Ecosystem Services in the Ōhiwa Catchment

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REPORT INFORMATION SHEET

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EXECUTIVE SUMMARY

Report Title: Ecosystem Services in the Ōhiwa Catchment
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This study has served as a proof of concept for the application of the ecosystem services approach as a framework for realising the full value of the services derived from ecosystems in a catchment. The results of the study, despite its limitations, provide a foundation that can support land management planning at the catchment level.

Objective

The main aims of this report were to: (i) provide an initial list of key ecosystem services related to the existing land uses in the Ōhiwa catchment; (ii) estimate their values using a desktop analysis, and (iii) compile and present the data in order to facilitate discussions around the full value of ecosystem services within the catchment. A second objective was to undertake a gap analysis in assessing ecosystem services for the catchment.

Key Results

(i) Seven major land-use groups within the in the Ōhiwa catchment, Bay of Plenty, have been identified. These were productive land uses (dry stock, exotic forests, dairy and horticulture) and natural land uses (indigenous forest, scrub, and wetlands and mangroves).

(ii) Key ecosystem services in the Ōhiwa catchment with market values were identified as food (meat, milk and fruit) and fibre (wool, wood and pulp), and the tradeable carbon sequestration credits from exotic planted forests. A number of ecosystem services with non-market values were also identified. These were: avoided erosion/sedimentation; flood mitigation/disturbance regulation; regulating nutrient (nitrogen) supply (e.g. avoided N leaching); pollination; water regulation; waste treatment; pest and disease regulation; water supply; recreation; species conservation; nutrient cycling; and soil formation.

(iii) Of the productive land uses, horticulture and dairy land uses were found to provide the highest market ecosystem values (i.e. net operating profit from production) per ha per year while exotic forestry, and dry stock (sheep and beef) provide the lowest market value. The market value of horticulture is more than five times higher than dairy and 18 times higher than exotic forestry.

(iv) Incorporating ecosystem services with non-market values showed that only one of the productive land uses (exotic forestry) has an overall positive ecosystem-service value. Among the natural land-use group, wetlands provide the highest value per ha followed by indigenous forest and scrub.

(v) Analysis of possible scenarios to enhance the values in the catchment demonstrated the usefulness of this approach to discuss land-use change and the implications of technology developments on the overall catchment state.

Implications of Results/Conclusions

The study gives a much fuller overall picture of the full value of the catchment within an ecosystem services framework. It provides the opportunity to explore ways to attain future goals for the catchment. The results of this desktop study, although preliminary, can be used in discussions about ecosystem services in the catchment and as a tool to support land-use planning.

Future Directions

The second aim of this report was to assist with identification of research gaps in valuing ecosystem services for the catchment. Gaps identified include the need to: estimate values of other ecosystem services (e.g. aesthetics, cultural heritage) and disservices (e.g. reduction in water yield, phosphate leaching); determine how the catchment governance group can work together with recreational groups to improve cooperation and increase recreational values in the catchment; estimate recreational values in different land-uses in the catchment; value products of natural land-uses (e.g. forest fruits, medicinal plants); include spiritual values; empirically validate all estimated values; analyse the cost of erosion and sedimentation from pasture areas; develop a method for bundling ecosystem services and explore potential markets for these bundles; analyse on-site and off-site costs of erosion from pasture and exotic forest areas; and develop a formal plan to obtain and address feedback from stakeholders.

Ecosystem Services in the Ōhiwa Catchment

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Scion

October 2014

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Introduction

Ecosystem services (ES) are referred to as the benefits derived to people from ecosystems (MEA, 2005). Ecosystem services are often categorised into four groups: provisioning[1], regulating[2], social and cultural[3], and supporting[4] services as shown in Figure 1.

All four groups of services contribute to human well-being attributes such as security, basic material for good life, health, social relations, and freedom, choice and action. Provisioning services have traditionally been considered more important than the other groups because of their market value. Other ES, such as recreational walking and mountain biking, are already recognised in policy but they have non-market values, which make them less clearly understood (or undervalued) compared with provisioning services. Other ES, particularly within regulating and social & cultural services (e.g. provision of habitats for native species) also have a non-market value and can be challenging to value. However, all ES should also be accounted for in decision making to ensure human well-being (UKNEA, 2011).

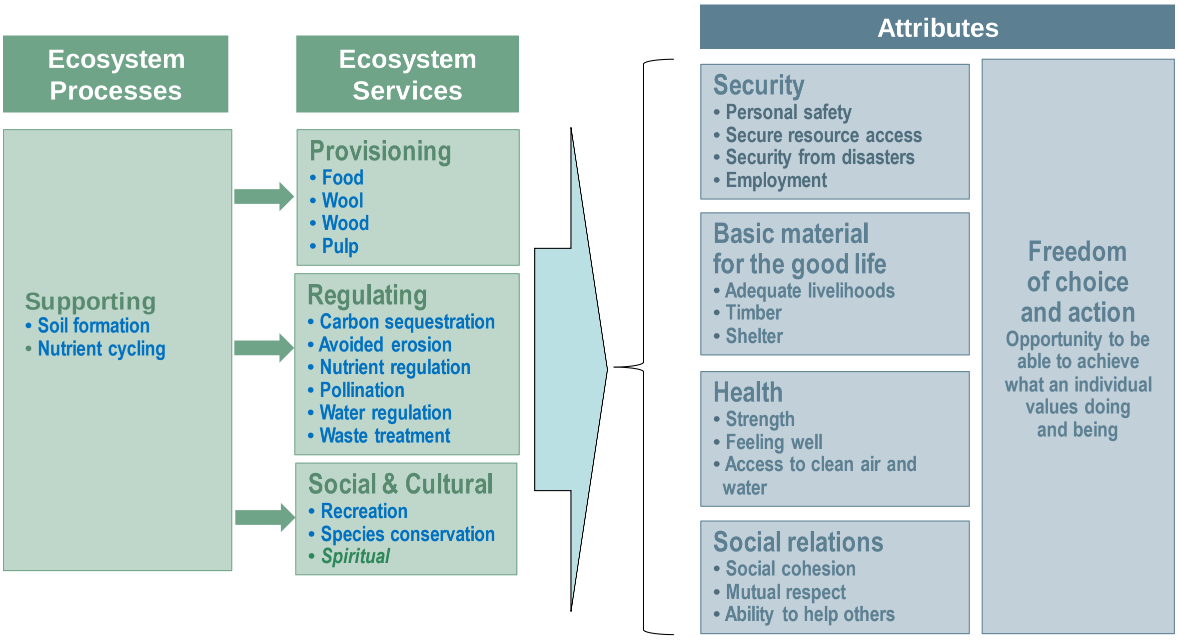

Figure 1. The interrelationships between ecosystem services and their attributes (Adapted from MEA (2005) and Yao et al.(2013)).

The land in the Ōhiwa catchment, Bay of Plenty, is used in a number of ways and provides multiple ecosystem service benefits to society. Ecosystem services already identified include healthy food, freshwater, wood and fibre, carbon sequestration, avoided erosion, recreation and heritage (EBoP, 2008).

This project aims to provide a better understanding of values of ES in the Ōhiwa catchment. We focused on identifying the ES provided by each key land use in the

[1] Provisioning services refer to the products derived from an ecosystem such as food, wool, wood and pulp. These products directly contribute to gross domestic product (GDP) mainly through export earnings and domestic sales.
[2] Regulating services are "the benefits obtained from the regulation of ecosystem processes" (MEA 2005). Indigenous and exotic forests provide regulating services, such as reduced erosion, carbon sequestration, improved water quality, and flood mitigation.
[3] Social and cultural services are the non-material benefits obtained from an ecosystem, such as recreation, aesthetic experience, spiritual enrichment, appreciation of biodiversity and conservation.
[4] Supporting services are the biological, chemical and physical processes that underlie the provision of the other three groups of services described above. Examples of these supporting services include soil formation, nutrient cycling and oxygen production. Supporting services indirectly affect society, as their impacts on people occur over a very long time.

catchment and providing an approximation of the indicative monetary value for each ES. This approximation was done by identifying key ES in the catchment and then estimating their values. Two approaches were used: (1) using available data; and (2) using results from a spatial economic model, which is described in Barry et al. (2014).

An ES approach can provide a good starting point for determining the appropriateness of interventions in delivering ecosystem benefit and in ensuring ecosystem function to safeguard critical and total natural capital under any intervention. Therefore, this work provides a good starting point to facilitate dialogue for a more comprehensive planning approach to land management (e.g. land-use change, agricultural extension) in the catchment.

