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Analysis of a Mechanism for Enhancing Biodiversity in New Zealand

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EXECUTIVE SUMMARY

New Zealand's planted forests are well recognised for the provision of forest products such as timber and pulp. Those products have market prices therefore their values are realised in market transactions. Planted forests also provide important services to nearby communities such as biodiversity, recreation and avoided erosion. These services usually do not have market prices and those who benefit do not necessarily need to pay for them. Also, maintaining and sustaining such services often incur costs and such services are sometimes disadvantageous to the forest enterprise. The aim of this work is to apply a mechanism called Payments for Ecosystem Services (PES) to the sustainable provision of biodiversity service in New Zealand's planted forests. This mechanism may benefit the public, the environment and the forest industry.

This study falls under FFR's Environment and Social Theme that includes the accounting of value of ecosystem services into the forest value chain as one of its aims.

In this study, a scenario of incorporating biodiversity values into the value chain was simulated by evaluating the viability of implementing a proposed biodiversity enhancement programme in New Zealand's future planted forests. Areas in the Central North Island region suitable for potential future planted forests that would suit the proposed programme were identified using Scion's spatial economic model, called Forest Investment Finder (FIF). This exercise builds on an economic valuation exercise by Yao et al. (2010)[1] that estimated that the national value of a proposed programme that aims to sustain and enhance falcon population in a Central North Island forests was approximately $11 million per year for five years (in 2010 NZ$).

The results show that once a future forest plot exceeds 415 hectares, it would be viable for a forest grower to participate in the PES programme. This is because the additional revenue provided by the programme to forest growers exceeds the implementation costs of undertaking a falcon conservation programme. Also, expanding existing planted forests into the identified future forest areas could offer an important land use to encourage sustainable provision of biodiversity services. Future studies should assess the viability of incorporating other ecosystem services (such as water quality, aesthetics, human health) into the value chain and examine how these ecosystem services would stack up and interact with each other while still meeting the goal of forest industry to produce tangible forest products.

INTRODUCTION

New Zealand’s international trade activities are closely aligned to the country's clean, green image[2]. Despite significant opportunities to expand and capitalise on this image, New Zealand continues to lag behind a number of countries in established environmental indices [3]. Tourism also relies heavily on this image of New Zealand and generates approximately NZ$27 billion annually for the economy[4]. Those domestic and international tourists who focus on nature-based tourism are found to spend more visitor nights in a destination than other tourists and also to spend more on average per trip to New Zealand[5]. As nature-based tourism includes trekking, mountain biking, bush walk and hunting, biodiversity plays a significant role in the country’s tourism industry. Thus, ecotourism provides incentives for New Zealanders to enhance biodiversity while promoting economic growth. The country also needs to strengthen its conservation efforts as biodiversity levels have declined substantially over the last four hundred years and 77% of threatened species are expected to decline further[3].

Planted forests provide important services such as avoided soil erosion, carbon storage, recreation, improved water quality, and biodiversity in addition to tangible forest products (e.g. timber, pulp) that have market prices[6-11]. Although these services substantially benefit the general public and other private businesses, they usually do not have market prices and those who benefit from them do not necessarily need to pay for them. Also, forest growers often do not receive recognition or revenue for providing them. Accurately defining and valuing services that do not have market values would help identify areas suitable for afforestation based on the relative magnitude of private net benefits to the forest grower and net public benefits to the wider population. Such an approach would assist with sustainable policy decision making in New Zealand.

It has been estimated that 32% of New Zealand's indigenous land and freshwater birds have become extinct in the last 700-800 years, largely as a result of human activities such as the introduction of invasive species and deforestation[12]. The New Zealand bush falcon (Karearea) is the only endemic species of raptor still occurring in New Zealand, which makes it an important species[13]. It is also considered as an important indicator of biodiversity as it is at the top of the food chain[14]. The falcon is classified as threatened using the New Zealand threat-classification system[15]. Clearance of New Zealand’s native bush has been a major factor in the reduction of falcon populations around the country[16]. However, the planting of new forests that are managed to support falcon breeding represents a significant contribution to the conservation of this threatened species.

