Environmental Impact Assessment of the Proposed National Environmental Standard for Plantation Forestry

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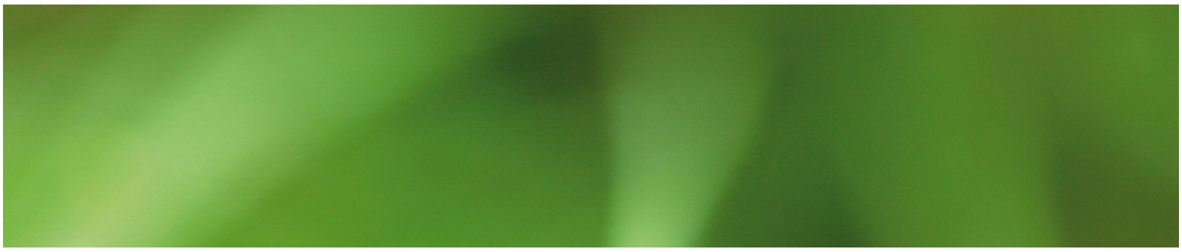

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REPORT INFORMATION SHEET

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Executive Summary

Report Title: Environmental Impact Assessment of the Proposed National Environmental Standard for Plantation Forestry
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The proposed National Environmental Standard (NES) for plantation forestry will result in positive environmental benefits compared to the status quo. The environmental variables assessed are wildings; erosion and sedimentation; and freshwater and riparian terrestrial biodiversity and quality. The environmental benefits identified and, in some instances, quantified, result in a higher benefit-cost ratio than the positive ratio estimated in the latest cost-benefit analysis (CBA) undertaken by the New Zealand Institute of Economic Research (NZIER) and Harrison Grierson (HG) in 2014. Although the NES will potentially result in regional and localised environmental costs in some instances, the identification of the latter has proven to be challenging with the tools used in this report. However, it has been assumed that these potential environmental costs will be mitigated, at a national level, by the improved certainty of environmental outcomes as a result of targeted controls of environmental risks under the NES.

In the case of wildings, it has been demonstrated that the higher controls of afforestation under the NES, using the Wilding Tree Risk Calculator (WTRC) in small forests, would result in avoided losses that would otherwise be incurred in the status quo. It has been identified that large corporate forests are currently controlling for wildings through the voluntary adoption of environmental codes of practice. However, it has been assumed that small forest owners are less likely to be applying such environmental codes. Indicative economic values of the avoided losses, due to higher afforestation controls, were delineated through per-hectare sheep and beef gross margins and the potential tourism and biodiversity losses in the Mackenzie Basin due to wildings.

In the case of sedimentation and erosion, the value of avoided erosion was estimated under three different erosion-reduction scenarios for small forests in areas where harvesting is considered a restricted discretionary activity – orange and red zones according to the Erosion Susceptibility Classification (ESC). Such reductions were assumed to be generated by controlled harvesting practises under the NES. Small forests owners were considered since it was identified that their harvesting practises represent a greater erosion-causing risk to councils compared to large corporate forests. The avoided erosion values ranged from $466 thousand to $10.6 million per year using different per-tonne dollar figures obtained in the literature.

In the case of freshwater and riparian terrestrial biodiversity and quality, although there are no scientific studies addressing the economic implications of setbacks and the Fish Spawning Indicator (FSI), a literature review and phone interviews were undertaken to qualitatively assess the potential implications of the NES. There is consensus that wider setbacks and the use of the FSI would result in environmental benefits under the NES. Furthermore, a number of economic studies were listed, using non-market valuation techniques, giving an indication of the potential values society places on high freshwater and riparian terrestrial biodiversity and quality standards.

Although the supplementary analysis contains potential quantitative environmental impacts, these impacts only serve to support the claim of the benefits generated by the NES compared to the status quo. The quantified impacts are descriptive rather than prescriptive. The dollar values assigned to such impacts are "indicative", rather than definitive, providing an order of magnitude of the potential benefits.

List of Abbreviations

MPI	Ministry for Primary Industries
MfE	Ministry for the Environment
MBIE	Ministry of Business, Innovation and Employment
RMA	Resource Management Act
CBA	Cost Benefit Analysis
NZIER	New Zealand Institute of Economic Research
HG	Harrison Grierson
WTRC	Wilding Tree Risk Calculator
ESC	Erosion Susceptibility Classification
FSI	Fish Spawning Indicator
NES	National Environmental Standard
GIS	Geographic Information System
NEFD	National Exotic Forest Description
FOA	Forest Owners' Association
NIWA	National Institute of Water and Atmospheric Research
LUC	Land Use Capability
SU	Stocking Units
NZEEM	New Zealand Erosion Empirical Model

Background

The Ministry for Primary Industries (MPI) is leading a process to achieve greater national consistency in the management of plantation forestry under the Resource Management Act 1991 (RMA). The government began work on this in 2009 when the Ministry for the Environment (MfE) started scoping the potential for a national environmental standard (NES) to address concerns about planning consistency. MfE developed draft proposals for an NES on plantation forestry between 2009 and 2012. The proposals were consulted on in 2010 and 2011 and MfE received significant stakeholder feedback. MfE also commissioned cost benefit analyses (CBAs) on the proposals.

Cabinet deferred work on the NES in 2013 while MfE worked through a suite of Resource Management reforms. At the same time, MPI was instructed to build on the existing work and to recommend solutions to the problem of national planning inconsistency. Since then MPI has been working collaboratively with a stakeholder working group to develop a draft set of nationally consistent rules for the key activities that make up the plantation forestry lifecycle. An NES is the preferred option for putting the draft rules into effect. As part of the policy analysis around this option, MPI commissioned New Zealand Institute of Economic Research (NZIER) and Harrison Grierson (HG) to refresh the CBA undertaken in 2012 based on the revised proposal and changes in the operating environment since that time. Environmental effects were left explicitly out of scope of NZIER's report.

Introduction

This report outlines a supplementary analysis to describe and value the environmental, social and non-timber/product-related effects of the proposed NES for plantation forestry, where possible. The development of the analysis aims to complement the latest CBA undertaken by NZIER and HG.

An NES would establish a national standard for a defined set of activities practiced in plantation forests in New Zealand. Such activities include mechanical land preparation, replanting, afforestation, pruning and thinning, quarrying, earthworks, harvesting and river crossings. Under the RMA, local authorities currently develop and enforce their own provision (e.g. rules, guidelines) to control forestry activities. This has resulted in wide variation in provisions around the country that are also subject to ongoing change. This leads to regulatory uncertainty and uncertain environmental outcomes.

The proposed NES makes use of a number of environmental risk assessment tools, which underpin the activity statuses[1] in the draft rules. Such tools ensure that the proposed NES rules are science-based and targeted to environmental risks. These tools include the Erosion Susceptibility Classification (ESC), the Wilding Tree Risk Calculator (WTRC), and the Fish Spawning Indicator (FSI).

Between 2010 and 2012, MfE commissioned Covec and Catalyst R&D (Irvine, et al., 2010) and NZIER and HG (Nixon, et al., 2012) to undertake CBAs of the NES proposal at different stages in its development. In 2014, MPI asked NZIER and HG to refresh the CBA completed in 2012 based on the revised proposal and new information. The authors concluded in their December 2014 report that "the quantified analysis returns a net benefit" (Nixon et al., 2014). The net benefit was measured through a benefit-cost ratio ranging from 1.08 to 1.14 conditional on different discount rates.[2]

[1] The activity status of a land use determines the level of control that a council has over how the activity is conducted, including whether or when consent is required.
[2] Recent work suggests the benefit-cost ratio is higher than this. This is the result of work by Landcare Research to refine the classification of erosion-prone land, which suggests a

Quantification of environmental effects was explicitly out of scope of the NZIER and HG report. Consequently, MPI contracted Scion to carry out supplementary work to describe and, where possible, value the additional costs and benefits using alternative valuation methods. The environmental risk assessment tools – ESC, WTRC and FSI –were used to assess the potential environmental impacts resulting from the NES, and the resultant economic implications.