Methods

Study Area

The Ōhiwa catchment covers 17,512 ha in the eastern Bay of Plenty. A map of this catchment is shown in Figure 2 along with the distribution of various types of land use. The map was produced using spatial data from the New Zealand Land Cover Database (LCDB) version 4.[5]

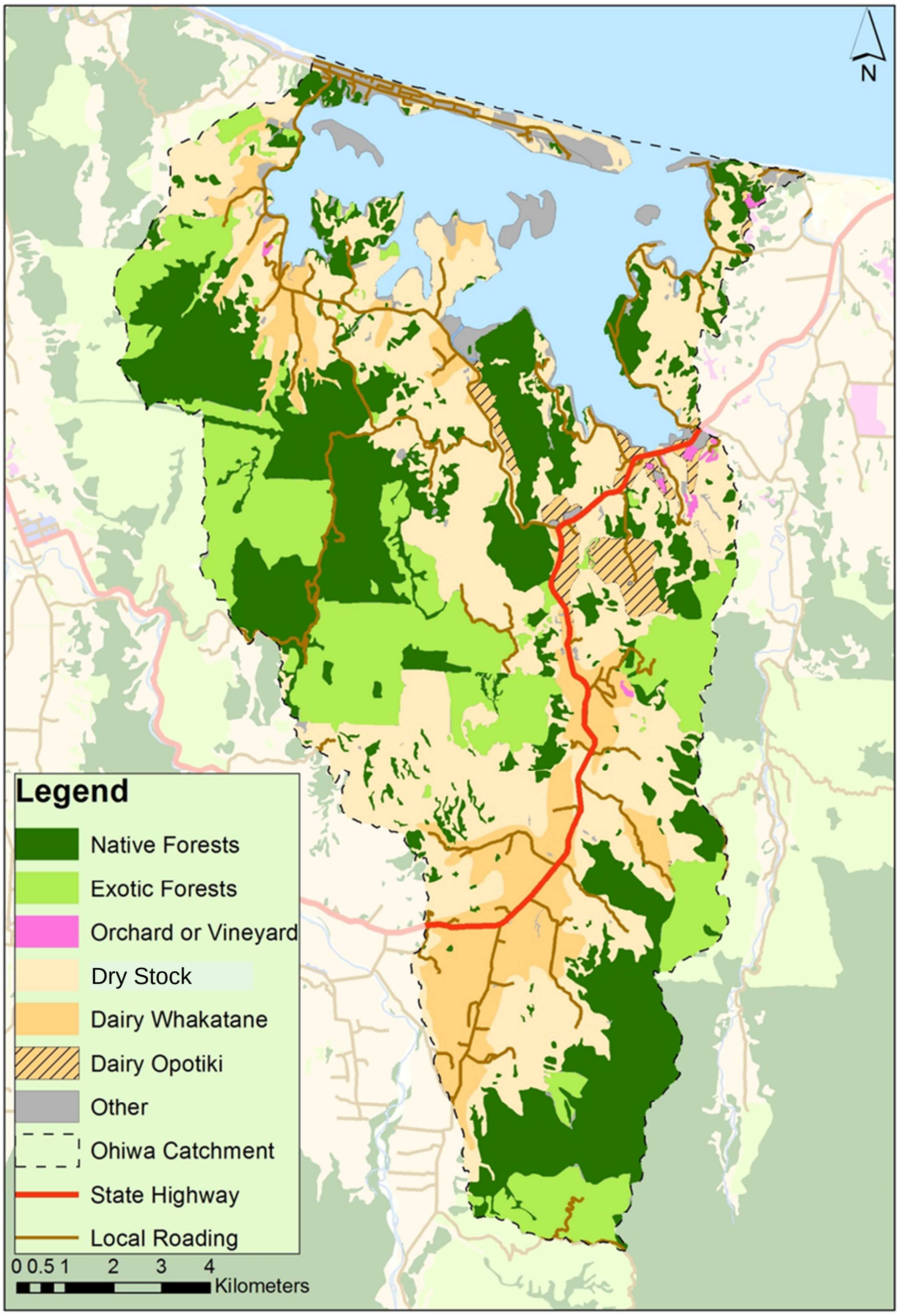

Figure 2. Map of the Ōhiwa catchment and harbour showing distribution of various land uses.

[5] https://lris.scinfo.org.nz/layer/412-lcdb-v40-land-cover-database-version-40/

The area of each of the seven major land-use groups within the catchment is shown in Table 1. Natural land uses (indigenous forest, scrub, and wetlands and mangroves) account for 46.3% of the total land area while productive land uses (predominantly, dry stock, exotic forests and dairy) make up the rest.

Table 1. Land-use distribution in the Ōhiwa catchment (Adapted from MacKenzie (2013)).

Land use		**Area (%)**
Productive		
	Dry stock	28.4
	Exotic forest	18.5
	Dairy	16.5
	Horticulture	0.3
Natural		
	Indigenous forest	20.7
	Scrub	13.8
	Wetlands and mangroves	1.8

Categorisation of Ecosystem Services

All the ecosystem services shown in Figure 1, except spirituality, were included in this analysis. Three additional ES, considered of importance to the Ōhiwa catchment, were assessed within regulating services. These were: water supply, pest and disease regulation (which includes biological control) and disturbance regulation (see Table 2).

Ecosystem services were separated in to those with market and those with non-market values. The two ecosystem services with market values were:

1) the products from productive ecosystems, such as food (meat, milk and fruit), wool, wood and pulp, and
2) the tradeable carbon sequestration credits from exotic forests.

None of the other ES currently have markets but their indicative values can be estimated (Barry, et al., 2014; Dhakal, et al., 2012; Yao, et al., 2010; Yao, et al., 2014). Thus, their monetary values reported here are considered as non-market values. The cost of carbon emissions from pasture remains a non-market value because there is no policy in place for farms to pay for them even though the nitrous oxide (NO_2) and methane (CH_4) emissions from dairy and dry stock can now be easily converted into carbon dioxide equivalent units which already have a market price.[6]

Assessment of Ecosystem Services

Two approaches were used to estimate the indicative values of ecosystem services.

Approach 1 – Secondary data (SD)

The first method used was to identify and collate values from data already published in peer-reviewed journal papers as well as other sources, such as reports. Relevant values were rescaled to the conditions in the Ōhiwa catchment and converted into 2012 New Zealand dollars using the Reserve Bank of New Zealand inflation calculator (http://www.rbnz.govt.nz/monetary_policy/inflation_calculator/) and the on-farm inflation for dry stock (Beef + Lamb New Zealand, 2014c)

Approach 2 – Forest Investment Finder plus (FIF+)

The second method was to apply a spatial economic model to estimate key ecosystem values for the Ōhiwa catchment. The model used is called the Forest Investment Finder

[6] https://commtrade.co.nz/

plus (FIF+) and was developed by Scion (Barry et al. 2014). The FIF+ model was used to estimate the annual value per ha of providing wood and pulp from exotic planted forests in the catchment. It was also used to estimate the values of carbon sequestration and avoided erosion. The value of avoided erosion represents the off-site benefits from soil stabilisation provided by exotic and indigenous forests such as avoided sedimentation of water-ways and flood mitigation. These off-site benefits accrue more to the general public and to a lesser extent the landowner.

The approach used to estimate each ecosystem service value is shown in Table 2.

The two approaches above produced indicative values of each group of ecosystem services provided by a ha of land in the catchment (dollars per ha per year). These values were summed up and then multiplied by the area of each land use in the catchment, resulting in the total value of ecosystem services per land-use type. This total value represents the current value of an existing land use in the catchment.

Specific methods for the calculation of each of the ecosystem services values can be found in Appendices A – D. It is important to note that the value of some ecosystem disservices (e.g. nitrate leaching) have also been calculated. Since they have environmental costs, they provide negative non-market values.

Feedback

The authors have communicated and discussed the results of this study with key stakeholders at different stages following the approach suggested by Peh et al (2013) in the Toolkit for Ecosystem Service Site-based Assessment (TESSA). Preliminary results were presented to the Ngāti Awa board on 25 July 2014 in Whakatane. Comments from this presentation were used to update the analysis and intermediate results were presented at a formal project meeting with the Bay of Plenty Regional Council's senior land manager on 18 September 2014 in Rotorua. His recommendations included a simple scenario analysis that could account for hypothetical land-use changes. Results from the new set of analysis were presented to the Ōhiwa Harbour Implementation Forum members (which include the councilours of the Bay of Plenty Regional Council and land managers) on 6 October 2014 in Ōpōtiki. All comments received from these engagements with stakeholders have been used to identify priorities and gaps to address in this research.

Scenario Analysis

The set of indicative values determined above can be used to estimate the impact of land-use change or introduction of new technology in the catchment. To provide an approximation of the impact of land-use change on the values, we can simply reduce an area of a particular land use and reallocate this land by increasing the area of another land use.

Three theoretical land-use change scenarios were developed to demonstrate the approach and these may stimulate land management discussions:

1) converting 320 ha of dry stock area to exotic forestry thus increasing the exotic forestry area by 10%

2) converting 32 ha of dairy to wetlands thus increasing the wetlands area by 10%

3) developing a technology that reduces nitrogen leaching in dairy, dry stock and horticulture farms by 25%. Under this scenario, we assumed that a new

technology is developed to reduce nitrogen leaching by 25% in the three productive land uses (dry stock, dairy and horticulture). There is no land-use change involved but the technology would be adopted in pasture and horticulture areas which account for 45% of the catchment.

Each scenario was quantified using a spreadsheet that contains the set of estimated ES values determined in this study. The financial effect of adopting each of these scenarios separately was then estimated. Neither the cost of land-use change nor the cost of new technology was included as they are outside the scope of this study.

Table 2. Method used to estimate values of key ecosystem services for the Ōhiwa catchment.

