The broader benefits provided by New Zealand's planted forests

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Abstract

New Zealand planted forests are primarily recognised for the provision of wood and fibre and they are increasingly recognised for their contribution to the nation's economic prosperity, environmental conservation and human well-being. The multiple contributions they provide can be viewed using an ecosystem approach. The approach can serve as a useful communications device between stakeholders. In this paper we present a case study where we applied analytic tools – the Forest Investment Framework and economic valuation – to demonstrate the full value of a planted forest estate. We show that the environmental and social values provided by the forest estate can be greater than the financial benefits. We conclude that the recognition and representation of the full value of forests in policy and decision-making is vital given the multiple benefits they provide to sustaining human society.

Introduction

New Zealand's 1.72 million ha of planted forests are a productive ecosystem primarily recognised for the provision of wood and fibre (MPI, 2015b). This ecosystem is increasingly recognised for its contribution to the nation's economic prosperity, environmental conservation and human well-being. The multiple contributions that the planted forest estate provides to society can be viewed using the framework developed from the Millennium Ecosystem Assessment (MEA, 2005). The framework provides a more inclusive view of the broader values that people derive from an ecosystem, which are referred to as ecosystem services (ES). The MEA categorises ES into four groups: provisioning, regulating, cultural and supporting services (Figure 1).

Provisioning services are the products derived from a planted forest such as logs, processed wood, fibre and fuel. Forest products directly contribute to gross domestic product (GDP). The New Zealand forest industry provides gross sales of about $5 billion in