This document (1) briefly summarises the agreed scope of the work as discussed during a planning meeting between Scion, MPI, NZIER and HG, (2) establishes the assumptions used in the supplementary analysis in accordance with those used by NZIER and HG in the latest CBA; (3) describes the assessment method and results for each environmental variable covered; and (4) discusses the overall impacts of the NES on the environment.

Scope of work

A meeting between MPI, Scion, NZIER and HG on 11 December 2014 was held to agree the scope of the analysis and to ensure that the assumptions used in Scion's analysis matched NZIER's assumptions to make sure that the analyses were complementary. Among the points agreed are the following:

- The main CBA developed by NZIER and HG assumed that the margin between the status quo and the NES would be gradually reduced along the 30-year time horizon due, in part, to the prior and continuing existence of the NES draft. In the status quo, the number of councils and forest owners that are aware of the existing draft document will increase and councils are expected to adopt parts or all of it over time in an *ad hoc* manner.

- The National Policy Statement for Freshwater Management (NPS-FM) will affect the status quo since it will promote measures to reduce nutrient leaching and sedimentation. The future effects of the NPS-FM are still uncertain since the regional government agencies in charge of implementing the policy are still working through the implementation plan. Hence, the supplementary analysis to be developed by Scion should be indicative and descriptive to reflect this uncertainty.

- Scion should measure the expected environmental impacts (cost and benefits) from the NES related to non-market environmental factors. NZIER and HG considered that most environmental impacts would either be very marginal or nonexistent since most large corporate forests already comply with the environmental codes of practice. However, NZIER and HG considered that it was worth looking into the following set of environmental impacts from small forests[3] since their owners were less likely to be applying such environmental codes:
    - Wildings resulting from afforestation,
    - Erosion and sedimentation, and
    - Impacts on freshwater and terrestrial biodiversity and quality.

- If, during Scion's research, the environmental or economic effects of the NES obtained from primary or secondary sources are not robust then it would be better not to attempt to quantify the impacts. Thus Scion will adopt a qualitative and descriptive approach to assess the environmental effects of the NES on plantation forestry.

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reduction in consent numbers over the numbers assumed by NZIER in their central scenario. Sensitivity analysis by NZIER shows the benefit-cost ratio is expected to be in the range of 1.41 – 2.98.

[3] MPI (2014) defined a small forest in the NEFD as a forest with less than 1,000 hectares.

- The environmental impacts from the NES identified by Scion should consider the tools that MPI and MfE have developed with other research organizations such as the ESC, WTRC and FSI.

Assumptions

The assumptions to be used for the supplementary analysis are summarized below. They take into account the points agreed by all the parties present at the 2014 meeting and follow the most updated CBA developed by NZIER and HG.

1. The environmental variables considered in this analysis are wildings; erosion and sedimentation; freshwater and riparian terrestrial biodiversity and quality.[4] The biophysical quantities and dollar values assigned to such impacts are "indicative", rather than definitive, providing an order of magnitude of the potential benefits/costs.

2. This supplementary analysis only considers the environmental impacts rather than the timber/product-related, logistical or administrative impacts (e.g. consent costs), which have already been considered by NZIER and HG. If the latter impacts are identified in any of the scenarios developed for this supplementary analysis, these are only described and not quantified.

3. A reduction of the potential environmental impacts (benefits and costs) is anticipated as a result of the changes expected in the status quo. This reduction is due to a number of factors including the prior and continuing existence of previous drafts of the NES, the Environmental Code of Practice for plantation forestry[5] and the NPS-FM in accordance with the findings by NZIER and HG. Adoption of such draft rules is expected to be *ad-hoc*. Therefore, it will not result in all the benefits expected from the introduction of an NES (i.e. consistency and certainty). This applies to regulations enforced by regional councils and practiced by corporate forests regarding wilding control, setback distances and fish spawning schedules.

4. A conservative afforestation forecast was assumed by considering marginal and highly erodible land suitable for new plantation forests to measure the environmental impacts resulting from higher wilding control. A Scion study, by Watt et al. (2011) was used as the reference to identify such potential afforestation areas. The forecast is deemed conservative as it only considers basic geological features (erosion susceptibility) to identify suitable afforestation areas and does not consider unknown effects resulting from simultaneous policy (e.g. NPS-FM, afforestation grants scheme or iwi afforestation intentions) and economic (e.g. carbon price) cross effects. Watt et al. (2011) is the only afforestation reference on which we based our conclusions on wildings since NZIER and HG undertook no afforestation forecast in the CBAs developed.

5. The supplementary analysis developed by Scion focused on wood supply regions when national assessment was not feasible due to the lack of national data. The regions were chosen according to where the NES will likely have the greatest effect. The idea of focusing on such critical regions is to demonstrate that if there are any environmental effects nationally, these effects will take place in these identified regions.

6. Regarding the environmental impacts from wildings, and erosion and sedimentation, it was assumed that these would be only experienced in small forests. It was identified that

[4] Such variables were agreed upon based on NZIER and HG's previous analysis and using their same set of assumptions.
[5] http://www.nzfoa.org.nz/resources/file-libraries-resources/codes-of-practice/44-environmental-code-of-practice/file

few or no impacts would come from large corporate forests since these already, generally, comply with high environmental standards through the environmental codes of practice. However, it was assumed that small forest owners are less likely to be applying such environmental codes.

Impact Assessment of Environmental Variables

Wildings

A large area of New Zealand is affected by the spread of introduced wilding conifer trees. Wilding conifers compete with native vegetation, change existing ecosystems, reduce available grazing land, limit future land use options, visually change landscapes, can affect surface flows and aquifer recharge in water sensitive catchments, and provide fuel for damaging wild fires.

The area affected by wilding conifers, at various densities, was estimated at approximately 805,000 ha in the South Island and approximately 300,000 ha in the North Island in 2007. Recent estimates by the Department of Conservation identify that approximately 5% of the area affected by wilding conifers is densely populated (>400 stems/ha), 20% is moderately populated (20-400 stems/ha) and 75% is sparsely populated (<20 stems/ha).

Assessment method

The maps generated by Watt et al. (2011) were used as the basis to identify potential future afforestation areas with high wilding risk, as afforestation is the only activity which has rules that are affected by the WTRC under the NES. Using nationally available spatial data sets, the authors identified areas within New Zealand that could be afforested in the future, concentrating on non-arable land classes that have limitations for sustainable use under perennial vegetation due to its highly erodible nature. Such non-arable land classes were considered by Watt et al. (2011) since no productive land use can be established in such classes other than forestry.

Watt et al. (2011) developed three scenarios based on erosion severities represented by Land Use Capability (LUC) classes.[6] According to the authors, the total estimated area suitable for afforestation was 2.9 million hectares (Table 1) in the least conservative scenario. Such scenario was considered in this report to include the maximum area of non-arable land with the potential to be afforested potential.[7] The largest proportion of the area identified in the third scenario is located in the South Island, particularly the Canterbury region.

The WTRC was used to identify the areas with high wildings risk within the potential afforested areas estimated by Watt et al. (2011). The WTRC was used as a means to incorporate wilding tree policy into the NES through a propensity or risk score (Ledgard et al., 1999). MfE developed the calculator along with the New Zealand Wilding Conifer Management Group composed of key government, research and private industry stakeholders. The main objective of the calculator was to inform decision makers of the risk resulting from wildings in afforested land due to species type, location, surrounding land uses and vegetation cover. The criterion used in this supplementary analysis to establish a risk

[6] All three scenarios included LUCs 7 and 8, with the highest arable limitations, except for the least conservative scenario including LUC 6 as well.

[7] As will be explained later in the report, sensitivity analyses were performed to include more conservative scenarios. We considered that it was easier and more intuitive to start with the largest afforestation potential and then use different afforestation percentages to include conservative estimates.

score was wind exposure of the afforested sites.[8] Geographic Information System (GIS) layers were developed with the WTRC wind exposure criterion and superimposed to the layers developed by Watt et al. (2011).