Ecosystem service		Land use[1]						
Class [2]	**Details**	**Productive**				**Natural**		
		Dry stock	**Exotic forestry**	**Dairy**	**Horticulture**	**Indigenous forest**	**Scrub**	**Wetlands and mangroves**
Provisioning	Food, wool, wood, pulp	SD	FIF+	SD	SD			
Regulating	Carbon sequestration/ emission and GHG regulation	SD	FIF+	SD				
	Avoided erosion and flood/disturbance regulation		FIF+			FIF+	SD	SD
	Regulating nutrient supply (e.g. avoided nitrate leaching)	SD	SD	SD	SD	SD	SD	
	Pollination	SD	SD	SD	SD	SD	SD	
	Water regulation [3]	SD	SD	SD		SD	SD	SD
	Waste treatment		SD			SD	SD	SD
	Pest and disease regulation/ Biological control	SD	SD	SD	SD	SD	SD	
	Water supply		SD			SD	SD	SD
Social	Recreation		SD			SD		SD
	Species conservation		SD			SD		SD
Supporting	Nutrient cycling		SD			SD	SD	
	Soil formation	SD	SD	SD	SD	SD	SD	

[1] Blank cells indicate that there were no appropriate data found to represent those values. A blank space does not necessarily mean that the ecosystem service has no value. It is very likely that the non-market value of that particular ecosystem service can be estimated because a value had already been estimated for other land uses.
[2] Classification of ecosystem services was based on MEA (2005).
[3] Defined in MEA (2005) as "The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas."

Results

Preliminary results were presented to the Ōhiwa Harbour Implementation Forum meeting held in Ōpōtiki on 6 October 2014. Thus, the concept of accounting for the full value of the key ecosystems in the catchment has already been introduced to the end users.

Indicative Values of Ecosystem Services

Estimated values of all the ecosystem services assessed across the Ōhiwa catchment are summarised in Table 3.

Provisioning ecosystem services

Horticulture and dairy provide the highest market values (i.e. net operating profit from production) per ha while exotic forestry and dry stock provide the lowest (Table 3). The market value of horticulture is more than five times higher than dairy and 18 times higher than forestry.

Regulating ecosystem services

The values of regulating services were either positive (i.e. carbon sequestration) or negative (i.e., nitrogen leaching). Dairy, horticulture and dry stock land uses all lead to the emission of carbon and concurrently leach significant amounts of nitrogen which are both environmental costs. In contrast, forests (either indigenous or exotic) sequester carbon and leach a minimal amount of nitrogen into the water ways so they result in a benefit to the environment. In addition, exotic forests also offer the regulating service of avoided erosion.

Indicative values for other regulating services were also calculated for the seven major land-use groups in the catchment. Wetlands, which account for less than 2% percent of the catchment, provide the largest quantified ecosystem benefits in terms of waste treatment, water supply and disturbance regulation (Table 3).

Social ecosystem services

The values of the two ecosystem services (recreation and native species conservation) studied here are about two times greater for indigenous forests than for exotic forests and slightly lower than the values found for wetlands (Table 3).

The net value of ecosystem services for each land use in dollars per ha per year is also presented in Table 3. The dairy, dry stock and horticulture land uses all have negative net ES values, mainly because of the high cost of nitrogen leaching. Only exotic forestry has a positive total ES value among the productive land uses, due to the high environmental and social benefits provided. Among the natural land-use group, wetlands provide the highest value per ha followed by indigenous forests and scrub.

The last two rows in Table 3 show the area and the total value of ecosystem services for each land use (in dollars per year), respectively. The dairy land use results in the lowest net negative ES value in the catchment (about -$29 million) due to the large area involved and the negative net ES value. Indigenous forests provide the highest positive ES value in the catchment of about $24 million, closely followed by exotic forests at $19.5 million. The relative total ES value of each of the seven land uses studied is shown in Figure 3. All three natural land uses and exotic forests have positive total ecosystem service values per year while three of the four productive land uses (dairy, dry stock and horticulture) have negative values. Based on the total indicative values by land use, the overall net value of ES in the Ōhiwa catchment is about $23 million per year (Table 3).

Table 3. Indicative values (in $ per ha per year) of key ecosystem services in the Ōhiwa catchment.

Ecosystem service		Land use[1]							
Type	**Details**	**Productive**				**Natural**			**Total**
		Dry stock	**Exotic forestry**	**Dairy**	**Horticul-ture**	**Indigenous forest**	**Scrub**	**Wetlands and mangroves**	
Provisioning	Food, wool, wood, pulp	158	483	1,686	8,810				11,137
Regulating	Carbon sequestration/ emission and GHG regulation	-16	48	-41					-9
	Avoided erosion and flood/disturbance regulation		121			166	166	12,737	13,190
	Regulating nutrient (nitrogen) supply (e.g. avoided leaching)	-3,200	2,800	-12,000	10,000	2,800	2,800		-16,800
	Pollination	69	206	69	233	206	206		989
	Water regulation [2]	8	6	8		6	6	42	76
	Waste treatment		244			244	244	11,721	12,453
	Pest and disease regulation/ Biological control	164	11	105	65	11	11		367
	Water supply		8			8	8	10,664	
Social	Recreation		900			1,800		1,978	4,678
	Species conservation		257			414		494	1,165
Supporting	Nutrient cycling		994			994	994		2,982
	Soil formation	3	14	3	6	28	28		82
Net ES Value ($/ha/yr)		***-2,814***	***6,092***	***-10,170***	***-885***	***6,677***	***4,463***	***37,636***	***40,990***
Area (ha)		4,914	3,201	2,854	51	3,576	2,380	316	17,292
TOTAL VALUE ($ per land use per year)		**-13,827,996**	**19,500,492**	**-29,025,180**	**-45,145**	**23,876,952**	**10,621,940**	**11,892,976**	**22,993,580**

[1] Blank cells indicate that there were no appropriate data found to represent those values. A blank space does not necessarily mean that the ecosystem service has no value. It is very likely the non-market of that particular ecosystem service can be estimated because that value had already been estimated for other land uses.
[2] Water regulation is defined in the MEA (2005) as "The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas."

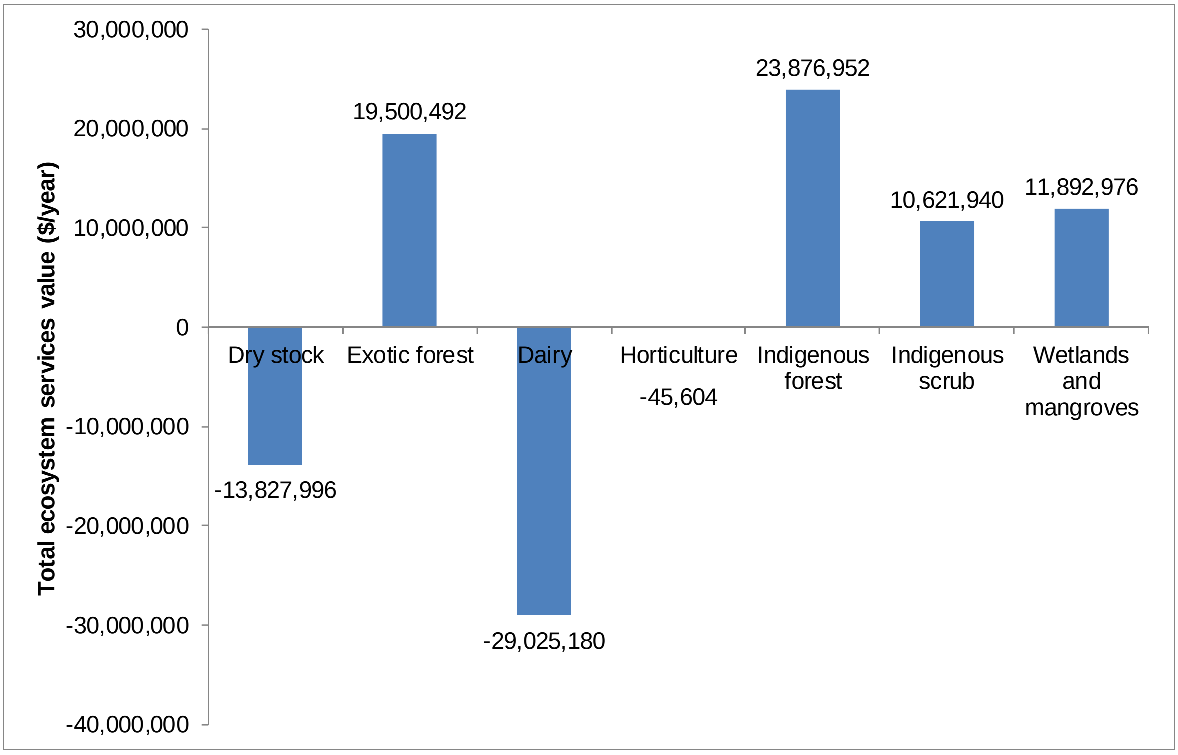

Figure 3. Bar chart showing the relative total ecosystem services value per year by land use.

Scenario Analysis

The Bay of Plenty Regional Council is looking for land management options that would lead to the improvement of the economic, environmental and social values in the catchment. To evaluate some possible options and demonstrate the approach, the impact on the catchment's overall ES value of adopting three theoretical scenarios was evaluated.

Scenario 1 involved converting 320 ha of dry stock area to exotic forestry thus increasing the exotic forestry area by 10%. For every ha of dry stock converted to forestry, there is a net gain of $8,906 per year. Therefore, adopting this land-use change scenario would result in an increase in the overall ES value in the catchment by $2.8 million.