This study investigates the potential provision of payments to land owners for planting forests and subsequently enhancing biodiversity in these forests firstly by encouraging the establishment of bush falcon populations then sustaining them. It builds on previous FFR-funded work that estimated baseline revenue from afforestation scenarios developed by Scion (Appendix 1) [17]. A scenario for implementing a programme that establishes a bush falcon population in a potential future forest area was modelled.

The key questions of this study are:

- Which areas with potential for future afforestation in New Zealand would also be suitable for a proposed biodiversity-enhancement programme?
- How can such areas be prioritised to encourage the greatest net benefit to the public?
- What effect would a biodiversity-enhancement programme have on the viability of future forests in New Zealand?

METHODS

Determination of Areas Suitable for Future Afforestation

Details of the criteria used for locating land considered suitable for future afforestation are provided in Appendix 1.

Information regarding the suitable areas (size, location etc) was loaded into the spatial economic model called the Forest Investment Finder (FIF) that has been developed by Scion [18]. The spatial component of FIF uses representative 25-m resolution surfaces to estimate the return to a potential forest grower of purchasing an area of land and converting it into a *Pinus radiata* D.Don (radiata pine) planted forest in perpetuity. Additional relevant information was also added to the model, such as a full report describing the spatial model that can be found in Watt et al. (2011)[19] while a report on the development of these surfaces into that spatial economic model can be found in Barry et al. (2014)[17]. The returns from forestry were estimated from predictive surfaces of volume (radiata-pine productivity, 300 Index), tons of biomass (bioenergy) and carbon sequestration (CO_2 equivalents, in tonnes per hectare) and were used to determine the economic viability (private net benefit) of land in New Zealand that could be potentially afforested.

Assessment of the Effects of a Biodiversity Enhancement Programme on the Viability of Future Forests

The viability of new forests in the areas identified above was based solely on revenues for timber and carbon as markets currently exist for these two products. However, falcons will not survive solely in newly planted areas so any future forests would need to be planted in areas adjacent to current forests. This is because falcons prefer to hunt at the edges of established forest stands [16] where prey densities and availabilities are high. Thus, a mosaic of stands that maximises the number of stands greater than twenty years old bordering those that are less than four years old is required.

The assumption was made that the proposed programme would be funded by a conglomeration of private corporations and administered by the Department of Conservation (DOC) in coordination with private investors, forest companies and/or community groups. It was also assumed that the majority of the residents in these areas would benefit from a new falcon population because the bush falcon is an iconic native bird species. All future forest was assumed to be less than four years old at the start of the programme. However, no data currently exist for valuing the effect of establishing a falcon population in new forests. Instead, estimation of the potential revenue that forest growers could receive was based on published economic valuation data[1, 20]. The published data relate to the public's "willingness to pay" to increase and sustain the existing bush falcon population in an already established forest (Kaingaroa Forest). It was estimated that the national value of that programme was approximately NZ$11 million per year for five years (in 2010). Therefore, another requirement was that future forest areas were situated close to the existing Kaingaroa Forest to ensure they had similar conditions in terms of climate and geological features. These areas were located in the Waikato, Bay of Plenty, and Gisborne regions.