Table 1. Potential Areas Suitable for Afforestation by Region in Hectares. Source: Watt, et al. (2011)

	Potentially Afforested
Auckland	21,294
Bay of Plenty	29,105
Canterbury	587,876
Gisborne	215,390
Hawkes Bay	340,243
Malborough	140,822
Manawatu - Wanganui	530,569
Nelson	3,574
Northland	56,799
Otago	403,846
Southland	150,269
Taranaki	77,528
Tasman	34,499
Waikato	199,780
Wellington	165,254
West Coast	15,500
TOTAL	2,972,531

Afforestation is considered a restricted discretionary activity (consent required) in the NES in any ESC zone where the wilding tree risk calculator score is 12 or greater.[9] NZIER and HG (2014) concluded that corporate forest owners and operators are generally controlling for wildings spread through the voluntary adoption of environmental codes of practice. However, it is assumed that small forest owners are less likely to be applying such environmental codes. Furthermore, certain councils such as Central Otago District, Dunedin City, Queenstown Lakes District and Southland District already have provisions in their plans seeking to control for wilding conifers.[10]

The unrestricted afforestation that would happen under the status quo in most regions (excluding Otago and Southland) was compared to the restricted afforestation that would happen under the NES to assess the environmental impacts resulting from the NES. Figure 1 provides a graphical representation of the areas considered to assess the environmental impacts with and without the NES (status quo). The environmental impact assessment was performed only on the dark coloured areas representing areas potentially afforested by small forest owners in the status quo or, otherwise, restricted under NES. Such assessment is possible under the plausible assumption that small forest owners will be discouraged by the additional cost and/or effort to acquire a resource consent in restricted discretionary areas (with a wilding risk score ≥12).

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[8] The assessment of the entire set of conditions (e.g. surrounding land use/cover) for all potential afforested areas was precluded by the lack of detailed geophysical and land-use information of the area surrounding the future seed sources (e.g. trees or plantations).

[9] Although afforestation is permitted in regions such as the Land Overlay 3A under the Gisborne District Council due to afforestation grants scheme, the area would still be subject to the wilding tree risk calculator provision.

[10] The Mackenzie and Marlborough District councils have proposed or considered provisions to control for wilding conifers. However, their final outcome is still yet to be decided.

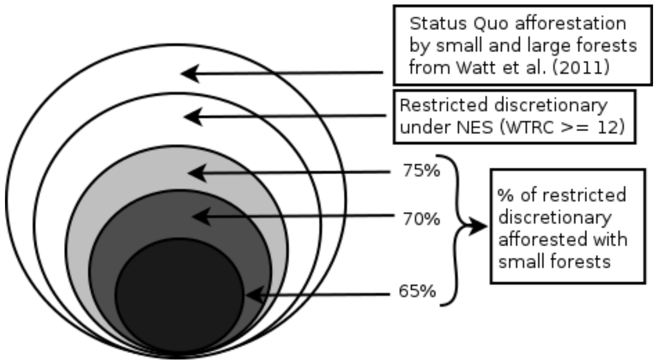

Figure 1. Areas Considered to Assess the Environmental Impacts from Wildings Under the NES

Environmental Impact

Since there is no information on the tree species that would likely be planted on the afforested sites identified by Watt et al. (2011), certain geoclimatic assumtions were made. Siting scores for new afforestation sites were calculated based on topex calculations (Chapman, 2000) by classifying topex values for a site into the 5 siting classes with values ranging from 0-4. An altitudinal limit for Radiata pine afforestations was applied based on FAO (2013), being 1000m above sea level in the North Island and 500m above sea level in the South Island. It was assumed that Douglas-fir will be the preferred plantation tree species above this altitudinal limit.

Assigning a risk score to the potential afforestation areas using the WTRC would result in scores of 12-19 (Table 2), assuming a worst-case scenario for the adjacent land.[11] Based on this categorization, and considering afforestation by large and small forest owners, afforestation would be considered restricted discretionary under the NES in approximately 2.1 million hectares since the wilding risk score is 12 or greater. The Canterbury region has the largest area of afforested land with high risk of wilding spread.

Table 2. Hectares Potentially Afforested (with Radiata Pine and Douglas-Fir) and Under Different Wilding Risk Calculator Scores

	Potentially	Wilding Risk Calculator Score								Restricted
	Afforested	12	13	14	15	16	17	18	19	Discretionary
Auckland	21,294	4,967	3,846	6,603	0	0	0	0	0	15,416
Bay of Plenty	29,105	8,889	5,340	5,707	0	0	0	0	0	19,937
Canterbury	587,876	82,252	42,248	57,995	14,905	70,718	88,891	48,111	85,581	490,701
Gisborne	215,390	45,293	33,207	62,500	0	4	12	26	223	141,266
Hawkes Bay	340,243	87,552	57,262	87,032	0	20	69	139	365	232,440
Malborough	140,822	20,568	12,745	21,393	0	72	198	154	252	55,383
Manawatu - Wanganui	530,569	128,637	86,250	130,735	3,769	12,314	11,199	8,454	20,243	401,601
Nelson	3,574	763	623	1,001	0	1	6	20	77	2,491
Northland	56,799	14,197	10,262	14,837	0	0	0	0	0	39,296
Otago	403,846	73,460	39,621	39,332	9,077	29,535	43,629	26,746	33,810	295,210
Southland	150,269	35,411	20,049	22,809	1,221	5,532	6,894	5,870	13,381	111,166
Taranaki	77,528	15,821	10,188	18,346	0	0	0	0	0	44,355
Tasman	34,499	7,288	4,225	5,927	174	1,368	1,612	1,037	2,377	24,007
Waikato	199,780	51,168	33,271	45,480	0	49	128	24	0	130,121
Wellington	165,254	39,149	26,500	45,403	0	0	0	0	0	111,052
West Coast	15,500	8,124	2,606	942	41	0	9	20	16	11,758
TOTAL	2,972,348	623,541	388,244	566,042	29,187	119,615	152,647	90,601	156,324	2,126,201

Nevertheless, the environmental impact assessment should only be performed on the areas potentially afforested by small forest owners as it is expected that most of the wilding problems will happen in small forests. According to the National Exotic Forest Description (NEFD) smaller scale forest owners with forests of less than 1,000 hectares made up between

[11] Worst-case scenario for the adjacent land means that the downwind land use (grazing) and vegetation cover scores are the highest in the WTRC (Ledgard, 2012).

25% and 30% of total forest area in the last three years (Ministry for Primary Industries, 2012, 2013 and 2014). However, small landowners have been undertaking small-scale new plantings in recent years. A more plausible assumption is that 75% of new afforestation would potentially be undertaken by small forest owners. This percentage was applied to the total national potential afforested area under restricted discretionary status since it is almost impossible to determine regional afforestation shares for small forests.

Due to the uncertainty around the area potentially afforested by small forest owners, a sensitivity analysis was performed around this figure (see Table 3). This uncertainty stems from the various environmental policies that will likely affect afforestation decisions by small forest owners such as the Emissions Trading Scheme (ETS) or the NPS-FM. The three additional percentages included in the sensitivity analysis were 65%, 70%, and 75% (Table 3).

Table 3. Afforestation Scenarios Under the Status Quo and Different Expected Small Forest Owner Area Shares in Restricted Discretionary Areas

Scenarios		Hectares
Status quo afforestation[a]		2,972,348
Total restricted discretionary		2,126,201
Small forest under restricted discretionary areas		
	65%	1,382,031
	70%	1,488,341
	75%	1,594,651

[a] Afforestation of marginal land under the status quo comes from Watt et al. (2011).

The last three rows of Table 3 show the potential afforestation areas that would result in environmental impacts from the more restrictive regulations under the NES regarding wildings. The impacts would take place in an area ranging from 1.4 to 1.6 million hectares under the different afforestation shares by small forest owners.