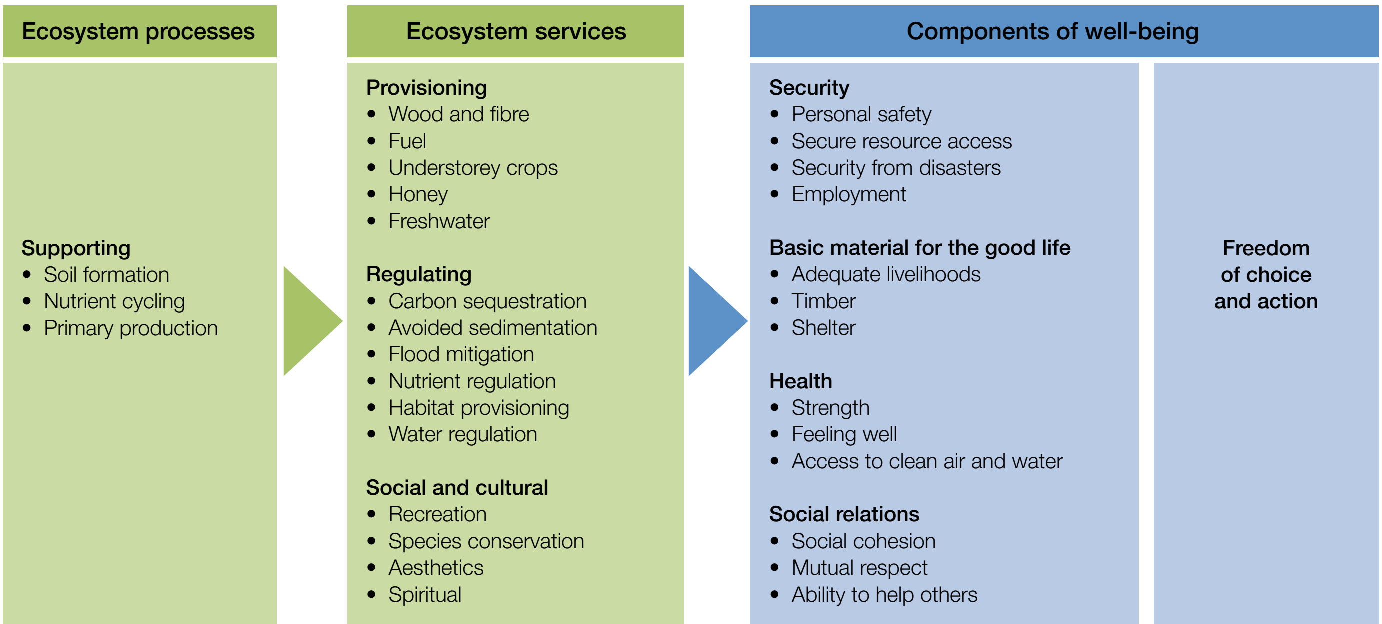

Figure 1: Ecosystem services provided by planted forests – adapted from MEA (2005) and (Yao et al., 2013)

exports and $3 billion in domestic sales annually, and directly employs about 20,000 people (MPI, 2016; Yao et al., 2013). Planted forests can also provide a place to grow high value crops, such as simulated wild ginseng, which is grown underneath pine forests in the Central North Island region (Scion, 2013). Planted forests also provide local benefits, such as clean drinking water to some rural communities and raw materials that can be used to generate heat and power for primary industries (Baillie & Neary, 2015; IEA, 2011).

Regulating services are the benefits obtained from the regulation of ecosystem processes. Planted forests provide regulating services such as carbon sequestration and storage, reducing erosion, improved water quality and flood mitigation (Turner et al., 2008; Yao et al., 2013). A planted forest in New Zealand can sequester more than 1,000 tonnes of CO_2/ha over a 28-year rotation, including above- and below-ground biomass and the litter layer (MPI, 2015a). Planted forests stabilise soil, especially on steep slopes, and consequently reduce soil erosion (Fahey & Marden, 2006). They also help produce quality water for most of their rotation, providing a useful freshwater resource to downstream users (Baillie & Neary, 2015). Nevertheless, planted forests have the potential to reduce water yield compared to pasture land use (Balvanera et al., 2006), as well as increase the risk of sedimentation, erosion and debris flows during the immediate post-harvest period (Zhang et al., 1993).

Mountain biking in the Whakarewarewa forest in Rotorua. Photo: Rodrigo Osorio

Cultural services are the non-material benefits obtained from an ecosystem, such as recreation, aesthetic experience, spiritual enrichment, appreciation of biodiversity and conservation. Several planted forests in New Zealand provide recreational opportunities to the local people and tourists. Activities are various and include walking, mountain biking, horse riding, running and exercising dogs. A large part of the 5,667 ha Whakarewarewa Forest in Rotorua is popular for its publicly accessible mountain biking (see photo), walking and horse riding trails (Turner et al., 2011). Another example is the 12,500 ha Woodhill Forest in West Auckland where businesses have invested in new facilities for four-wheel driving, paintballing and flying-fox adventures (see www.woodhillforest.co.nz/woodhill-activities/).

Supporting services are the biological, chemical and physical processes that underlie the provision of the other three groups of services. Examples include soil formation, nutrient cycling, water regulation and oxygen production. Supporting services indirectly affect society, as their impacts on people occur over a very long time. These services can be quantified and valued, but care needs to be taken when considering these values alongside provisioning, regulating and cultural services to avoided double counting.

Development and integration of the ecosystem approach in NZ

Forest ecosystem services (FES) can be classified into two groups: those that have a market value (e.g. $150/m^3 of pruned log at mill); and those that provide direct and indirect benefits to the public. These public benefits are very important, but they do not have a market price so they can be easily be taken for granted until they are gone. Services such as clean water and fresh air are becoming scarce in many countries and, for an increasing number of people, these services are gradually becoming priceless. For example, the current worth of the bottled water industry is more than $200 billion globally and expected to increase to more than $400 billion in 2024 (see www.transparencymarketresearch.com/bottled-water-market.html).