Scenario 2 involved converting 32 ha of dairy to wetlands thus increasing the wetlands area by 10%. For every ha of dairy converted to wetland, the catchment gains $47,806 per year. This is almost six times as the gains in Scenario 1. The overall increase in ES value in the catchment would be $1.5 million.

Scenario 3 involved the application of a technology that reduces nitrogen leaching in dairy, dry stock and horticulture farms by 25%. The adoption of this technology would result in a significant reduction in nitrate leaching cost for each of the three land uses (Dairy: 54% N cost reduction; Horticulture: 50%; Dry Stock: 66%). These environmental cost reductions would lead to a gain of $29 million per year in the overall ES value or more than doubling the overall ES value in the catchment from $23 million to $52 million.

The total ES values by land use for the status quo and the three different scenarios are summarised in Table 4 and Figure 4.

Table 4. Overall ecosystem services value by land use for the different scenarios (in 2012 NZ$ per year).

Scenario	Dry stock	Exotic forestry	Dairy	Horticul-ture	Indigenous forest	Natural scrub	Wetlands and mangroves	Overall ES value	Change from status quo
Status Quo	-13,827,996	19,500,492	-29,025,180	-45,604	23,876,952	10,621,940	11,892,976	22,993,580	0
Scenario 1 - 10% increase in exotic forestry	-12,927,235	21,450,541	-29,025,180	-45,604	23,876,952	10,621,940	11,892,976	25,844,390	2,850,811
Scenario 2 - 10% increase in wetlands	-13,827,996	19,500,492	-28,703,808	-45,604	23,876,952	10,621,940	13,082,274	24,504,249	1,510,670
Scenario 3 - 25% reduction in N leaching	-3,508,596	19,500,492	-10,474,180	209,396	23,876,952	10,621,940	11,892,976	52,118,980	29,125,400

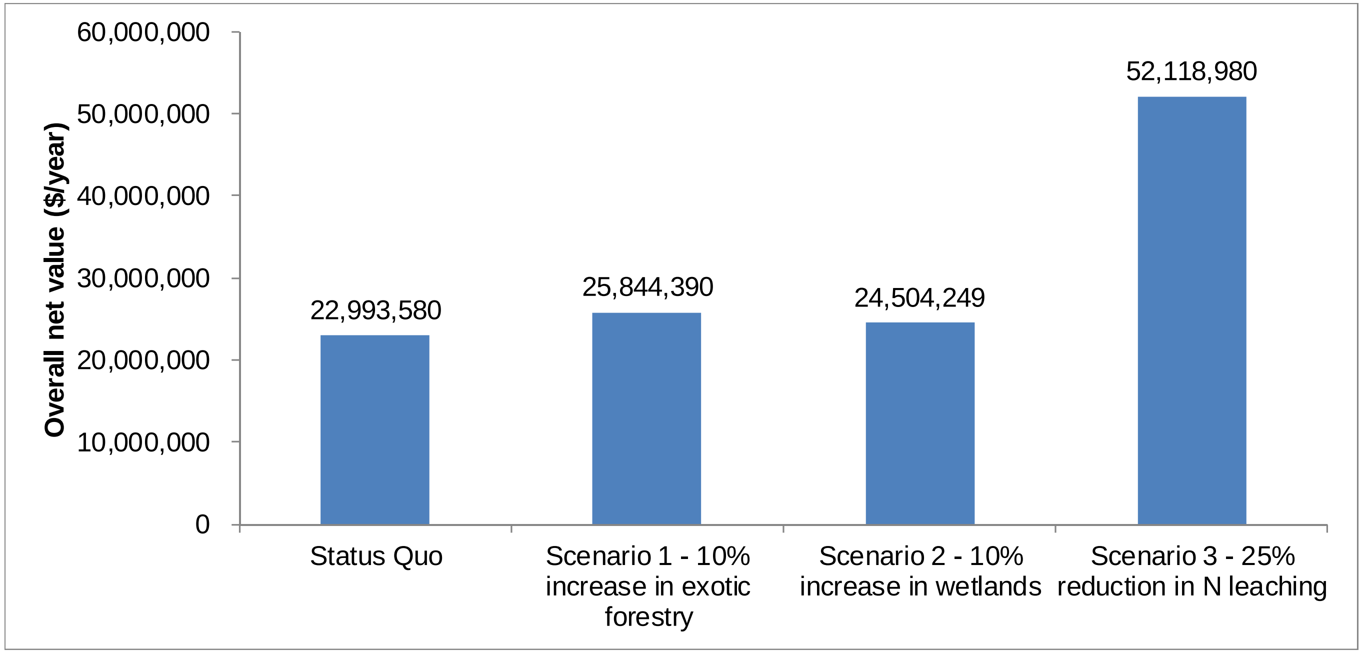

Figure 4. Bar chart showing the overall ecosystem services value in the catchment by scenario.

Gaps Analysis

The second aim of this report was to assist with identification of research gaps in assessing ES for the catchment. Gaps identified include:

a) Estimation of other ecosystem services values such as aesthetics, cultural heritage, water quantity from different land uses and other water quality parameters such as water clarity for recreation value;
b) Determination of how can the catchment governance group work together with recreational groups to improve cooperation and increase recreational values in the harbour and catchment;
c) Estimation of recreational values in different land uses and amenities (e.g. Rawhiti forest; Waiotahi forest, Ōhiwa walkway);
d) Valuation of products of natural land uses (indigenous forests, scrub and wetlands), such as forest fruits, medicinal plants and native species;
e) Assessment of Māori spiritual values of all iwi groups;
f) Field validation of all ecosystem service values;
g) Development of a method for bundling non-market ecosystem services (in particular, carbon and nutrient regulation services) and exploration of emerging markets for the preferred ecosystem service bundles;
h) Analysis of on-site and off-site costs of erosion from pasture and exotic forest areas, and
i) Development of a formal plan to obtain and address feedback from stakeholders.

The estimation of the value of other disservices, such as reduction in water yield or leaching of other nutrients (e.g. phosphorus) in water ways in the catchment, should also be undertaken in the future.

Discussion

The estimated ES values presented in this report are indicative and should be treated with caution. Despite its limitations, the study has served as a proof of concept of the application of the ES approach for accounting for their full value in the Ōhiwa catchment. The ES approach can help land-use planners and decision makers by identifying land-use trade-offs at the catchment level.

The agreed approach for this desktop exercise to analyse the set of estimated ES values was a simple additive approach. However, if more data and resources were available, a more complex approach (which accounts for the ratios of the values of ecosystem services and uses different discount rates for market and non-market benefits) would provide better results (e.g. Barry et al. 2014). Another analytical approach would be to look at the ecosystem services as groups or bundles of interconnected services, therefore, instead of assigning a value of cost or benefit per ecosystem service, one could estimate the values of different combinations of ecosystem services. Again, this type of analysis would require more data and resources to undertake.

This study provides a practical example of trade-offs in ecosystem services in a catchment. While most of the productive land uses (dry stock, dairy, horticulture) result in a net negative ES value, the high-quality land where these activities occur should be prioritised for food production but should this activity be done in a more sustainable way i.e. offsetting their negative ES values with activities that may provide net positive ES values. For example, exotic forests may offer nitrogen credits, which can help offset excess leaching in dairy farms if a nitrogen cap and trade scheme existed in the catchment. Obviously, converting all the pasture land into exotic forests would be unrealistic and would result in other negative consequences such as loss of jobs.

Although dry stock, dairy and horticulture resulted in indicative negative ES values — mainly because of nitrate leaching and greenhouse-gas emissions — these land uses may provide positive ES values such as recreation (farm stays) and pollination (honey production). On the other hand, natural land uses — in addition to the ES benefits indicated in this study — could also provide disservices that have not been accounted for, such as mosquitoes in wetlands. The estimation of natural land uses disservices may require much more information about the local biota as noted by Dunn (2010).

Results from analysis of three simple scenarios (which involved either land-use change or technology development/adoption) provide an idea of the costs or benefits arising from such changes, and have already served as a starting point for discussing options that could potentially provide the greatest benefits to the economy, society and environment. Results suggest that shifting to a more sustainable productive land use (dry stock to exotic forestry) or converting a relatively small area of dairy farms to wetlands can lead to a significant gain in the overall ecosystem services value in the catchment. Adoption of a technology or a more environment friendly farm practice that reduces nutrient leaching in water ways can potentially double the overall ecosystem services value.

As discussed in the *Methods* section of this report (*Feedback* sub-section on Page 9), this study has benefited from both formal and informal feedback from key stakeholders in the catchment. For example, a preliminary analysis was discussed with the Ngāti Awa board on 25 July 2014 and with the Ōhiwa Harbour Implementation Forum members on 6 October 2014. The importance of obtaining feedback early on and during the project cannot be stressed enough as a key component of current and future research projects, even if desk-based, as it has been pivotal to improve the study according to the needs of the stakeholders and to identify key gaps to address in future studies.

The study has revealed some knowledge gaps but also how to address these gaps. Field validation and the estimation of key ecosystem services, in particular, recreation, is pivotal to the refreshed Ōhiwa Harbour Strategy. A methodological gap that deserves further study is the development of a method for bundling or combining ecosystem services in the catchment. Bundling of ecosystem services could provide incentives for landowners to partner with government agencies to achieve broad conservation goals (Deal, et al., 2012). Special attention should be given to services with a current and potential future market value such as carbon and nutrient regulation services, on-site and off-site effects and rescaling the results at the enterprise level. Future studies should explore what it could mean to the individual land holder to undertake different land-management actions.