Economic Valuation

The benefits generated by the NES are represented by the avoided losses, achieved by the restricted afforestation under the NES, that would otherwise be incurred under the status quo. These potential losses include loss of productive farmland (i.e. sheep and beef), biodiversity and tourism due to the wildings spread in the status quo.

Wilding spread from unrestricted afforestaton in high risk areas would result in the reductions of: (1) dry-stock stocking units (SUs) and (2) gross margins ($/hectare). The estimation of total economic (i.e. gross margins) losses in a region would entail identifying the locations of potential wilding seed sources. It is almost impossible to identify such seed sources from the maps provided by Watt et al. (2011) since there are no forests in such areas to date.[12] However, an alternative representation of the potential economic losses from unrestricted afforestation are the actual gross margins obtained by sheep and beef farmers in highland areas. Such gross margins are listed in Table 4 for different regions in New Zealand (Beef and Lamb New Zealand, 2015; Morris, 2013). It is important to note that the stocking rates listed in Table 4 are the lowest ones in the region representing the less productive areas

[12] A wilding spread model that takes into account areas identified as seed sources is necessary to estimate the perimeters (i.e. hectares) affected and the subsequent economic impacts. The limitation of exactly locating such seed sources precludes the modelling of spread scenarios for this analysis.

where wilding trees are most likely to spread.[13] The lowest stocking rates are used to avoid the overestimation of environmental and economic impacts in the different regions.

Table 4. Potential Gross Margin Losses from Wilding Spread in Productive Highland with Sheep and Beef Farms (Source: Beef and Lamb NZ, 2015)

Farm Classes	Stocking rate [a] (SU/ha)	Income ($/SU)	Expenditures ($/SU)	Gross Margin ($/SU)	Gross Margin ($/ha)
South Island high country [c]	0.7 [b]	86.5	52.2	34.4	24.0
South Island hill country [d]	2.0	90.3	50.8	39.5	78.9
North Island hard hill country [e]	6.0	69.1	39.8	29.3	175.6
North Island hill country [f]	7.0	87.7	47.7	40.0	280.1

[a] Minimum figures to reflect the low productivity in the highlands.
[b] Figure obtained from Morris (2013).
[c] Extensive run country at high altitude carrying fine wool sheep, with wool as the main source of revenue. Located mainly in Marlborough, Canterbury and Otago.
[d] Mainly mid-micron wool sheep mostly carrying between two and seven stock units per hectare. Three quarters of the stock units wintered are sheep and one quarter beef cattle.
[e] Steep hill country or low fertility soils with most farms carrying six to 10 stock units per hectare. While some stock are finished a significant proportion are sold in store condition.
[f] Easier hill country or higher fertility soils than Class 3. Mostly carrying between seven and 13 stock units per hectare. A high proportion of sale stock sold is in forward store or prime condition.

The losses in tourism resulting from wildings would be due to the degradation of landscapes (e.g. tussock) mainly in the South Island. Landscape degradation would be the result of uncontrolled afforestation in high wilding risk areas under the status quo. The lack of detailed national tourism data precludes an exhaustive assessment of wildings nationally. Hence, a case study area has been chosen to generate indicative values of the potential losses in tourism under the status quo. The Canterbury region has a large high wilding risk area (Table 2) and the Mackenzie Basin is one of the most affected areas in the region. The Tourism Industry Association (TIA) New Zealand (2009) forecasted that international visits to the Mackenzie Basin would reach 510,000 in 2015. Average expenditures by international visitors in New Zealand are approximately $2,455 (Ministry of Business Innovation and Employment, 2014).[14] Assuming that current wilding infestation in the Basin is 10%, a forecasted increment to 11% would potentially reduce visits by 3,900 according to the weed-recreation mathematical relationship estimated by Odom et al. (2005). This would be equivalent to a loss of approximately $9.5 million ($2,455 * 3,900) in tourism expenditures from international visitors alone.[15]

It is worth mentioning that the $9.5 million is an upper bound of the potential losses due to a 1% increment in wildings invasion. In reality the loss would be smaller since not all of the $2,455 spent in average in New Zealand by international visitors would be spent in the Mackenzie Basin. Furthermore, wildings would most likely not be a deterrent to all visitors since some of them would not even notice that trees are not supposed to be there. However, we have estimated the maximum loss based on a robust mathematical relationship and serves as evidence of the benefits the NES would generate to the tourism industry by restricting potential afforestation areas through the WTRC.

The losses in biodiversity resulting from wildings would be due to the changes in the flow of services associated with a specific ecosystem. Such change in the flow of the services

[13] Wilding trees tend to spread into areas that are lightly grazed or not at all. As such, the land wilding trees spread into may actually not be very productive.
[14] Average expenditures by international visitors for the entire country was estimated from MBIE's 2014 forecast of 2.8 million international visitors spending $6.8 billion (MBIE, 2014). This national figure is considered to be the best approximation to average expenditures by international visitor in the region.
[15] For a more detailed explanation of such calculation refer to appendix A of this report.

provided by biodiversity would be the result of uncontrolled afforestation in high wilding risk areas under the status quo. As an example of how valuable biodiversity is to society, Kerr et al. (2007) completed a choice experiment exercise that analysed people's preferences on the outcomes of a proposed wilding pine control program in the Mackenzie Basin.[16] Although the authors do not specify details of the control levels of the proposed program, this is the only study in New Zealand that attempts to value the loss of biodiversity resulting from wildings invasions. Hence, one of the caveats of using such study is that it cannot directly be compared to the expected controls on afforestation under the NES. However, the study provides estimates of the amount of money that a "typical" respondent would pay for a program that guarantees the prevention of extinction of three endangered species found in the basin. On average, a respondent would pay about $33, $56 and $54 per year for five years for the conservation of *Hebe cupressoides* (plant), *Brachaspis robustus* (grasshopper), and *Galaxias macronasus* (fish), respectively. From a sample of 165 households, the authors aggregated the results over 300,000 households in the South Island and concluded that the public would be willing to spend $24 million, $54 million, and $50 million to protect the three respective species by controlling for wilding conifers. The previous elicited estimates are indicative values of the potential benefits generated by the avoided wildings spread resulting from a stricter afforestation control under the NES.

Key Findings

- Considering areas potentially afforested by small forest owners, with a risk score higher than 12 (restricted discretionary), and regions outside Otago and Southland (already include control provisions in their plans); the potential environmental impacts would take place in a range of 1.4 to 1.6 million hectares. The losses incurred by sheep and beef farmers (e.g. gross margins per hectare) in low productive highland areas, due to wildings invasion under the status quo, are indicative of the potential cost savings resulting from the NES.
- Compared to the status quo, a hypothetical 1% increment in wilding infestation would cost the Mackenzie Basin tourism industry, at the most, $9.5 million only from reduced expenditures by international visitors. It is worth mentioning that the $9.5 million is an upper bound of the potential losses since, in reality, not all tourist visits would be discouraged by wildings. However, this is a regional example and indicative evidence of the cost savings (i.e. benefits) the NES would generate to the tourism industry.
- According to Kerr et al. (2007), 300,000 households in the South Island would be willing to spend $24, $54 and $50 million to protect *Hebe cupressoides*, *Brachaspis robustus*, and *Galaxias macronasus*, respectively, if a better wilding control program was in place. Assuming that such control program is similar to the NES, such biodiversity values are further evidence of the benefits generated by the NES.

Erosion and Sedimentation

The terms erosion and sedimentation are clearly differentiated by Krausse et al. (2001) as "the two different ways in which soil erosion can cause economic impacts." According to the authors, the impacts from erosion are direct and on-site such as agricultural production loss, farm infrastructure damage, utility network damage, etc. The impacts from sedimentation are diffused and indirect; examples include reduced water quality, water storage loss in reservoirs, loss of water-dependent recreational activities such as fishing, swimming, boating, etc. According to Fahey et al. (2003) and Fahey et al. (2006) the activities practiced in

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[16] Choice experiment and contingent valuation belong to the stated preference approach to economic valuation. These are survey based approaches which provide respondents a carefully structured simulated market and elicit their willingness to pay for a change in provision of environmental services.

plantation forests that generate the highest sediment yields are roading (or earthworks), logging (or harvesting), and post-harvesting (or mechanical land preparation).