A proposed biodiversity mechanism called Payments for Ecosystem Services (PES)[21] was used to determine whether or not payments to forest growers were applicable. In this scenario, forest growers are regarded as 'sellers' of the ecosystem service (ES) because they are in a position to safeguard the delivery of the ES. As long as participation in the programme is voluntary, the 'sellers' are unlikely to accept a payment lower than the cost of providing the ES Ideally this would be 'output based', so that compliance [21] in providing the service could be observed before payment is provided. However, costs incurred to establish a falcon population may not actually result in a population successfully being established. For example, it is still possible that falcons may not survive or may move to another forest. Therefore, an 'input-based' PES approach was [redacted] successful falcon population is established in the future forest. The preferred method for ensuring the survival of one breeding pair in the forest involves hatching chicks in captivity and rearing them there for 25 days. After this time, they are transported to the release site and placed into a ‘hack box’ where they are left for two weeks to ‘imprint’ on the area and recognise it as home. After this time, they are released and they slowly learn to fly and hunt until they eventually become independent and disperse to join the wild breeding population [22]. The Wingspan Birds of Prey Trust in Rotorua has successfully used this method (called *hacking*) to introduce falcons into new area. Five birds would be hacked out (released) each year for five years. Based on an approximate survival rate of 20% and a fledging rate of approximately 50%, one pair of birds would be established after five years.

Releasing five falcons per year for five years will have a Present Value Cost of **NZ$99,517** at an 8% discount rate or **NZ$110,861** at a 4% discount rate. Details of the calculations used for determining the net present costs and benefits for the programme are provided in Appendix 2. These costs are independent of forest size. Therefore growers planting larger forest would be able to spread this cost over a wider area. All else being equal (between implementing a programme and not implementing), a rational forest grower would not enter the programme unless the revenue they receive from the programme is greater than or equal to the cost of implementing the programme. This is because potential growers face a fixed cost regardless of the size of their forest but may only receive marginal revenue depending on their forest size. Thus, the minimum size under which a forester would consider implementing the programme would be 415 ha (i.e. the net present cost of the hack programme divided by the net present revenue per hectare). It should be noted that the threshold area may vary according to the discount rate used in valuation.

There may be some additional costs associated with harvesting and land preparation but no data were available. Furthermore, Seaton (2007)[23] noted that it is straightforward for forest owners to avoid negative impacts on falcons by implementing with relatively minor modifications to current forestry practices.

Finally, an issue of providing a PES often comes down to the *additionality* it would provide, i.e. would the service have been provided without the payment. For all these cases, the PES is additional because it is highly unlikely that a falcon population would exist without the payment. **Essentially it provides potential forest growers with a voluntary payment mechanism to encourage biodiversity which, under certain conditions, makes economic sense**.

RESULTS

The programme outlined above would generate revenue of NZ$60 per hectare per year for five years. The revenue is provided on a per hectare basis because once a population is established, it will grow to the capacity of the forest, so the larger the forest, the greater the biodiversity enhancement. The positive relationship between forest area and added value to the forest viability using a PES approach in shown in Figure 1. Modelling the investment decisions of a potential forest grower, the Net Present Revenue of receiving an annual payment for five years was **NZ$240 per hectare** with an 8% discount rate or **NZ$267 per hectare** with a 4% discount rate (see Appendix 2).

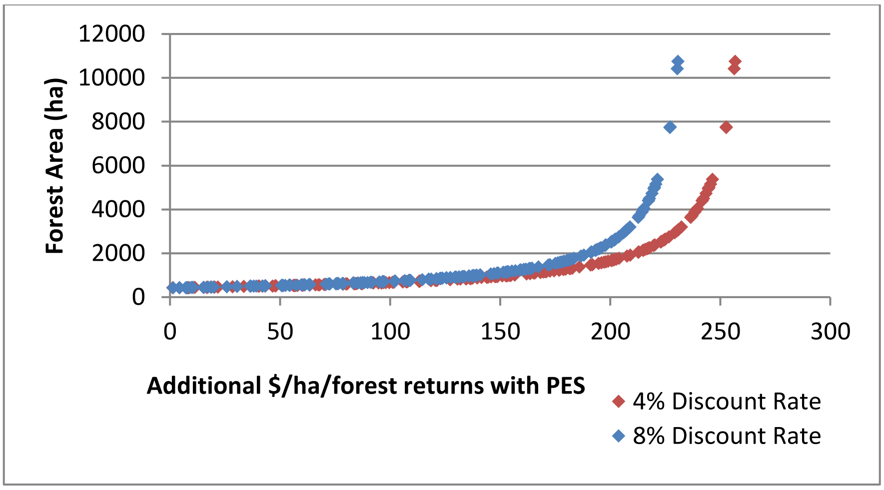

Figure 1: Positive relationship between area of forest and the value added from PES