Lastly, with the increasing emphasis on sustainability and stakeholder participation in land-use management in New Zealand, there is a need to consider the contribution of spiritual values to human well-being and environmental conservation. Although these values were out of the scope of this study, it is recommended that future work include these values as per feedback from iwi and the wider community living in the catchment. The inclusion of these values requires alternative approaches (e.g. non-monetary valuation), such as indexes and indicators generated together by communities and researchers.

Conclusions and Recommendations

This desktop study has provided preliminary estimates of the values of key ecosystem services in the Ōhiwa catchment. This represents one of the first initiatives of the Bay of Plenty Regional Council to get an idea of how to better understand an ecosystem services approach to planning. The approach can be used as a tool to support land-use planning that accounts for community values and aspirations in the catchment by identifying, recognising and sustainably managing the key ecosystem services.

The results of this study can be used in discussions about ecosystem services in the catchment. Although the current overall net value of the catchment is positive, key services such as water quantity and other aspects of water quality (e.g. nutrient concentration, issues associated with phosphorous leaching) have not been included in the analysis. Given the recent water reforms in New Zealand, this is a key area that deserves more detailed analysis.

Future work should be undertaken to improve the quality of the data compiled for this desktop study since the quality of the output information relies on the quality of the input estimates. Alternative valuation approaches could also be used, for example, using indexes to explore trade-offs across land uses for those ecosystem services for which monetary values are either not available or would not be appropriate to use (for example, spiritual values). Future work should also look at the implication of alternative land-management scenarios to the individual landholder.

Different scenarios from those shown in this study could be developed using the set of ecosystem services values provided here or a different set and/or a different accounting approach, such as bundling ecosystem services. For instance, different prices of carbon sequestration and nutrient regulation services, first individually and then bundled, would provide a better understanding of the impact of developing policies to establish markets for ecosystem services.

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Ngāti Awa management staff and stakeholders provided helpful feedback on the preliminary results.

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Appendix A. Provisioning Services: Milk, meat and fruits

Provisioning ecosystem services include marketable goods such as milk solids, meat, wool, fruits and timber. The estimation of the value per ha by land use of such marketable goods (except timber) by land use is explained below.

Dairy

Sixteen percent of the Ōhiwa catchment is under dairy land use. The main product studied in this project was milk solids comprised of milk fat and protein. To estimate the value of dairy ($ per ha), the following publicly available information was used:

- The amount of milk solids 2008–2012 produced in the Ōpōtiki and Kawerau/Whakatane districts in kg per effective area.
- The national inflation adjusted dairy company pay-out for 2008–2012 in 2012 New Zealand dollars per kg of milk-solids.
- The annual operating profits and gross revenue for 2008–2012 in the North Island for owner-operator farms.
- Land Cover Database (LCDB) version 4.0 maps to estimate the dairy land area in each district LUC 2, 3 and 4 (Senior, et al., 2009).

First the revenue per ha in each district was calculated by multiplying the amount of milk solids (kg per effective ha) by their inflation-adjusted price ($ per kg) for each year, (2008–2012). The ratio of operating profit and gross revenue in the North Island was used to estimate the median percentage of profits (Table A1). This percentage (29.8%) was used to estimate the median profit for each region (29.8% by median revenue) (Table A2).

The weighted average of dairy ES value was calculated using the proportion of dairy land use in each district in the catchment (18% in Ōpōtiki and 82% in Whakatane) (Table A2).

Table A1. Key items used in dairy value calculations.

Item	Units	2008-09	2009-10	2010-11	2011-12	2012-13	Median
Kawerau/ Whakatane production**	Avg kg of milk solids per effective ha	915	832	877	991	927	915.00
Ōpōtiki production**	Avg kg of milk solids per effective ha	823	763	771	890	865	823.00
Dairy company pay out – NZ***	$/kg of milk solids*	5.59	6.82	8.02	6.44	6.18	6.44
Revenue Kawerau/ Whakatane (estimated)	$/ha*	5,115	5,674	7,034	6,382	5,729	5,729
Revenue Ōpōtiki (estimated)	$/ha*	4,601	5,204	6,183	5,732	5,346	5,346
Gross farm revenue North Island (owner-operator)***	$/effective ha	5,055	5,733	6,954	7,151	6,385	6,385
Operating profit North Island (owner-operator)***	$/effective ha	685	1,708	2,474	2603	1,735	1,735
Percentage (operating profit/ gross farm revenue)	%	13.6	29.8	35.6	36.4	27.2	29.8

*inflation adjusted
**Production values (LIC and DairyNZ, 2009, 2010, 2011, 2012, 2013)
***Company pay outs, gross farm revenue and operating profits (DairyNZ, 2010, 2011, 2012, 2013, 2014).

Table A2. Revenue and profit by land use in the Ōhiwa catchment.

Item	Land use						
	Dry Stock		Dairy		Horticulture	Tourism	
	Steep hill	Rolling hill	Ōpōtiki	Kawerau/ Whakatane	Bay of Plenty (Kiwifruit)	Ōpōtiki	Whakatane
Total revenue ($/ha)	598	869	5,346	5,729	43,076	7,964	28,080
Direct costs ($/ha)	308	452	NA	NA	29,556	NA	NA
Operating profit ($/ha)	142	161	1,593	1,707	8,810	NA	NA
Weighted average operating profit ($/ha)	158		1,686				

Dry Stock

The main products of dry stock (sheep and beef farms) are wool, meat and cash crops. The estimates of provisioning services for the dry stock land use are based on publicly available data from Beef+Lamb New Zealand for the Central North Island-Waikato-Bay of Plenty region, including two types of farms, hard hill country and hill country. All data was transformed to 2012 prices using the on-farm deflators (Beef + Lamb New Zealand, 2014c).

The main assumptions made were that (i) all pasture in rolling hills and steep hill (land management suites) to be considered dry stock area and (ii) that rolling hills and steep-hill land management suites (as reported in the Ōhiwa Harbour Sediment and Mangrove Management Plan) correspond to hill country and hard hill country in the Beef+Lamb classification, respectively. The percentage of dry stock land in rolling hills and steep-hill land management suites (Table A3) were calculated using data from Senior et al. (2009). Next, we estimated the median farm income, total working farm expenses and farm profit per land management suite (Table A4).

Lastly, the weighted average value of dry stock ($ per ha) was estimated using the percentage of sheep per land management suite in the Ōhiwa catchment (82% in rolling hills and 18% in steep hill) (Table A2).

Table A3. Percentage of land use under pasture by land management suite.

Land management suite	Total in catchment	Pasture by land management suite	Dry stock in catchment	Dry stock per by land management suite
Steep hill (hard hill country)	28.1	25	7.025	18
Rolling hill (hill country)	59.4	55	32.67	82

Source: Based on Senior et al, 2009, p.2-3.

Table A4. Dry stock farm income and profit indicators by land management suite (in $/ha).

Item (inflation adjusted)	2008-9	2009-10	2010-11	2011-12	2012-13	Median
Steep hill (hard hill country)						
Farm income	493.27	575.22	619.65	760.35	598.01	598.01
Total working expenses	252.64	288.33	307.61	364.08	327.21	307.61
Farm profit	108.51	142.29	190.01	274.46	111.09	142.29
Rolling hills (hill country)						
Farm income	740.70	763.64	883.57	1017.46	869.33	869.33
Total working expenses	392.36	415.36	451.91	494.35	475.87	451.91
Farm profit	75.89	93.50	190.31	298.25	161.26	161.26

Source: Beef+Lamb New Zealand (2014a and 2014b).

Horticulture

In order to calculate the value of fruit production in the Ōhiwa catchment, we used the Bay of Plenty Kiwifruit orchard model (Ministry for Primary Industries, 2012). We estimated the median value of total revenue and operating profit in $ per ha considering a 5-ha kiwi orchard as per the model. The operating profit was $ 8,810 per ha (Table A2).

The median operating profit in 2012 NZ$ per ha per year for the four productive land uses are illustrated in a map in Figure A1. Since part of the catchment is located in the Ōpōtiki District and the other part in the Whakatane District, and operating profit data for dairy were found for both districts, two median profits for dairy are shown in the map.