Assessment Method

MfE and the University of Canterbury developed the ESC with the objective of "analysing the risks of erosion, sedimentation and environmental harm associated with plantation forestry activities in New Zealand" (Bloomberg, et al., 2011). The ESC is the environmental risk assessment tool that underpins the activity statuses assigned to all plantation forestry activities in the NES. In increasing order of risk (i.e. lowest to highest), the ESC zones are separated into green, yellow, orange and red zones. Although the activity statuses of different activities vary, most of the activities in the green, yellow and orange zones are permitted. The activity statuses of mechanical land preparation, earthworks and harvesting are the only ones that change between controlled and restricted discretionary in orange and red zones.

Scion conducted a survey late 2014 of all regional councils to gauge their thinking about forestry, erosion and debris flows (Harrison et al, 2015). The result of those interviews has helped to identify potential outcomes under the NES. Environment Southland and Canterbury reported that erosion was not currently perceived as a problem in their region. All other councils believed that their own guidelines or regulations regarding erosion and sedimentation control would match or better those set out in the NES. Furthermore, all councils (except Northland) claimed that large corporate forests were doing all that was reasonable to control erosion and sedimentation from harvesting practices. The general consensus was that the NES would have little effect in large corporate forests in relation to erosion and sedimentation.

However, the regional councils also mentioned that among small forest owners there was a greater risk that good harvesting practices were not always being followed, leading to an increased risk of higher sedimentation and erosion rates. These smaller operators were the main cause of concern to regional councils since they are not necessarily familiar with the forestry code of practise. It is expected that the easier to follow regulations provided by an NES, in addition to increased guidance material, will result in increased compliance with the rules from this sector leading to lower sedimentation and erosion yields.

Harvesting has a restricted discretionary status in the most susceptible ESC zone (i.e. red colour in class 8e) according to the NES proposed rules. In the case that small forest owners needed resource consents to undertake such activities, certain preventive measures would be necessary to avoid high erosion rates. Thus, it was assumed that the erosion and sedimentation yields would be lower in the orange and red zones as a result of the conditions imposed by the NES.[17] Landcare Research erosion specialists mentioned that, although the reduction in erosion and sedimentation would highly depend on specific terrain characteristics, it would be safe to assume that stricter control of harvesting practices would help to reduce erosion and sedimentation in small forests by 2% to 7% in the best case scenario.

A comparison was made between erosion and sedimentation yields produced during the harvest season under the status quo and reduced yields under the NES to measure the environmental impacts resulting from the NES. Comparisons were only made in small forests located in orange and red zones. To identify current small forests, a GIS layer containing the forestland owned by large corporate forests was subtracted from the total planted forest layer obtained in the Land Cover Database (LCDB). Current erosion impacts under the status

[17] Since the primary control mechanism in the harvesting rules is a harvest plan, in practice, some environmental benefits are expected in the ESC zones where such activity is either controlled or permitted. However, there is greater certainty of benefits where consent is required, therefore restricted discretionary was used as the threshold for this assumption.

quo were estimated with the New Zealand Erosion Empirical Model (NZEEM) (Dymond et al., 2010; Schierlitz, 2008). Since NZEEM measures both erosion and sedimentation in sedimentation yield units, both environmental phenomena were jointly assessed. A harvest-adjustment parameter from Fahey et al. (2006) was used to estimate the sedimentation generated during the harvest season.

Environmental Impact

The erosion and sedimentation yields in tonnes per year that would result from harvesting in small forests located in orange and red susceptibility zones under the status quo and the NES are given in Table 5. Total erosion and sedimentation yield under the status quo would be 23 million tonnes per year as generated by NZEEM and adjusted for harvest season using Fahey et al. (2006). Gisborne has the highest current yields.

Table 5. Erosion and Sedimentation Yields from Harvesting (tonnes/year) in Small Forests Located in Orange and Red Susceptibility Zones Under a Status Quo and NES

Region	Status Quo	Sedimentation Reduction Under NES		
		2%	5%	7%
Northland	1,500,376	30,008	75,019	105,026
Auckland	4,762	95	238	333
Bay of Plenty	99,716	1,994	4,986	6,980
Waikato	151,265	3,025	7,563	10,589
Gisborne	17,797,778	355,956	889,889	1,245,844
Taranaki	199,506	3,990	9,975	13,965
Hawkes Bay	655,107	13,102	32,755	45,858
Manawatu	725,105	14,502	36,255	50,757
Wellington	1,828,519	36,570	91,426	127,996
Tasman	147,852	2,957	7,393	10,350
Marlborough	112,521	2,250	5,626	7,876
Nelson	1,898	38	95	133
Canterbury	23,327	467	1,166	1,633
West Coast	20,827	417	1,041	1,458
Otago	8,050	161	402	563
Southland	11,227	225	561	786
TOTAL	23,287,837	465,757	1,164,392	1,630,149

The last three columns of Table 5 show the environmental impacts from avoided sedimentation and erosion under the more restrictive rules of the NES. Using different assumptions there would be a yield reduction of between approximately 466 thousand and 1.6 million tonnes per year in the most and least conservative scenarios, respectively. It is worth mentioning that the erosion and sedimentation yield estimates were generated for a single harvest event. Since there are no age class records of the different small forests, no time dimension has been considered.

Economic Valuation

Monetary values were assigned to the avoided erosion to measure the environmental effects of erosion and sedimentation under the NES. Avoided erosion under the NES would be considered a benefit from the stricter rules around harvesting practices in small forests located in orange and red zones.

Krausse et al. (2001) estimated that the national economic cost of soil erosion and sedimentation in New Zealand is approximately $126 million per year. They included costs from on- and off-site impacts directly related to erosion and sedimentation phenomena. The on-site erosion cost was estimated to be $75.8 million per year largely due to agricultural production losses and damages to farm infrastructure, private property, road/rail infrastructure, utility network, and recreational facilities. The off-site sedimentation cost was estimated to be $27.4 million per year due to insured losses from increased flood severity and impacts on consumptive water quality, water storage, power generation, navigation, and water conveyance. In the total annual economic cost, they also included avoidance/prevention costs of approximately $23.5 million per year. Dymond et al. (2012) then inflated and used the total cost estimated in Krausse et al. (2001), and the annual estimate of eroded soil exported to the sea of 200 million tonnes by Dymond et al. (2010), to arrive at a per-tonne cost of $1.

The value of avoided erosion from new forests was estimated to be $6.5 per tonne by Barry et al. (2014). The value was estimated from discussions with regional and city councils in New Zealand. They account for avoided flood damage ($0.9 per tonne) and avoided water treatment cost to consumptive water ($5.6 per tonne). The final figure, $6.5 per tonne, was very similar to the off-site cost of soil erosion of $6.6 per tonne estimated by Pimentel et al. (1995) (accounting for inflation and currency conversion rates).

Table 6. Annual Value of the Avoided Erosion Expected Under the NES for Different Reduction Scenarios

Reduction Scenarios	Avoided Erosion (tonnes/year)	$1/tonne [a] ($/year)	$6.5/tonne [b] ($/year)
2%	465,757	465,757	3,027,419
5%	1,164,392	1,164,392	7,568,547
7%	1,630,149	1,630,149	10,595,966

[a] From Krausse et al. (2001) and Dymond et al. (2012).

[b] From Barry et al. (2014).

The total avoided erosion resulting from the more restrictive regulations under the NES can be valued using the estimates in Table 5 and the per-tonne dollar values from Krausse et al. (2001), Dymond et al. (2012) and Barry et al. (2014). The monetary values range between $466 thousand and $10.6 milion per year (Table 6). These are very conservative estimates since erosion and sedimentation arising from earthworks and mechanical land preparation should also be considered and the assumption of when these impacts will occur has been limited to when consent is required.