Several global initiatives have been undertaken over the last 15 years to prevent the further degradation of natural capital and the flow-on ecosystem services they provide. These initiatives focused on the need to recognise and represent the services that have emerging markets (carbon sequestration, avoided nutrient leaching), as well as those with non-market values (including recreation, conservation and biodiversity, and cultural and spiritual values) (MEA, 2005; TEEB, 2010; UKNEA, 2011). The ecosystem approach can serve as an influential and useful communications device by providing a common language to identify and discuss the multiple values of an ecosystem amongst a wide range of stakeholders (Barbier et al., 2009; Boyd et al., 2015; Wallace, 2007).

The success of the approach is demonstrated by its growing acceptance and adoption in both the developed and developing world. In 2011, the Forest Stewardship Council decided to incorporate ES in their strategy formulation and this contributed to the development of ForCES (Forest Certification for Ecosystem Services), which is currently being piloted in Chile, Indonesia, Nepal and Vietnam (see http://forces.fsc.org/).

There has also been a growing interest from New Zealand government agencies and industries to integrate the ES approach into strategies and policies to sustainably manage both productive and conservation ecosystems. Examples include:

- A study of the Ōhiwa catchment commissioned by the Bay of Plenty Regional Council where that study applied an ES approach to help gain a better understanding of the 'value' of land cover/land use as a service in the catchment (Yao & Velarde, 2014)
- The recently updated regional policy statement of the Waikato Regional Council emphasised the need to recognise, maintain and enhance ecosystem services values to sustain their important contributions to human well-being (WRC, 2016)
- The 'Environment Domain Plan 2013' report published by Statistics New Zealand outlined a plan to undertake ecosystem services assessment and this has been envisioned to contribute to the development of a new system of national accounting (see www.stats.govt.nz/browse_for_stats/environment/environmental-economic-accounts/environment-domain-plan.aspx)
- An assessment of the key ecosystem services provided by the Wenita Forest Products forest estate (Yao & Harrison, 2016).

Tools for analysing forest ecosystem services

Several tools and frameworks have been developed to quantify, value and analyse forest ecosystem services (Yao et al., 2016). Aside from provisioning services with market values, indicative values (e.g. $ per recreational visit), quantities (tonnes of CO_2 equivalent) or qualitative descriptions of ecosystem services may be used to represent and/or recognise forests' wider values in policy and resource management discussions.

Forest Investment Framework (FIF)

The FIF is a spatial economic tool developed by Scion that has been used by government agencies, indigenous groups and the forest industry to analyse ecosystem services in New Zealand (Yao et al., 2016). It combines biophysical, spatial, economic and environmental data to provide indicative ES values from existing and planned forests anywhere in New Zealand. The FIF enables the quantification and estimation of forest benefits, whether through market (cash) income from timber, non-wood products and carbon sequestration, or non-market returns such as the values directly or indirectly placed on avoided sedimentation.

- **Timber viability component:** this component in FIF assesses which among prospective afforestation sites would be profitable or not. The FIF calculates revenue using a timber-yield surface for radiata pine that enables the estimation of volume of logs that can be harvested at each prospective site and corresponding log prices. Production cost surfaces are calculated based on reported and imputed costs (e.g. establishment, silviculture, roading and harvesting) as well as impedances derived from biophysical characteristics (e.g. rainfall, slope and erosion class). Profitability, in the form of land expectation value (LEV), is then calculated using the revenue and cost estimates, and an appropriate discount rate.
- **Environmental benefits component:** carbon sequestration and avoided erosion, two key environmental benefits of planted forest, can be quantified and valued. The amount of carbon sequestered is estimated from the same productivity surface used to determine timber productivity combined with the C-change carbon model (Beets et al., 1999). To calculate the indicative revenue from sale of carbon credits, the estimated spatially explicit quantity of carbon sequestered is multiplied by the reported carbon price in New Zealand. The value from the sale of logs and carbon credits represent the two main revenue surfaces in FIF.