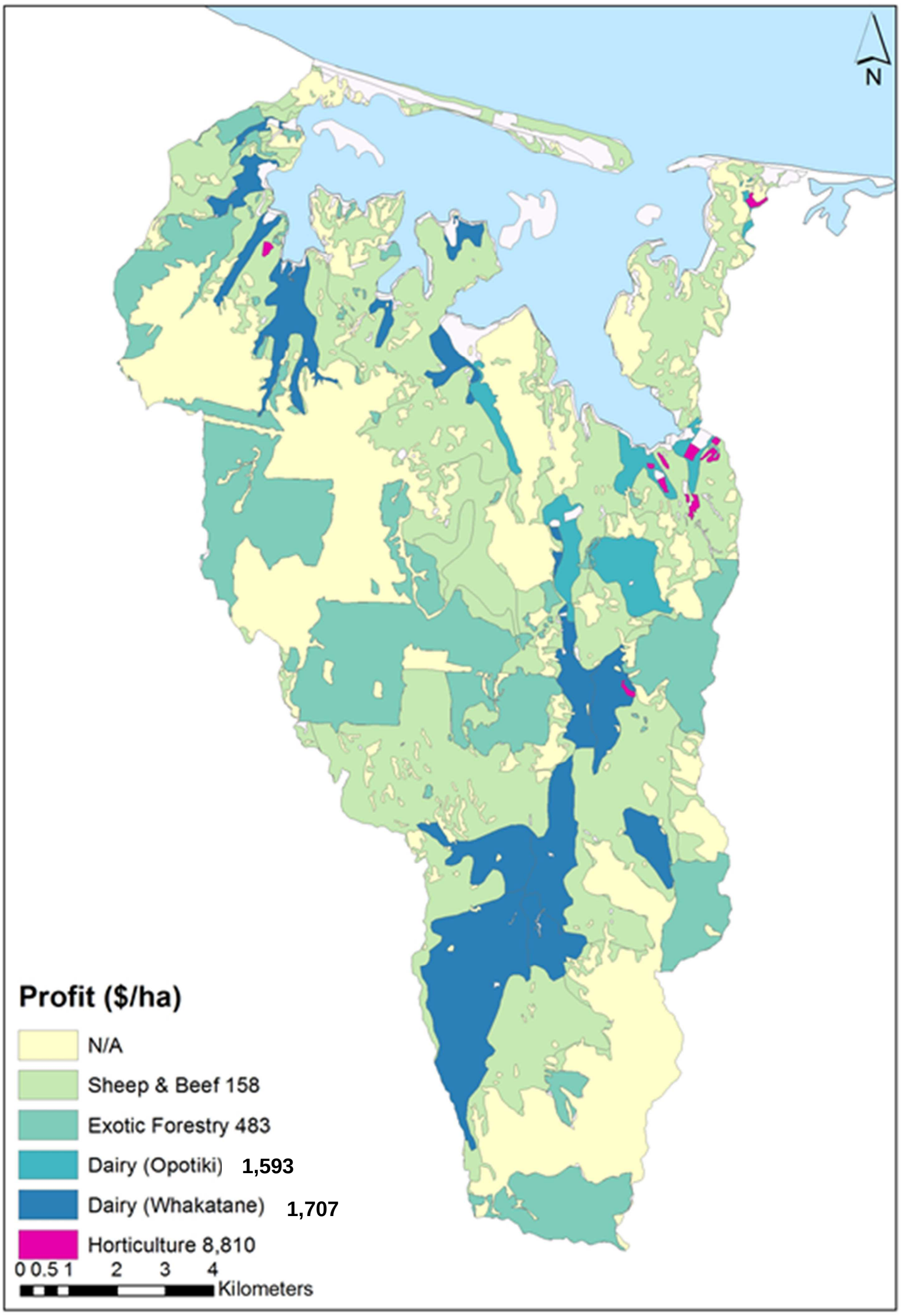

Figure A1. Median operating profit ($/ha/year) from productive land uses in the catchment.

Appendix B. Provisioning Services: Timber

The FIF+ model (Forest Investment Finder Plus) (Barry, et al., 2014) was used to estimate timber values of exotic forests in the catchment, using the following data, assumptions and caveats:

- All data on costs and prices are an estimate at a generic/national level. These may not represent site-specific costs accurately.
- A *Pinus radiata* structural (framing) regime (thinned to 600 stems per ha from initial planting of 900 stems per ha), with a rotation length of 28 years.
- A discount rate of 8% was used as it broadly represents the range of discount rates used currently by forest growers for forest market valuations.
- The assumption that $1m^3$ of *Pinus radiata* timber = 1 tonne.
- Prices for timber were based on an average price for each log grade over 12 quarters taken from the MPI indicative radiata pine log prices index. (http://www.mpi.govt.nz/news-resources/statistics-forecasting/forestry/indicative-new-zealand-radiata-pine-log-prices.aspx).

For each regime, the Net Present Value (NPV) of forestry in perpetuity was calculated using a discounted cash flow analysis. The economic analysis generally followed the method of Polglase et al. (2008). The NPV represents the difference between costs and revenues, all related to the same time period (2012 NZ$). Each cost and revenue surface was discounted to the present depending on the year for which the cash-flow occurred (Table B1). The cash-flow analysis followed that of Boardman et al. (2006).

Table B1. Economic data used to estimate the Net Present Value of exotic forests in the catchment.

Cost	Revenue
Establishment (years 1,2,3 @ $/625m²)	Timber ($/tonne)
Silviculture (Thinning, year 7 @ $/625m²)	
Access-road construction[a] ($/km)	
Internal landings ($/625m²)	Carbon ($/NZU)
Internal-road construction ($/625m²)	
Harvesting ($/tonne)	
Transport[b] ($/tonne/km)	
ETS compliance ($/625m²)	

[a] As the catchment has an established road network, the spatial economic modelling exercise assumes that there is no need to construct access roads.
[b] Transport was estimated from the central point of each forest to both the port of Tauranga and to the nearest processing plant or saw mill. We assumed that 49% of the logs were transported to the port of Tauranga, and 51% were sent to the closest processing plant or mill from the central point.

Appendix C. Regulating Services

Regulating services are "the benefits obtained from the regulation of ecosystem processes" (MEA, 2005). Different land uses provide regulating services such as carbon sequestration, reducing erosion and nutrient regulation.

Carbon sequestration and greenhouse gases (GHG) regulation

Exotic Forestry

Under the New Zealand Emissions Trading Scheme (ETS), landowners are able to receive revenue for the carbon sequestered in their exotic forests. This makes carbon sequestration a market benefit for the private landowner. Carbon credits (expressed in New Zealand Units or NZUs) earned during the growth of the forest are surrendered at the time of harvest. Usually a small amount of credits would be retained due to the below-ground biomass left in the forest but this would have little economic effect. The level of carbon sequestration is calculated from the same surface used to determine timber productivity (300 Index) combined with the C-Change carbon model (Beets et al., 2011, 2012).

Carbon credits provide revenue during growth followed by a liability at harvest (Manley, 2012). The price for an NZU has been dropping steadily since its inception. We have assumed a price of NZ$ 4 based on the carbon price history reported by Carbon CommTrade (www.commtrade.co.nz). The estimated return for carbon is calculated using non-declining yield (Buongiorno and Gilles, 2003) so the potential revenue may be slightly underestimated.

The productivity surfaces for carbon measured the total carbon sequestered in tonnes per ha. This was then converted to CO_2 equivalents using the mass ratio of carbon to CO_2 (1:3.67) (United States Environmental Protection Agency, 2005). The annual carbon revenue is then the non-declining yield times the price of carbon. Carbon is calculated using an annuity rather than actual estimates of carbon sequestered and emitted over time. The annuity was used for ease of evaluating the economics of carbon within the Geographic Information System (GIS), and that the two accounting approaches lead to similar, though not the same estimates of NPV of carbon credit revenues. The annuity provides a lower estimate NPV than the actual estimates over time so it is more conservative.

Dairy and Dry Stock

Carbon dioxide emissions (CO_2 equivalents (CO_2-eq)) for dairy and dry stock were calculated adapting the models from Timar and Kerr (2014) as follows:

$$\textbf{Dairy GHG emissions} = EF^{milk}\,MS + IEF^{meat}\,SR + EF^{fert}\,N$$

$$\textbf{Dry stock GHG emissions} = IEF^{meat}\,SR + EF^{fert}\,N$$

Details of the model parameters for dairy and dry Stock GHG (e.g. "EF", "MS") are provided in Tables C1 and C2, respectively. The dairy stocking rates and milk production were obtained from dairy statistics published by Livestock Improvement Corporation and DairyNZ (LIC and DairyNZ, 2009, 2010, 2011, 2012, 2013), the dry stock stocking rates were obtained from Beef+Lamb New Zealand (2014a, 2014b), and the remaining model parameters were obtained from Timar and Kerr (2014). Note that while the emission factors (EF) used in these models were directly taken from the Climate Change

(Agriculture Sector) Regulations 2010, the rest of parameters correspond to the Land Use in Rural New Zealand model (Timar and Kerr, 2014).

The GHG emissions per district in dairy and dry stock land management suite in the Ōhiwa catchment are shown in Table C3. The weighted average GHG emissions in the Ōhiwa catchment were estimated using the proportion of dairy land use in each district (Kawerau/Whakatane 82% and Ōpōtiki 18%) and the proportion of dry stock in each land management suite (82% rolling hills and 18% in steep hill), respectively.

Table C1. Parameters of dairy for the GHG emissions model.

Term	Description	Units	Value
EF^{milk}	Emission Factor	kg CO_2-e per kg milk solid	8.50
MS	Land use intensity (milk solid production)	kg milk solids per ha	District median MS 2008–2012
IEF^{meat}	Implied emission factor for meat	kg CO_2-e per dairy cow	400.92
SR	Stocking rate	Dairy cows per ha	District median SR 2008–2012
EF^{fert}	Emission factor for fertiliser	kg CO_2-e per kg nitrogen	5.72
N	Fertiliser intensity	kg nitrogen per ha	0.118*MS

Table C2. Parameters of dry stock for the GHG emissions model.

Term	Description	Units	Value
SR	Stocking rate	Dairy cows per ha	Land management suite median SR 2008-2012
IEF^{meat}	Implied emission factor for meat – Northland – Waikato-Bay of Plenty	kg CO_2-e per dairy cow	363.0 – Farm class 3 (rolling hills) 369.8 – Farm class 4 (steep hill)
EF^{fert}	Emission factor for fertiliser	kg CO_2-e per kg nitrogen	5.72
N	Fertiliser intensity	kg nitrogen per ha	0.118*MS

Table C3. GHG emissions from dry stock and dairy (Timar, et al., 2014).