Key Findings

- The environmental impact assessment regarding sedimentation and erosion under the NES was undertaken for small forests located in red and orange colour ESC zones where harvesting has a restricted discretionary status. Different yield reduction scenarios were considered plausible due to the higher harvesting controls expected in such zones.
- The NES would result in a total of 466 thousand, 1.1 million and 1.6 million tons per year of avoided erosion and sedimentation using yield reduction scenarios of 2%, 5% and 7%, respectively.
- The NES would result in a range of avoided erosion and sedimentation benefits of approximately $466 thousand to $10.6 million per year depending on the yield reduction scenario and price per tonne assumed (e.g. $1 or $6.5/tonne).

Freshwater and Riparian Terrestrial Biodiversity and Quality

The impact of the NES on freshwater and riparian terrestrial biodiversity and quality was qualitatively assessed considering the likely impacts from (1) setback increments and (2) the use of the Fish Spawning Indicator (FSI). This qualitative assessment was achieved through literature reviews and interviews with different stakeholders to get a sense of the potential environmental impacts of the NES and its economic implications.

Assessment Method

Setback Increments

The proposed NES has setback conditions for perennial streams and rivers, lakes and wetlands that apply to the forestry activities of afforestation, replanting, mechanical land preparation, and earthworks. These conditions aim to establish appropriate setback distances from water bodies to reduce the risk of operations such as harvesting or earthworks causing sedimentation or damage to riparian areas and degrading water quality, and in-stream and terrestrial habitats. A different set of conditions is proposed to limit riparian disturbance during harvesting activities. The minimum setback distance in the current environmental code of practice is 5m (Forest Owners Association, 2007). This distance has been used as the benchmark to assess the environmental impacts of increasing the setback distance to 10m and is in line with NZIER and MPI data.

There is no data available on the performance of a 5m riparian buffer in mitigating the effects of forestry activities on riparian areas and stream environments in New Zealand. Therefore, a qualitative assessment of potential environmental effects under the NES was undertaken through a literature review. The review focused on the effect of different setback distances on terrestrial biodiversity, water quality, freshwater biodiversity and its economic implications on recreation activities.

Fish Spawning Indicator

One of the aims of the proposed NES for plantation forests is to "ensure that the impact of forestry activities on freshwater fish species is minimised". To that end, MPI contracted NIWA to produce a report (i.e. Smith, 2014) outlining fish spawning periods and sensitivity to forestry disturbance. MPI used this data, along with other publically available data sets (the New Zealand Freshwater Fish Database and the River Environment Classification), as a basis from which to develop a tool (i.e. FSI) able to determine the habitat and spawning periods of 21 indigenous and introduced species. The FSI is new and untested. In order to evaluate this tool Scion undertook telephone interviews with several of the members of the NES stakeholder working group. The sample included three forest company personnel, three regional council representatives and one Fish and Game representative. The participants were asked if they were familiar with the proposed FSI. If they were, then they were asked to provide feedback on the possible environmental benefits and costs associated with implementing the FSI.

Environmental Impact

Setback Increments

There is limited scientific information available on the performance of a 5m riparian buffer in mitigating the effects of forestry activities on riparian areas and stream environments in New Zealand. A number of studies have assessed the effectiveness of a range of buffer widths in mitigating impacts of harvesting activities (Boothroyd et al., 2004; Graynoth 1979; Langer et al., 2008; Quinn et al., 2004; Row, et al., 2002 and Thompson et al., 2009), but only one study specifically assessed the effectiveness of a 10m buffer at protecting in-stream values at one stream site (Thompson et al., 2009).

In the Coromandel region, Langer et al. (2008) found that the retention of riparian buffers assisted in maintaining indigenous plant diversity during harvesting activities. However, buffers <10m in width were more susceptible to increases in adventive pioneering species exploiting the high light environments, at least in the short-term. Parkyn et al. (2000) , in line with Langer et al. (2008), recommended a minimum 10m riparian width to maintain indigenous biodiversity and natural succession with the likelihood of weed invasion along the riparian buffer margins. They did not, however, assess the effectiveness of different riparian buffer widths in mitigating the impacts of harvesting activities

Riparian buffer widths ranging from 8-27m were effective in maintaining channel bank stability, high shade levels, lower periphyton biomass, lower stream temperatures, and lower organic inputs from harvesting compared with clear-cut harvesting to the stream edge. The buffers also maintained fish and aquatic invertebrate communities similar to those in unharvested or indigenous forest streams (Boothroyd et al., 2004; Quinn et al., 2004 and Rowe et al., 2002). Graynoth (1979) also recorded relatively little change in the aquatic environment and stream faunas in a Nelson stream where the riparian buffer width ranged from 30-150m. A setback of this width was less effective in buffering against increased nutrient inputs (nitrate and phosphorus) from harvesting and was ineffective in excluding either point-source sediment (from a skid site) or finer suspended sediment (from point-source routing of runoff along skid trails) from entering the stream channel. It did however, screen against the large amounts of bedload material that entered the streams that were harvested to the stream edge.

In comparison, the 10m buffer along a stream at a hauler site in Southland was effective in maintaining shade levels, and reducing logging slash inputs (Thompson et al., 2009). While increases in fine sediment, nutrients (nitrate, dissolved reactive phosphorus), and algal growth were recorded in these streams, they were less than that measured in streams harvested to the stream edge. The characteristics of the invertebrate community were similar in the stream with the 10m buffer and those at clear-cut harvest sites. Based on this one site, a 10m buffer has a limited capacity to reduce some of the impacts of harvesting on stream environments and was less effective in mitigating harvesting impacts when compared to the wider buffer widths discussed above. However, a 10m buffer is likely to be more effective in protecting stream environments on flatter topography where there is greater control over tree felling and extraction within the stream and riparian environment and a low risk of sediment run-off from ground-based harvesting activities.

Some overseas publications have highlighted the need for buffers much wider than 10m to maintain riparian biodiversity and in-stream habitat, water quality and biodiversity (Little et al., 2014; Miettinen et al., 2012). A 10m buffer is therefore only likely to reduce the impacts of forestry activities to varying degrees and constitutes a compromise between environmental and economic considerations.

Aquatic and terrestrial biodiversity are influenced by a wide range of factors such as riparian characteristics, hydrology, water quality and habitat. These factors have been considered in assessing the likely enviromental impacts when increasing the setback distance from 5 to 10m on riparian terrestrial biodiversity, sedimentation, water quality and in-stream habitat and biota. While there will be a time delay in the establishment of riparian vegetation in the extended area out to 10m and subsequent impact on riparian and stream characteristics, the assessment below is based on comparing an intact 5m buffer with an intact 10 m buffer. From the knowledge gathered in the literature and Brenda Baillie's professional experience (Scion), the environmental impacts resulting from a riparian setback distance change from 5 to 10m are:

- Unlikely to have any discernible effect on <u>hydrology</u>. Other catchment-scale changes such as clear-cut harvesting will have a greater influence on hydrological regimes.
- Unlikely to have a significant impact on reducing <u>sedimentation</u>. The main sources of sediment reaching waterways during harvesting include run-off from roading activities, landslides, and channel-bed scouring with minor contributions from slope erosion (Fahey et al., 2006; Fransen et al., 2001; Marden et al., 2006). A riparian buffer of 10m is unlikely to provide any meaningful additional protection against these processes, particularly

landslides. Reduction in sedimentation is better addressed through best management practices that reduce the sources of sediment generation.