Choosing the appropriate discount rate is important because of the potential to include new ecosystem services and corresponding payment mechanisms in the future. In these cases, other ecosystem services need to be accurately defined and valued so that other PES schemes can be offered. Once the value of these services is understood and appropriate discount rates identified, PES can be provided to forest growers to help encourage sustainable land use through economic incentives.[1] It is crucial, as in this case, to understand the baseline revenue (private net benefits) of afforestation projects so that PES are only provided for services that would not be provided beyond this point. Otherwise, payments are not actually encouraging change but rather offering payment for a service that would have been provided anyway, thus the payment is not additional and public funds are better focused on encouraging sustainable land use change elsewhere. Using an 8% discount rate, there are 33,962 ha of land (in 22 plots) that are currently economically viable for afforestation (Table 1; Figure 2), which would benefit from introducing the biodiversity-enhancement programme outlined above.

Table 1: Viable forest area suitable for falcon PES

Discount rate (%)	Area of viable forestry (ha)	Percentage of viable forestry at the given discount rate
8	33,962	13
4	115,344	44

There would be an increase in viability from the provision of the PES for all these plots (Figure 2). A greater number of forests are viable when a 4% discount rate is applied because revenue from

[1] As the proposed programme to increase the falcon populations would provide a public good, one can justify

timber (which is accrued at the end of a rotation) is not as heavily discounted as with a rate of 8% (Figure 3). This means that more forests would be profitable before applying any PES. The locations of the viable forests are shown in Figure 4.

The total cost of introducing the PES outlined above would be approximately NZ$ 8 million with an equal value to the public. The provision the PES would be additional (i.e. will not be provided without the payment). The larger the forest, the greater the number of falcons, so the greater the benefit provided to the public (Figure 1) and hence the larger the payment necessary to provide this ecosystem service. The total budget is an important consideration when deciding which should receive a PES. Land that will already be profitable for the owner once forested is much more likely to be converted. The additional inclusion of an ecosystem service will be provided at little cost to the government or other concerned organisations. These areas would, therefore, be a priority for a PES that encourages the establishment of falcon populations. However, it may be necessary to provide additional information or community support [24] to increase awareness of the potential profitability of these marginal agricultural areas for forestry. In the analysis conducted here, no areas of unviable future forests would become viable as a result of the PES. If these did occur, they would be a greater priority because of the other environmental co-benefits that would accompany the PES, for example the improved water quality and avoided soil erosion benefits that come with afforestation.