Avoided erosion benefits are quantified using the New Zealand Empirical Erosion Model (Dymond et al., 2010) to estimate the reduction in sediment due to land stabilisation. The volume of sediment reduced is spread over the 28-year rotation period where it is assumed that full canopy cover provides maximum soil protection when land is changed from bare land (e.g. pasture) to forestry. It is also assumed that sedimentation from forestry may be the same or worse during the first three years of establishment, as during harvesting. The FIF avoided erosion component assumes that off-site avoided erosion takes the value of approximately $6.50/tonne of sediment prevented from going into the waterways (Barry et al., 2014). This value is composed of avoided flood damage and avoided water filtration costs and can be considered as a conservative estimate of the public benefit of avoided erosion (Porou et al., 2012).

Economic valuation

Planted forests provide cultural benefits (e.g. conservation of native species, recreation) that are realised by the general public. Several methods can be used to estimate and quantify these cultural benefits. Two survey-based economic valuation techniques (travel cost and choice modelling), and an example based on an approximate market price and other relevant data, are described here.

Travel cost is a survey-based method. There is no entrance fee for walking or mountain biking in the Whakarewarewa Forest in Rotorua. However, this does not mean that a recreational visit does not have a value. More than 700 forest regular forest users, about one-half walkers and the other half mountain bikers, were asked how much it cost them to travel to the forest, the amount of time they spent in the forest and other factors. The analysis of the responses suggest that the value of a walking and a mountain biking visit were approximately $40 and $55 (in 2016 NZD), respectively (Dhakal et al., 2012).

Multiplying those median visit values by the total number of visits for each activity per year would provide an aggregate value of recreational visits for Whakarewarewa Forest. The aggregated value can be treated as a conservative estimate of the annual public benefit that the forest provides to visitors. This value should be treated as over and above the provision of timber and environmental values such as carbon and avoided erosion. This should not suggest that the forest company should not be cutting trees as only a small fraction of the forest gets harvested every year and a large majority of the production forest remains untouched. In addition, damaged or destroyed mountain biking trails can be restored or upgraded post-harvesting.

Another survey-based method is the discrete choice experiment approach (Carson & Louviere, 2011). A questionnaire on biodiversity values was developed around the scenario of a proposed five-year biodiversity programme that would guarantee an increase in abundance of iconic species (e.g. brown kiwi, bush falcon) in planted forests (Yao et al., 2014). The survey containing the valuation scenario was completed by more than 1,500 households across New Zealand.