- Likely to increase the amount of shading over the stream channel, particularly in smaller sized streams.
- Likely to improve the level of protection against water temperature increments and extremes, particularly in smaller-sized streams.
- Likely to increase the ability of the riparian buffer to mediate, but not necessarily negate a post-harvest increase in nutrients.
- The above three factors are likely to assist in reducing the level of nuisance algal blooms.
- Likely to provide additional channel bank stability, but will have limited ability to protect against any increase in channel bank erosion as a result of any post-harvest increases in flow.
- Likely to contribute to the maintenance of terrestrial organic inputs into the water body but would not be of sufficient width to maintain a natural source of large woody debris to the stream system.
- Likely to increase the buffering capacity against excessive inputs of logging slash from harvesting.
- Likely to provide additional protection to the maintenance of in-stream habitat.
- Likely to provide some assistance in maintaining the structure, integrity and biodiversity of the riparian ecosystem.
- Likely to provide a higher level of protection to riparian and stream environments from ground-based harvesting operations than hauler-based harvesting operations.
- All of the above factors will improve the ability of the 10m riparian buffer to provide some level of protection to aquatic biota such as aquatic invertebrate and fish communities.

Fish Spawning Indicator

The level of feedback from the telephone interviews varied as the tool is very new and has yet to be fully evaluated by some of the members of the NES stakeholder working group. Their comments, along with Scion's desktop evaluation of the FSI, are outlined below.

There was a general consensus of the potential environmental impacts generated by restricting certain forestry activities using the FSI. Its implementation should facilitate the protection of the more sensitive and at-risk indigenous and sport fish species against any potential negative impacts from in-stream forestry activities. These impacts include:

- Increased protection of at-risk or threatened indigenous fish species during the critical spawning period;
- Maintenance and enhancement of fish abundance and biodiversity (species and genetics);
- Provision of food sources provided by indigenous and sport fisheries;
- Cultural ecosystem services relating to recreational opportunities, and spiritual, educational and scientific values;
- Including the FSI in the proposed NES for plantation forests will provide a formal method to assess the potential risk to fish populations;
- The impact of the FSI on harvesting and river crossing activities will also be influenced by geographical location. In the latest version of the NES proposed rules, many of the 21 indigenous fish species in the "timing of works for fish" table under "all activities" are in small geographically isolated areas and the impact of the FSI is likely to be limited in these situations. The FSI is likely to have a greater influence on river crossing and harvesting activities in forests located close to the sea and with no natural barriers to migration, as these streams have inherently higher fish diversity.

Economic Valuation

Assigning an economic value to the possible environmental benefits and costs of implementing the FSI is challenging given that the tool is very new and has yet to be implemented. It is suggested to pursue a further assessment of the economic impacts resulting from the implementation of the tool once it has been promoted to the industry and regional councils. However, economic valuation studies in New Zealand provide evidence that the improvement of freshwater and terrestrial biodiversity and quality can have both environmental and social benefits. Although those benefits are important, their values are not reflected in market transactions.[18]

Economic studies have estimated recreational and biodiversity conservation values for programmes that lead to water quality improvement. These values could serve as an indication of the potential economic benefits resulting from the NES.

The choice experiment study by Marsh et al. (2011) estimated that the median respondent would be prepared to pay about $51 per year for a proposed programme that would guarantee an improvement in water clarity (i.e. seeing the bottom of a recreational freshwater ecosystem) in the Waikato region. The choice experiment study by Yao et al. (2014), estimated that the median respondent would be prepared to pay about $6 per year for a proposed programme that would increase the abundance of a native fish (i.e. giant kokopu) in suitable water ways in New Zealand planted forests. The values may be aggregated at the regional or national level by multiplying estimated values by the number of households. However, the values should be treated as indicative and used for discussion purposes only. Some caution should be taken in aggregating those values as the sample of respondents interviewed may not be representative of the whole population.

The travel cost method is a revealed preference approach to economic valuation. The willingness to pay for a recreational visit of a typical respondent is estimated based on his/her observed or reported behaviour. Having no entrance fee does not necessarily mean that a fishing visit has no value. The method estimates the value of a fishing visit based on the amount of time the respondent fishes, the cost of travelling to the fishing destination and other factors. For example, Sharp et al. (2005) estimated that the average value of an angling visit in the Waitaki catchment was about $46. If the catchment gets about 50,000 angling visits a year, the value of angling would be approximately $2.3 million a year. Again, as with the choice experiment method, the values should be treated as indicative and used for discussion purposes only. Some caution should be taken in aggregating those values as the sample of respondents interviewed may not be representative of the whole population.

Other examples of economic valuation studies that estimated water quality improvement can be found in Kaval et al. (2010). They compiled 19 studies that estimated the value of recreation in New Zealand that consist of refereed journal articles, reports, discussion papers, and graduate theses. Five out of 19 studies focused on valuing freshwater recreation. All the above mentioned studies, and other relevant papers related to water quality improvement values in New Zealand, are listed in appendix B.

Key Findings

- According to the literature and professional experience, there will be positive environmental impacts under the NES due to the extension of buffer distances from waterbodies (from the 5m benchmark to the 10m requirement). Such benefits can be summarized as positive changes of abiotic factors (e.g. shading and temperature) that

[18] Economic valuation techniques such as choice experiment, contingent valuation, travel cost and spatial economic models have been developed to provide their indicative monetary values that can help in policy discussions.

promote higher terrestrial and aquatic biodiversity, and a higher protection of waterbodies from nutrients, algal blooms and logging slash.

- Based on interviews with some members of the NES stakeholder working group, the FSI's implementation is expected to result in a higher protection of the more sensitive and at-risk indigenous and sport fish species.
- The economic valuation of the aggregate environmental benefits resulting from longer setback distances and FSI implementation, both included in the NES, has been precluded by a lack of environmental datasets and the recent creation of the tool. However, the literature on the economic valuation of freshwater and terrestrial biodiversity and quality is indicative of the economic and social benefits that would potentially be generated by the NES.

Conclusions

The proposed NES for plantation forestry would result in positive environmental benefits compared to the status quo. The environmental benefits identified and, in some instances, quantified, result in a higher benefit-cost ratio than the ratio estimated in the latest CBA undertaken by NZIER and HG in 2014. The environmental variables assessed were wildings; erosion and sedimentation; and freshwater and riparian terrestrial biodiversity and quality.

In the case of wildings, it was demonstrated that the higher controls of afforestation under the NES using the WTRC in small forests would result in avoided losses (i.e benefits) that would otherwise be incurred in the status quo. The potential environmental benefits under the NES would take place in a range of 1.4 to 1.6 million hectares. Indicative economic values of such avoided losses were delineated through per-hectare gross margins earned by sheep and beef farmers in low productivity highland areas. The lack of detailed national environmental data precluded an exhaustive assessment of the benefits generated by the NES to the tourism industry and biodiversity. However, the biodiversity and tourism industry in the Mackenzie Basin, being one of the areas heavily affected by wildings in the status quo, would benefit from avoided losses due to a higher control of wilding conifers.

In the case of sedimentation and erosion, the value of avoided erosion was estimated under three different erosion-reduction scenarios for small forests in ESC zones where harvesting is a restricted discretionary activity (orange and red zones). Such reductions were assumed to be generated by controlled harvesting practises under the NES and would result in a range of 466 thousand to 1.6 million tons per year of avoided erosion. By assigning a set of prices to avoided erosion (e.g. $1 or $6.5/tonne), the benefits would range from $466 thousand to $10.6 million per year using different per-tonne dollar figures obtained in the literature.

In the case of freshwater and terrestrial biodiversity and quality, although there are no scientific studies addressing the economic implications of setbacks and the FSI, a literature review and phone interviews were undertaken to qualitatively assess the potential implications of the NES. There is a consensus that wider setbacks and the use of the FSI would entail environmental benefits under the NES. A setback distance increment of 5m would result in positive changes of abiotic factors (e.g. shading and temperature) that promote higher terrestrial and aquatic biodiversity, and a higher protection of waterbodies from nutries, algal blooms and logging slash. The FSI implementation would also result in a higher protection of the more sensitive and at-risk indigenous and sport fish species. However, constraints on harvest timings and logistics would result in higher operational costs. A number of economic studies, using non-market valuation techniques, give an indication of the potential values society places on high freshwater and terrestrial biodiversity and quality standards.