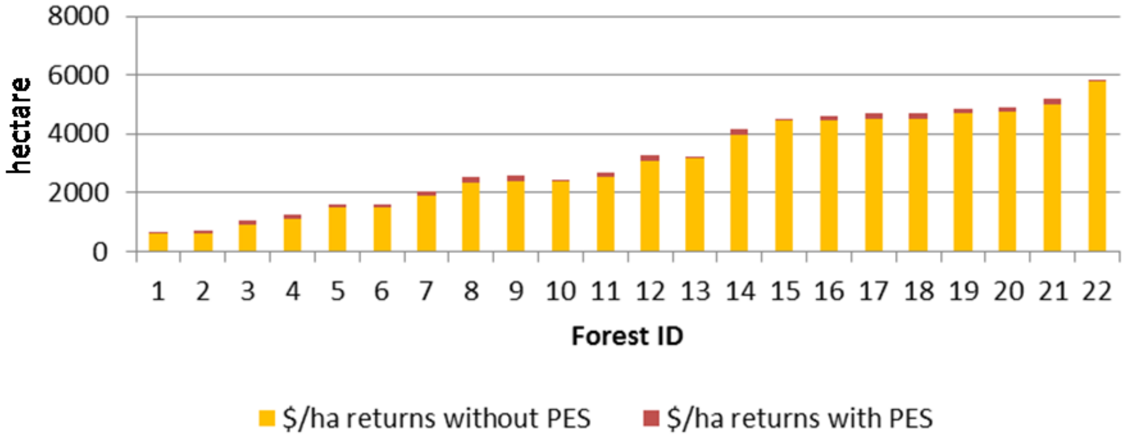

Figure 2: Increase in financial return per hectare from introducing a PES for economically viable forest plots using an 8% discount rate.

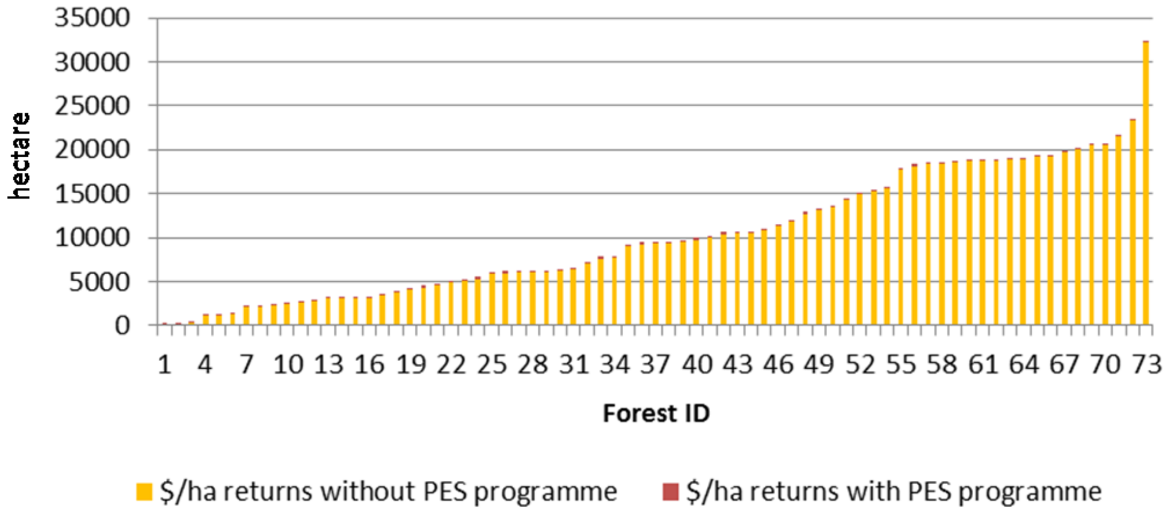

Figure 3: Increase in financial return per hectare from introducing a PES for economically viable forest plots using a 4% discount rate.