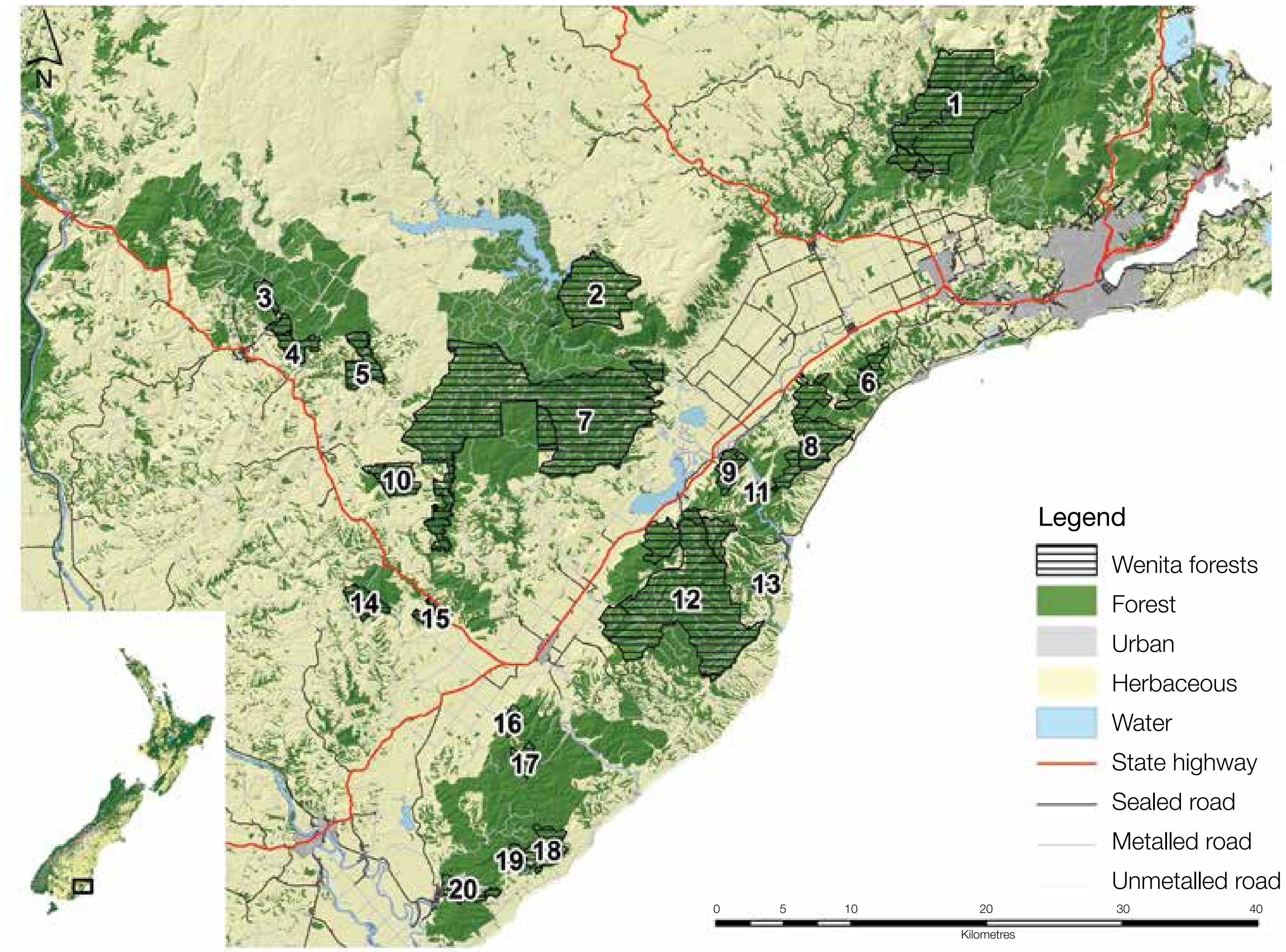

Figure 2: Map of the Wenita forest estate showing the major forest blocks and the neighbouring areas