Although the analysis contains potential quantitative environmental impacts, these impacts only serve to support the claim of the benefits generated by the NES compared to the status quo. Since the nature of the quantified impacts is descriptive rather than prescriptive, all of the identified impacts are summarized in a matrix in Table 7. The matrix lists the directions (i.e. positive or negative) of the potential impacts indicating only the order of magnitude rather than definitive economic values.

Table 7. Net Benefits Resulting From the NES for Different Environmental Variables

Environmental Variable	Benefit	Cost[a]	Net
Wildings	+	0	+
Sedimentation and Erosion	+	0	+
Freshwater and Terrestrial Biodiversity and Quality	+	0	+

[a] Negative outcomes are mitigated by the stringency provision.

The final conclusion of this supplementary analysis is an indication, supported by evidence, of a higher benefit-cost ratio compared to the one estimated by NZIER and HG. The last column in Table 7 shows the net impacts per environmental variable under the proposed NES would result in positive benefits compared to the status quo and a higher benefit-cost ratio. The net benefit estimated by NZIER and HG was measured through a benefit-cost ratio ranging from 1.08 – 1.14 conditional on different discount rates.[19] Thus, considering that the benefit-cost ratio estimated by NZIER and HG is positive, the environmental benefits identified and, in some instances, quantified, certainly result in a higher ratio.

Although there will be negative outcomes due to the "one size fits all" approach, the environmental costs will be mitigated at a national level by the improved certainty of environmental outcomes as a result of targeted controls of environmental risks under the NES. The cost-benefit ratio estimated by NZIER and HG represents the lower bound of the range of potentially higher benefits when considering environmental non-market factors. As a result, the cost column in Table 7 contains zeros since there are no foreseen environmental costs at this stage of the proposal.

A range of different environmental and economic impacts were estimated in the sensitivity analyses performed with the objective of considering the high uncertainty regarding the interactions of the NES with other national policies such as the NPS-FM and ETS. Added to this uncertainty, NZIER and HG also identified in their latest CBA that the margin between the status quo and the proposed NES will narrow over time due to the adoption of the NES draft by councils. However, such adoption by councils will be in an *ad-hoc* manner lacking the consistency and increased certainty that the proposed NES will achieve.

[19] Recent work suggests the benefit-cost ratio is higher than this. This is the result of work by Landcare Research to refine the classification of erosion prone land, which suggests a reduction in consent numbers over the numbers assumed by NZIER in their central scenario. Sensitivity analysis by NZIER shows the benefit-cost ratio is expected to be in the range of 1.41 – 2.98

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Appendix A. Estimation of Tourism Economic Losses from Wildings

The mathematical relationship used to estimate the reduction in annual visits was obtained from page 447, equation 2, of Odom et al. (2005) and is the following one:

$$v = \frac{V_{max}(x_{min} - w_t)}{k_m + (x_{min} - w_t)}$$

where v is the number of visits (510,000), V_{max} is the maximum number of possible visits (estimated below), x_{min} is the wilding concentration at which v becomes zero (same as in the original study 0.6), w_t is wildings density (assumed to be 10%) and k_m is a half-saturation constant (same as in the original study 0.3). The 10% infestation was estimated by dividing currently infested area by total conservation area.

The maximum number of possible visits was estimated by solving the previous formula for V_{max} and assuming that v is the 2015 forecasted international visits estimate to the Mackenzie Basin according to the Tourism Industry Association (TIA) New Zealand (i.e. 510,000):

$$V_{max} = \frac{v * [k_m + (x_{min} - w_t)]}{(x_{min} - w_t)}$$

Once V_{max} was estimated (816,000 visits), it was replaced in the first equation and a new number of visits (v) was estimated using a new wildings density of 11% to reflect a 1% change from the current density. The latter is a very conservative assumption of what would happen under no afforestation controls in small forests under the status quo.

The original (510,000) and new number of visits (506,127) are represented by the red circle and green triangle, respectively, in Figure 2. Hence, a 1% increase in wildings density results in approximately 3,870 less visits according to the mathematical relationship estimated by Odom et al. (2005) and modified to reflect the current situation in the Mackenzie Basin. By multiplying this reduction in visits (3,870) by the average expenditures by international visitors in New Zealand of $2,455, it results in an equivalent loss of approximately $9.5 million.

It is worth noting that the visit-density relationship is not linear but of a concave nature. This entails that at lower density levels the reduction in visits is less drastic compared to the reductions at high density levels. The intercept on the horizontal axis implies that at a 60% density level, there will be no more visitors.

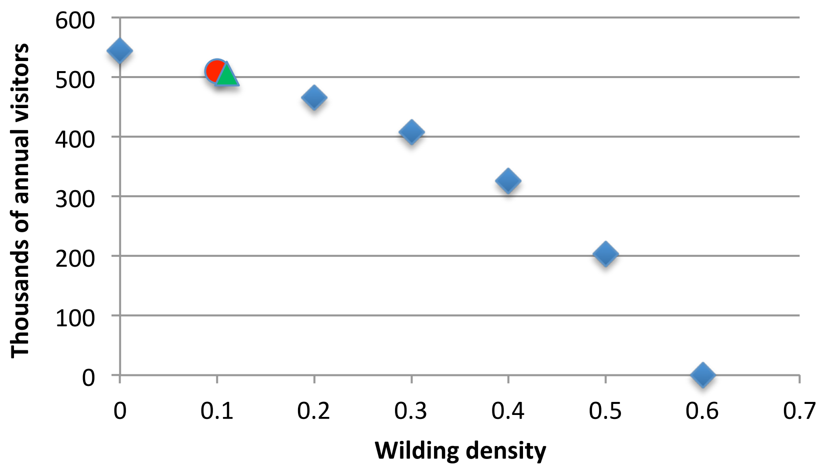

Figure 2. The Relationship between Wilding Density and Annual Visitors

Appendix B. Compilation of Environmental and Social Values of Freshwater Quality and Biodiversity in New Zealand.

Ecosyst. Service	Item valued	Valuation method	WTP ($)[a]	Unit	Source
Biodiversity	Increase in abundance of Giant kokopu in planted forests	Choice experiment	6.81	per person/year	Yao, et al. (2014)
Recreation	Increase in swimming satisfaction 50%	Choice experiment	35.86	per person/year	Marsh, et al. (2011)
Recreation	Increase in swimming satisfaction 70%	Choice experiment	57.54	per person/year	Marsh, et al. (2011)
Recreation	Increase in swimming satisfaction 90%	Choice experiment	81.03	per person/year	Marsh, et al. (2011)
Biodiversity	Ecological - small eels (present/absent)	Choice experiment	47.72	per person/year	Marsh, et al. (2011)
Biodiversity	Ecological - large eels (present/absent)	Choice experiment	67.58	per person/year	Marsh, et al. (2011)
Recreation	Is trout present? (Y/N)	Choice experiment	63.64	per person/year	Marsh, et al. (2011)
Recreation	Water clarity (Can you still see the bottom? Y/N)	Choice experiment	51.49	per person/year	Marsh, et al. (2011)
Recreation	Angling at the Waitaki Catchment	Choice experiment	45.92	per person/visit	Sharp, et al. (2005)
Recreation	Rangitata River Salmon Angling	Travel cost	5.33	per person/visit	Kerr, et al. (2004)
Recreation	Rangitata River Salmon Angling	Travel cost	13.72	per person/visit	Kerr, et al. (2004)
Recreation	Canoeing at Wanganui River Level 1	Travel cost	111.04	per person/visit	Sandrey (1986)
Recreation	Canoeing at Wanganui River Level 2	Travel cost	150.63	per person/visit	Sandrey (1986)
Recreation	Fishing in Greenstone & Caples Valleys	Contingent valuation	65.58	per person/visit	Kerr (1996)
Recreation	Recreational Fishing in Rakaia River	Contingent valuation	82.53	per person/visit	Gluck (1975)
Recreation	Recreational benefits of the in-stream flows	Travel cost	16.81	per person/visit	Cocklin, et al. (1994)

[a] Willingness to pay in 2014 NZ$ (4th quarter).