Item	**Land use**			
	Dry stock		**Dairy**	
	Steep hill (Hard hill country)	**Rolling hills (Hill country)**	Ōpōtiki **district**	**Kawerau/ Whakatane district**
GHG emissions (t CO_2-eq)	3.15	3.66	8.65	9.51
Weighted average GHG emissions (t CO_2-eq)	3.57		9.35	

Horticulture

Carbon dioxide emissions for horticulture were not reported in the main summary table of this report (Table 3) since the available values on the sequestration side only included carbon stock values (not flows), carbon dioxide emission values found included the whole life-cycle assessment of kiwi fruit production.

Rahman et al. (undated) reported carbon stocks rather than flows, making these results incomparable to the rest of productive the land uses. It is important to note that more than 77% of the carbon stock values reported were found in the soils.

Mithraratne et al. (2010) have analysed the carbon foot printing for the kiwifruit using a cradle to grave approach, however, these values result in larger carbon dioxide emissions figures compared with the information available for the rest of land uses that only consider emissions directly derived from production.

Therefore, carbon storage values of kiwifruit orchards are not reported in the summary table (Table 3) but they are reported below for reference to the reader (Table C4).

Table C4. Carbon storage in a conventional kiwifruit orchard.

Factor	Vines	Litter	Root	Soil	Total
Biomass dry matter (t per ha)	17.20	7.76	1.01		25.97
Total carbon (t per ha)	9.55	4.15	0.32	49.68	63.7**
Contribution to carbon storage (%)**	14.99	6.51	0.51	77.99	100.00

Source: (Rahman, et al., undated) **Estimated values.

Avoided erosion

Avoided erosion is defined as the change in sedimentation levels from changing bare land into forests. We estimated avoided erosion values in two land uses in the catchment 1) exotic forests and 2) indigenous forests.[7] The value of avoided erosion in exotic forests was lower compared with indigenous forests because it considers the negative impacts of establishment, harvesting and land excavations in the former. The value of avoided erosion in this exercise refers to off-site benefits of reduced erosion from having trees in the landscape. Specifically, these off-site benefits are avoided sedimentation of waterways and flood mitigation which are considered as public benefits that have non-market values. The methodology used to estimate avoided erosion is explained in Box 1.

[7] Avoided erosion values for other land-uses were not calculated due to lack of data.

Box 1. Method to estimate avoided erosion.

"The first step is to estimate avoided sedimentation using the New Zealand Empirical Erosion Model (NZEEM) (Dymond et al., 2010). The NZEEM calculates the amounts of sediment generated under the planted and indigenous forests (in the catchment) in tonnes of sediment per square kilometre per year. The model assumes full canopy cover and therefore maximum soil protection when land use is changed from pasture to woody vegetation. However, sedimentation from forestry during harvesting and early establishment periods may be the same or worse than other land uses (Fahey, et al., 2006; Marden, et al., 2005; Marden, et al., 1993). Therefore, a range of estimated values of sedimentation level with forest age are used to further estimate the sedimentation avoided over an entire single forest rotation compared with the current land cover for the same time period (Fahey & Marden, 2006). These estimates relate to a paired catchment study of sediment flows between pasture and forestry over time, whereby harvesting and early establishment can increase sedimentation relative to pasture from sidecast (area where movement of excavated material downslope occurs during road and landing construction), old road lines, shallow landslides and channel-bed scouring (Fransen, 1998). In the case of indigenous forests, neither harvesting nor any major excavations occurs, therefore greater soil protection and higher avoided sedimentation values are provided.

The second step, is to calculate the value of avoided erosion by using the economic data collected for avoided sedimentation based on avoided expenditure costs. These values were derived from discussions with regional and city councils in New Zealand. The councils reported avoided flood damage value of NZ$ 0.90 per tonne) and avoided water treatment costs to consumptive water (NZ$ 5.60 per tonne). Therefore, an estimate of NZ$6.50 per tonne of avoided erosion was applied to the NZEEM results to determine the benefit of having an existing planted forest (Barry et al. 2014). The values of avoided sedimentation and flood mitigation have been annualised to dollars per hectare per year for a consistent economic comparison with other land uses."

The values of avoided sedimentation and flood mitigation have been annualised to dollars per hectare per year for a consistent economic comparison with other land uses."

Source: Modified from Barry et al, 2014, pp. 137-138.

To identify the location of exotic and indigenous forests in the catchment, we used the Land Cover Database version 4.0. Based on this database, the avoided erosion valuation was done on 3,239 ha of exotic forest and 4,086 ha of indigenous forests, respectively (Table C5). Results suggest that, on average, the value of avoided erosion provided by indigenous forests is about 37% higher than exotic forests. This may be due to many different factors such as slope, soil type, soil structure, and also our assumption that no harvesting occurs in indigenous forests.

Table C5. Summary of forest data and avoided erosion values.

Item	Exotic forest	Indigenous forest
Number of forests	28	215
Total area (ha)	3,239	4,086
Median avoided erosion value ($/ha/year)		
- Avoided sedimentation	$93	$127
- Flood mitigation	$28	$29

The southernmost section of the catchment has steep areas covered in either exotic or indigenous forests. Those areas have the highest avoided erosion values as shown in Figure C1.

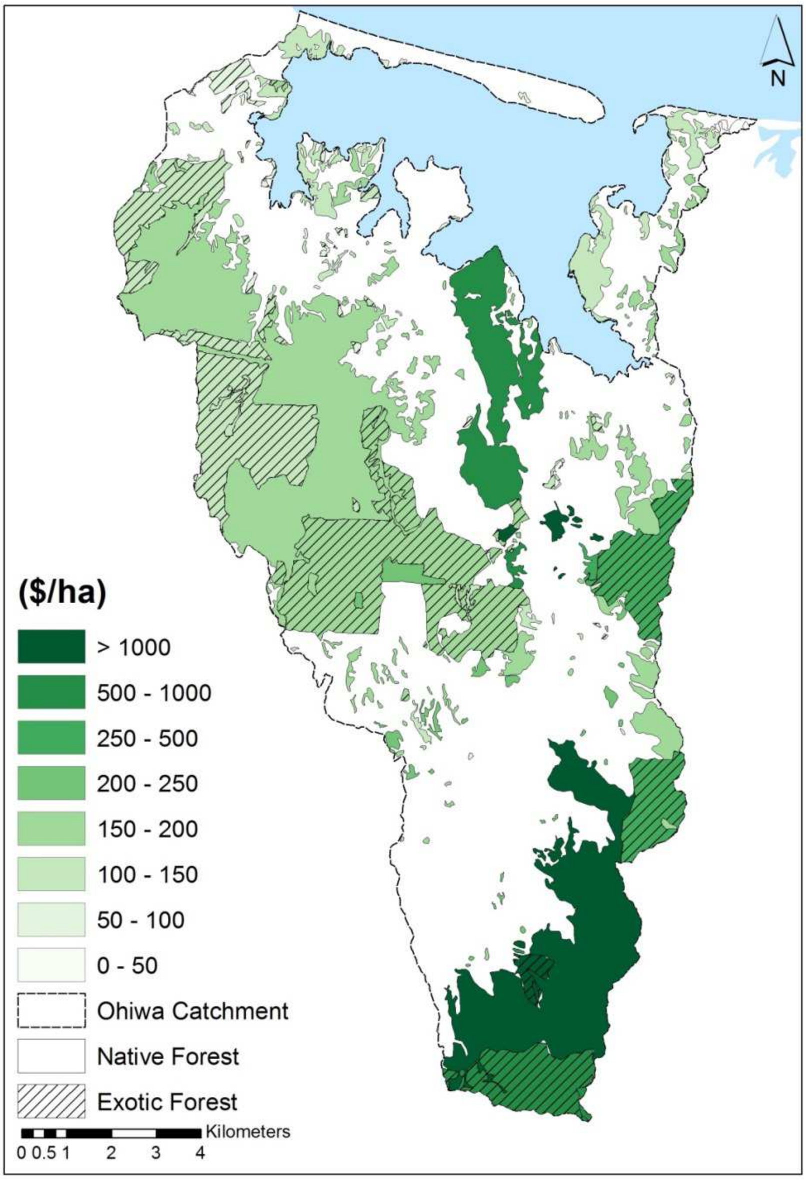

Figure C1. Map of the catchment showing avoided erosion values in planted and indigenous forests.

Regulating nutrient (nitrogen) supply (e.g. avoided leaching)

Based on the literature review by Menneer et al. (2004), productive land uses such as pasture, horticulture and exotic forests contribute to nitrogen leaching which can lead to the reduction of water quality of ground and surface waters. They reported an average nitrogen leaching rate for dairy farms of 65 kg per ha per year (varying between 15 to 115 kg per ha per year) (Table C6). For one specific kiwifruit orchard, they found a nitrogen leaching rate of 50 kg per ha per year. For dry stock farms, we used their calculated average nitrogen leaching for in New Zealand of 13 kg per ha per year. We assumed that average nitrogen leaching from undisturbed exotic forests and indigenous forests to be about 3 kg per ha per year based on previous research (Parfitt, et al., 1997; Parfitt, 2002, 2003).