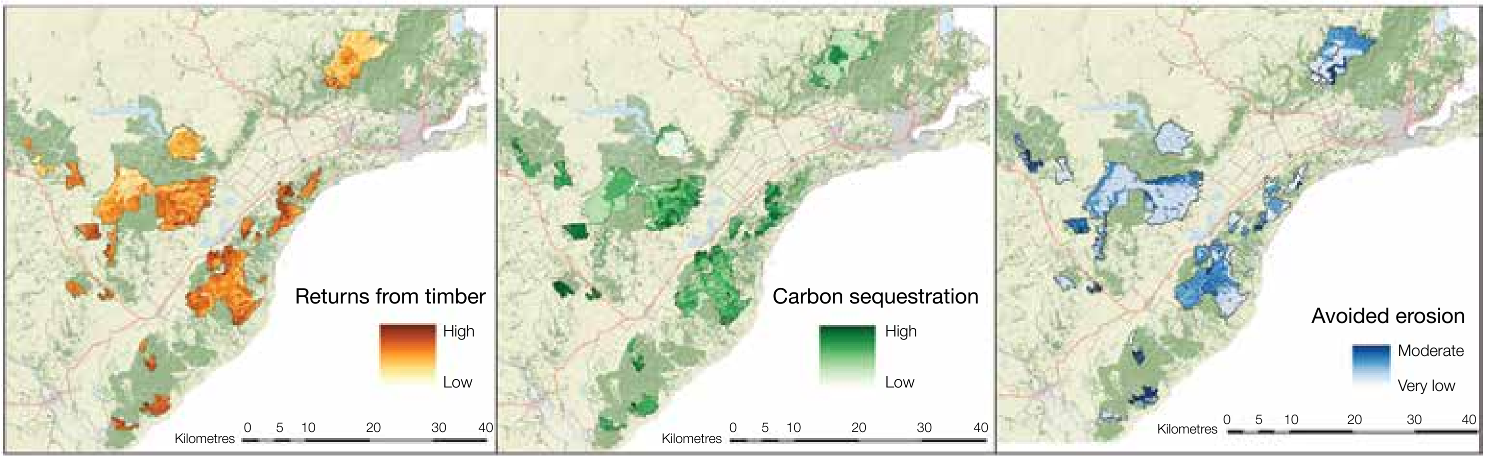

Figure 3: Spatially explicit estimates of the values of timber, carbon and avoided erosion in the Wenita forest estate

Results show that a typical New Zealand household respondent would pay approximately $264 (minimum of $126 to a maximum of $693) per year for five years for the proposed programme (Yao, 2016). This suggests that planted forests can provide biodiversity values and people would be willing to pay to support the proposed programme.

Another method to estimate the value of a public benefit is to assign an approximate price to a tangible product (e.g. game meat) that a particular forest provides to the general public (Naidoo & Ricketts, 2006). Several commercial forest owners in the country operate a hunting permit system, whereby they manage the number of recreational hunters operating in their forests and the locations in which they hunt. By keeping track of the number of licence holders and the number of animals hunted, forest owners can calculate an approximate annual value of recreational hunting. An application of this method in a planted forest estate will be described in the next section.

Case study: analysing forest ecosystem services in a planted forest estate

Wenita Forest Products recently commissioned Scion to provide a better understanding of the wider benefits provided by the Wenita forest estate (Figure 2), the largest planted forest in Otago. Although Wenita primarily aims to produce timber and generate timber profits, the true value of the forest can only be accounted for when all ecosystem services are considered. We applied the FIF to quantify timber production, carbon sequestration and avoided erosion services, and the price-based valuation technique to quantify the value of recreational hunting (Yao & Harrison, 2016).

FIF provides spatially explicit estimates of the value of the three ecosystem services across the forest estate. The indicative value of those ecosystem services illustrating the ranges in values for each ecosystem service are presented in Figure 3. Areas with darker shades have higher values while lighter shades have relatively lower values. All values are specific to the Wenita forest estate only.

Carbon sequestration contributes the greatest proportion to the total value of the forest (54%), followed by timber (41%) then avoided erosion (5%) (Figure 4). The small value for avoided erosion is expected as erosion rates in the forests are classified as low to moderate compared with the rest of New Zealand.

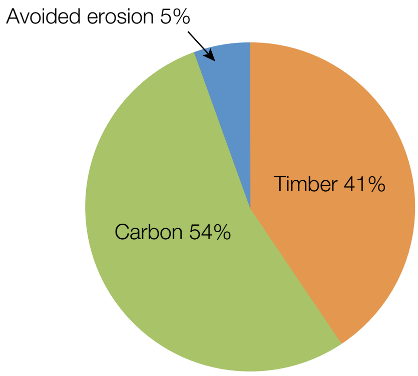

Figure 4: Distribution of ecosystem service values in the estate

An indication of the contribution of each ecosystem service to the 'true' value of the forest by block can be seen when individual values for timber, carbon and avoided erosion are stacked (Figure 5). While all 20 forest blocks produced a profit, the proportion of timber profit for the blocks ranged from 23% to 53% of the total ecosystem value. This suggests that carbon and avoided erosion accounts for a significant proportion of the total ecosystem value. Avoided erosion is not a major contributor to the true value of Wenita forest estate as three-quarters of the forest blocks had avoided erosion values of less than 9%. However, avoided erosion values contribute more than 11% of the total value for four forest blocks (4, 17, 18, 19) situated in higher erosion areas.