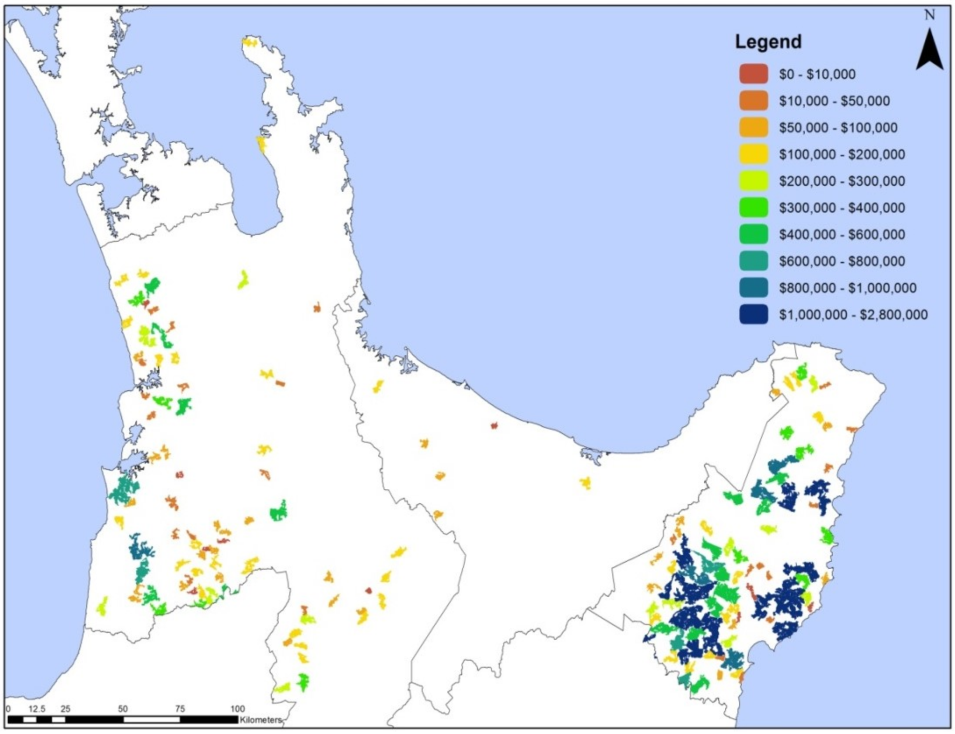

Figure 4a. Map of North Island showing the location of future forests covered by the proposed biodiversity enhancement programme (discounted at 4%).

Note: Dollar values in the legend represent profit per forest from a 28-year rotation of *Pinus radiata*. Larger forests have a greater increase in viability.

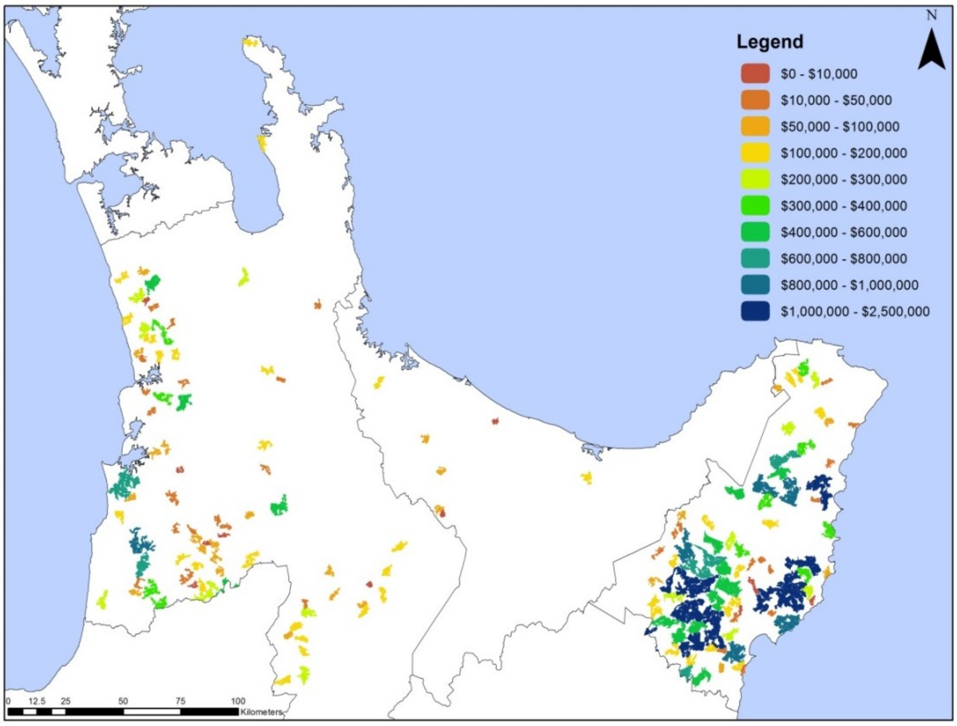

Figure 4b. Map of North Island showing the location of future forests covered by the proposed biodiversity enhancement programme (discounted at 8%).