Table C6. Average nitrogen (N) leaching, allowances and environmental costs and benefits.

Land use	Average N leaching rate (kg N/ha/year)*	N Leaching allowance (kg N/ ha/year)**	Excess N (kg N/ha/year)***	Environmental Cost/Benefit $/ha ($400/kg)**
Dairy	65	35	30	-12,000
Horticulture	50	25	25	-10,000
Dry stock	21	13	8	-3,200
Indigenous forest	3	10	7	2,800
Exotic forest (undisturbed)	3	10	7	2,800

*Menneer, et al. (2004).
**Allowance and price of a kg of nitrogen based on Barns (2014).
*** Negative means cost of leaching, non-negative means the value of avoided nitrogen benefit.

The nitrogen leaching allowance column of Table C6 was derived from Barns (2014) which suggest allowances per ha per year of 35kg for dairy and 13 kg for dry stock in the Rotorua catchment by 2032. We assumed that the same allowance could be adopted for Ōhiwa catchment. We have also assumed an allowance for horticulture (kiwifruit) falling in between the two land uses at 25 kg per ha per year. Ten kg was set as the allowance for indigenous and undisturbed exotic forests. If this cap system takes place at present, dairy, kiwifruit and dry stock are producing excess amounts of nitrogen while the forest ecosystems have a positive balance and could result in nitrogen leaching credits. If a cap and trade system was to take place immediately, the dairy, kiwifruit and dry stock land uses would need to offset their shortfall by buying nitrogen credits. Assuming a nitrogen price of $400 per kg per ha per year (Barns, 2014; MacGibbon, 2011), the leaching cost of having a ha dry stock farm is about $3,200 per year while the nitrogen benefit of an exotic forest is about $2,800 per ha per year.

Other Regulating and Supporting Services

van Meeuwen-Dijkgraaf et al. (2010) provided indicative values of ecosystem services of different land-use groups in the Kaimai-Tauranga catchment estimated based on Costanza et al. (1997). They reported those ES values in 2009 NZ$ per ha per year. They suggested that those values are indicative and should be treated with a “great deal of caution”. With very limited data on regulating services and supporting services in New Zealand, we included in the analysis their estimates of values for six regulating services, which are: flood/disturbance regulation, greenhouse gas regulation, water regulation, waste treatment, biological control and water supply. We have also considered their estimates for two supporting services — nutrient cycling and waste treatment. Those values from Meeuwen-Dijkgraaf et al. were converted to 2012 NZ$ using the Reserve

Bank of New Zealand's inflation calculator (http://www.rbnz.govt.nz/monetary_policy/inflation_calculator/).

Biological control and pest and disease regulation
Dominati et al. (2014a, 2014b) provided indicative values of pest and disease regulation services from soils in dry stock areas in Hawke's Bay and dairy in the Waikato. Although we have included rescaled values in the table, we again advise to treat those values with caution as they are very specific to the soil conditions in those regions and we do not have data to properly rescale those for the Bay of Plenty region.

Pollination
The pollination ES value for dairy (NZ$ 68.90) was estimated based on van Meeuwen-Dijkgraaf et al. (2010). Pollination ES values for other land uses were estimated using pollination functional richness indexes as shown in Table C7. These indices from the Canterbury region were the only reference that the authors found that compared pollination values across land uses in New Zealand (Rader, et al., 2014).

Table C7. Pollination values in the Ōhiwa catchment.

Land use in Rader et al, 2014	Equivalent land use in the Ōhiwa catchment	Functional richness (model)*	Functional richness values	$ value (2012)
NZ native garden	Indigenous forests, Scrub	0.00000	0.20000	205.98
Blackcurrant	Horticulture	0.02575	0.22575	232.50
Dairy	Dairy dry stock	-0.13310	0.06690	68.90**

Sources:
*Rader et al. (2014)
**Adapted from van Meeuwen-Dijkgraaf, et al., (2010)

Appendix D. Social Services

Recreation

The Ōhiwa harbour catchment provides a wide variety of recreational and tourism opportunities. These include walking, recreational fishing, swimming, wind surfing, water skiing and recreational boating (http://www.boprc.govt.nz/environment/coast/ohiwa-harbour/recreation/).

This section describes how the values of recreation were calculated for planted and indigenous forests in the catchment based on a recent study that rigorously estimated indicative values of forest recreational visits in the Bay of Plenty Region.

Based on Dhakal et al. (2012), the estimated value of a mountain biking visit in Whakarewarewa Forest in Rotorua is about $53 per visit (in 2012 NZ$). This forest has about 120 km of mountain biking trails that are distributed across the 3,778 ha of production forest. The forest received about 130,000 mountain biking visits in 2014. Multiplying $53 per visit by 130,000 annual visits and dividing the product by the area of the forest, the value of exotic forests is about $1,800 per ha per year.

Rawhiti forest is a production pine forest in the Ōhiwa catchment that can be regarded as the equivalent of Whakarewarewa forest in terms of providing recreational mountain biking in the catchment. Given that Rawhiti forest is smaller and the number of visits is less than Whakarewarewa forest, we assumed that the recreational value per ha was about half of Whakarewarewa. With a strong growth in mountain biking demand in the Bay of Plenty region and around the country, exotic forest areas in the catchment can have mountain biking trails if access is permitted. Therefore, we have assumed that the exotic forests in the catchment have a recreational value of about $900 per ha per year. This value is justifiable because exotic forests can also provide other recreational opportunities such as walking, running, horse riding, zip lining and motocrossing.

Recreational activities in indigenous forest and scrub areas are highly valued because they offer very high aesthetic values and provide opportunities, for example, to see or hear native bird species. The Tauwhare Pā in the catchment provides recreational walking opportunities to both locals and tourists. It offers high quality views over the Ōhiwa harbour, Ohakana Island, Port Ōhope and the East Cape. Given the very high aesthetic views offered by existing indigenous forests, we assume that their recreational value per ha was about twice as that of exotic planted forests.

This desktop exercise did not find any study that estimated recreation values on New Zealand farms. However, this does not mean that farms do not provide recreation values, and, therefore, these values are considered a knowledge gap for dairy and dry stock farms.

Biodiversity Conservation

Yao and Kaval (2010) provided evidence that New Zealanders value the increase in abundance of indigenous species on both private and public land based on a survey sample of more than 700 people across New Zealand. They found that a typical respondent would pay about $42 per year to increase the abundance of native plants, birds, fish and lizards on private land (e.g. exotic forests, pasture areas) and these respondents would pay twice as much to have this improvement on public land (e.g. DOC reserve). As there has been an increase in abundance of brown kiwi and other native species in exotic and indigenous forests in the catchment, we have assumed that forest areas in the Ōhiwa catchment have been providing residents with those biodiversity values.

To describe our very conservative estimate of the value of biodiversity conservation in indigenous forests in the catchment, we referred to earlier work by Yao and Kaval (unpublished) that estimated the willingness to pay for biodiversity enhancement on public land in the Bay of Plenty region. This value was estimated to be about $110 per year (in 2012 $NZ). Bay of Plenty had a household population of about 26,500 in 2013.[8] Assuming that 50% of these households would pay $110 per year for biodiversity conservation on public forests composed mainly of indigenous forests, this translates to an aggregate biodiversity value of about $1,500,000 per year. The Ōhiwa catchment has about 3,600 ha of indigenous forests, which mostly had an improvement in biodiversity levels over the past few years (MacKenzie et al., 2013; Palmer, 2014). By dividing the aggregate value of $1,500,000 by the area of indigenous forests, we arrive at a per ha biodiversity value of $414 per year.

For biodiversity conservation values in exotic forests, we referred to Yao et al. (2014) which estimated the willingness to pay of a typical New Zealand household respondent for an increase in abundance of key native species (e.g. brown kiwi) in exotic forests to be about $63 per year for a medium-term conservation programme. Using the same aggregation approach and calculation in indigenous forests, the biodiversity conservation value of exotic forests in the catchment is around $257 per ha per year.

Tourism

Tourism data obtained included electronic card transactions of both domestic and international tourists in accommodation, food and beverage services, transport, retail sales and other sales per year from 2009 to 2013 for the Ōpōtiki and Whakatane district (Ministry of Business, Innovation and Employment, 2013). It was assumed that the main attraction in the catchment is the Ōhiwa harbour area, equivalent to 2,640 ha and this value was used to provide the estimations of $ per ha by district (see Table D.1). Finding data on operating costs for tourism proved to be beyond the scope of this project due to the extreme diversity of potential activities involved. Nevertheless, tourism values calculated based on other secondary data collected are presented for reference only (Table D1). In this report, tourism values in indigenous forests and scrub were assumed to be included in the recreation values estimated.

Table D1. Tourism revenue in Ōpōtiki and Whakatane districts.

District	2009	2010	2011	2012	2013	Million $ (median)	$/ha
Ōpōtiki	20.8	22.5	21.0	21.0	21.8	21	7,964
Whakatane	75.2	74.1	73.6	72.2	74.7	74	28,080
Total	96.0	96.7	94.5	93.2	96.5	95	36,044
Average	48.0	48.3	47.3	46.6	48.3	48	18,022

[8] http://www.stats.govt.nz/Census/2013-census/profile-and-summary-reports/quickstats-about-a-place.aspx?request_value=13853&tabname=

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