example, 23.5% of the terrestrial area of the Bay of Plenty region is currently Forestry. In the absence of detailed data, the model assumes that 23.5% of the new land infested by woolly nightshade as it spreads *could be* Forestry. Whether it *is* Forestry depends on whether Forestry is a primary habitat, secondary habitat, or not a habitat for this pest.

Table A3.3 shows the how the land use/habitat type weightings are calculated. The pest is assumed to currently occupy *proportionally* the same mix of land uses/habitat types as it potentially can. In this case, for example, 38.5-39.5% of the current extent of woolly nightshade is assumed to be Forestry. This percentage is held constant as the pest spreads across the region in the model.

Table A3.3: Estimated proportion of each land use/habitat type expected to be occupied by woolly nightshade (*Solanum mauritianum*) in the Bay of Plenty region based on habitat use categories. In the absence of more detailed information, pests are assumed to occupy 5-25% of all primary habitat in the region and 1-4% of all secondary habitat. 'Production' land use/habitat types are highlighted in orange, 'non-production types are highlighted in green. 'Marine' and 'Aquaculture' land use/habitat types were not included in the calculations.

Land Use/ Habitat Type	Total Area in region (ha)	Habitat Use by Pest	Estimated Potential Occupancy (ha)		Percentage of all Habitat Occupied	
			Min	Max	Min	Max
Dairy	159,125	primary habitat	7,956	39,781	20.5	21.0
SheepBeefDeer	172,800	primary habitat	8,640	43,200	22.2	22.8
Horticulture	27,374	primary habitat	1,369	6,844	3.5	3.6
Forestry	299,019	primary habitat	14,951	74,755	38.5	39.5
Urban	14,624	primary habitat	731	3,656	1.9	1.9
Native	517,485	secondary habitat	5,175	20,699	13.3	10.9
Coastal	5,791	secondary habitat	58	232	0.1	0.1
Estuarine	21,645	no/negligible impact	0	0	0	0
Freshwater	23,610	no/negligible impact	0	0	0	0
TOTAL	**1,241,473**		**38,880**	**189,167**	**100**	**100**

- Calculating overall per hectare impact regardless of land uses/habitat types

It is now possible to calculate a per hectare impact across the whole region irrespective of land use/habitat type. This calculation is done by multiplying the initial per hectare per land use/habitat type impacts in Table A3.2 by the "Percentage of all habitat occupied" values from Table A3.3 and summing the result. These calculations are presented in Table A3.4.

Table A3.4: Current per hectare impact (minimum and maximum estimates) of woolly nightshade (*Solanum mauritianum*) on an average hectare of land in the Bay of Plenty region, irrespective of land use/habitat type, proportional to how much of each land use/habitat type is occupied by the weed.

Land Use/ Habitat Type	Estimated Impact ($/ha occupied)		Percentage of all Habitat Infested		Average per Hectare Impact ($/ha)	
	Min	Max	Min	Max	Min	Max
Dairy	54.63	267.08	20.5	21.0	11.18	56.17
SheepBeefDeer	7.39	36.12	22.2	22.8	1.64	8.25
Horticulture	95.2	465.44	3.5	3.6	3.35	16.84
Forestry	17.47	85.4	38.5	39.5	6.72	33.75
Urban	0	0	1.9	1.9	0	0
Native	27.8	61.2	13.3	10.9	3.70	6.70
Coastal	62.35	137.25	0.1	0.1	0.09	0.17
Estuarine	0	0	0	0	0	0
Freshwater	0	0	0	0	0	0
TOTAL			**100**	**100**	**26.68**	**125.37**

The total impact of woolly nightshade on a hectare of occupied land in the Bay of Plenty is therefore $26.68-125.37, with a mid-value of $76.03. These values are reported in the "Assumptions" table of the "Cost-benefit analysis results" page for each pest in the CBA outputs. These impact values are applied to the weed as its spread is modelled over the duration of the assessment.

Increasing Pest Impacts

Assessing the costs of current and potential pest impacts is a complicated exercise. Predicting pest impacts is an active area of research and there is a great deal that is not well understood, especially about the impacts of pests on natural ecosystems. The Harris Model uses precise estimates of the annual loss of production (in dollars) per pest species. Estimating these parameters with a useful degree of precision is impractical in all but the simplest cases. The Harris Model extrapolates the best estimate of current pest impacts per hectare per year into the future, multiplied by the projected increase in pest area, with a compounding 8% discount rate. We found that this simplification leads to inaccurate results for some species, particularly low-incidence pests. For example, the notorious pasture pest, nassella tussock (*Nassella trichotoma*), has been so well controlled that it is currently not common in pastoral land and its current average annual per hectare impacts are low. However, if regional control was relaxed, it is likely that it would reinvade high value land and reach damaging densities, in which case its annual impacts per hectare would become much higher than they are now. The same applies to incipient pests that experience elsewhere shows will become a serious problem if they are not controlled, but which are currently restricted to low-value lands or occur in low densities. To deal with these kinds of cases, we have modified the Harris Model to allow the annual per hectare pest impacts to increase through the duration of the CBA.

In year one we use our estimates of the current annual impacts per hectare (see above) then increase this value linearly up to our estimated potential impact at the mid-point of the species spread. For example, if a weed was estimated to take 100 years to reach its maximum extent, we assume that it will reach its potential annual impact per hectare by 50 years. If this weed was estimated to be already 30 years into its spread, we increase the weed's per hectare impacts linearly to reach its potential in 20 more years.

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