Note: Dollar values in the legend represent profit per forest from a 28-year rotation of *Pinus radiata*. Larger forests have a greater increase in viability.

DISCUSSION

New Zealand private and public corporations (and multinationals) support a range of conservation projects. For example, the Bank of New Zealand and Genesis Energy support the conservation of brown kiwi and blue duck respectively. Air New Zealand supports the native-species translocation programme operated by the Department of Conservation while the Matariki Forests managed by Rayonier has created a kakabeak (native plant) nursery at a school in Napier. Based on increasing involvement of private corporations in conservation projects, it was assumed that a conglomeration of private corporations could be established that would fund the proposed programme. In the authors' opinion, this approach would be a private-environment-public win-win-win scenario. It would provide an opportunity for private corporations to exercise their corporate social responsibility, at the same time as benefiting the New Zealand environment, and the general public would be happy to see (or know) that an important native species is protected.

The theory behind a PES approach is that it seeks to internalise what would otherwise be an externality [25]. In this case, the biodiversity enhancement is the positive externality because a third party, the public, would be benefitting from it. If a forest grower alone faced just the cost of enhancing the falcon population from implementing a hack programme, they would be worse off. If only the public benefited, adoption of this programme would be unlikely. However, an incentive to adopt is generated by providing a payment to the forest owner that is worth the value of providing this ecosystem service to the public.

Payment schemes for biodiversity-enhancing land-use measures have become increasingly important in other parts of the world, such as Europe[26, 27]. In Japan, the provision of payments to encourage biodiversity has been vital in reintroducing a culturally important species, the white stork, which had become extinct in the wild. The programme encouraged farmers to adopt more sustainable rice production practices to improve those ecosystems that sustain storks. This programme helped to provide a price premium for rice grown more sustainably, ‘white stork rice’, while also helping improve the local economy, and enhancing biodiversity [28].

Planted forests may offer an important land use with which to encourage the provision of these ecosystem services. Demand for land will become increasingly competitive as the human population increases so conservation will comes at a much higher opportunity cost. Among New Zealand’s productive ecosystems, planted forests could be considered as as being highly adaptable for providing habitats to threatened native species[8, 29, 30], such as the New Zealand bush falcon.

CONCLUSION

There are areas in the central North Island that could be used to encourage the conservation of falcon populations through a PES mechanism even under a conservative 8% discount rate. Expanding the area of investigation would require further study into the public willingness to pay for such enhancement. The mechanism outlined above shows the important considerations when implementing a programme to encourage sustainable land use decision making. When developing these mechanisms, it is important to understand, define and value particular ecosystem services of interest, which may often vary across space. An estimation of the baseline revenue of projects is crucial for determining the efficiency of payments. This report offers an example of implementing a PES to help ensure efficient and effective allocation of very limited funds, when the value of the ecosystem service is not well defined. By collecting information and undertaking robust estimation of values of ecosystem services from forests across space and time (for example there may be a delay in water quality benefits from afforestation), a better understanding of the public and private net benefits can be gained to help further prioritise public expenditure on projects with the greatest net public benefits. It is also recommend that future studies look at the viability of incorporating other ecosystem services (such as water quality, aesthetics, human health) into the value chain and examine how these ecosystem services would interact with each other while at the same time still meeting the goals of the forest industry to produce tangible forest products. It is also important to study the feasibility of establishing new markets for services provided by New Zealand’s forests and other ecosystems.

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APPENDICES

Appendix 1: Criteria for Determining Areas Suitable for Future Afforestation

- The sub-categories from first-order classes grassland, and scrub and shrubland, from the AgriBase™ enhanced Land Cover Database 2 (LCDB2) [31] were selected.
- Removal of sub-categories for fernland, manuka and or kanuka, matagouri, broadleaved indigenous hardwoods, sub-alpine shrubland, and grey scrub from scrub and shrubland and tussock from grassland, to minimise further ecosystem loss.
- Shrubland classes were excluded as they are considered native carbon sinks.
- Land with the potential for high returns was excluded; this was everything except beef, deer, grazing other peoples' stock, not farmed-idle, sheep, mixed sheep and beef, and unspecified for low producing grassland and beef for high producing grassland.
- Land use capability (LUC) classes were used to exclude arable and slightly limited non-arable land classes and to differentiate between the three scenarios on the basis of erosion severity [32].
- Using a 500-m resolution normalised climate surface [14], regions with annual temperature below 7.9 ^{o}C were excluded, as productivity for *Pinus radiata* is very low below this threshold.
- Areas were limited to a predicted 300 Index of 5m^3/ha/yr and a site index of 13.5 m [33] as productivity values have not been recorded below these parameters.
- Grassland and shrubland areas that have unique biodiversity value and would not naturally support trees were excluded using a number of predicted vegetation classes [34].
- Department of Conservation estate and current plantations were also excluded.

Appendix 2: Present Value Costs and Benefits

Hack Costs
A cost breakdown suitable for budgeting for the captive rearing, release and monitoring of New Zealand falcons is presented. The budget includes the cost of rearing the chicks in captivity up to the point of release, the cost of the equipment required to release the birds using a standard soft-release hack method and the staff time required to feed and monitor the birds once they have been released. This cost breakdown is for the release of one bird. Each additional bird released during that breeding season will cost an additional $1,500. N.B. if birds are to be released during more than one breeding season the same costs will apply <u>each breeding season</u>, minus the cost of the hack release box, aerial and receiver [16].

Budget for releasing <u>one</u> falcon

Cost of rearing a falcon to the point of release:	In NZ$
Bird food & staff time:	1,000
Time to attach transmitter (10 hours – as need to re-trap after release to refit the transmitter):	500
Transport to release site (within North Island – assume double for South Island):	400
Releases - staff time:	
Feed while in box (1 hour per day for 10 days):	250
Feed and monitor every day for first 2 weeks (10 hours per day for 14 days):	3,500
Feed and monitor every other day for two more weeks (10 hours per day for 7 days):	1,750
Feed and monitor once a week for 6 months (10 hours per day for 24 days):	6,000
Equipment and fuel:	
Hack release box:	400
Radio-transmitter (per unit):	300
Aerial and receiver:	1,000
Vehicle hire and fuel ($80 per day for 55 days):	4,400
General disbursement costs:	500
TOTAL per breeding season:	**$20,000**

20,000 base rate for rearing, release and monitoring of one bird
1500 x 4 for four additional birds each season
= 26,000 x 5 years
$130,000 minus hack box, aerial and receiver costs ((4 x (400 + 1000)) = 5,600)
= $124,400 ($26,000 + (4 x 24,600))
Discounted annually using the present value (PV) formula:

$$PV_C = \sum_t \left(\frac{C_t}{(1+r)^t}\right),$$

where C_t is the cost in year t and r is the discount rate[35]. Therefore, to release five falcons per year for five years will have a Present Value Cost of **NZ$99,517** at an eight percent discount rate and **NZ$110,861** at a four percent discount rate.

Falcon Willingness to Pay (WTP) Value

MEASURE	Median WTP	Lower bound	Upper bound
Willingness to pay	$13.74	$6.23	$19.89
No. of willing taxpayers	825,600		
Total willingness to pay	$11,340,213		
Area of Kaingaroa forest [36]	189,000		
Willingness to pay/ha	$60.00/ha for 5 years		

Source: Yao et al. (2010)[1]

Net Present Revenue of an annuity payment of NZ$60ha-1 for five years;

$$PV_{AR} = AR\left(\frac{1}{r} - \frac{1}{r(1+r)^T}\right),$$

where *AR* refers to the annuity amount, *r* is the discount rate and *T* is the total length of time for the payment provision.