The stacked columns depict the values of planted forests across all benefits. Having an idea of these values enables more targeted and informed decisions

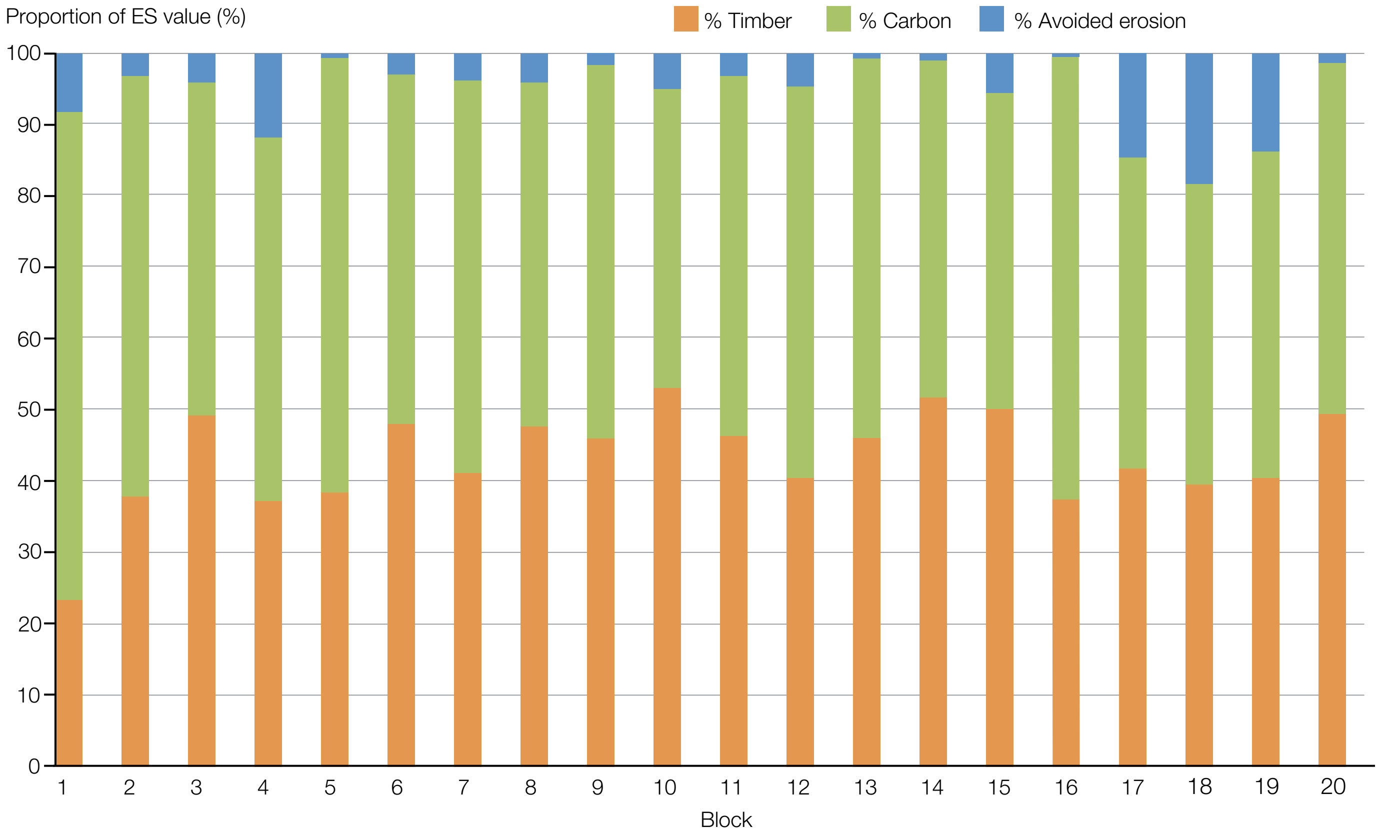

Figure 5: Distribution of ecosystem service values by forest block

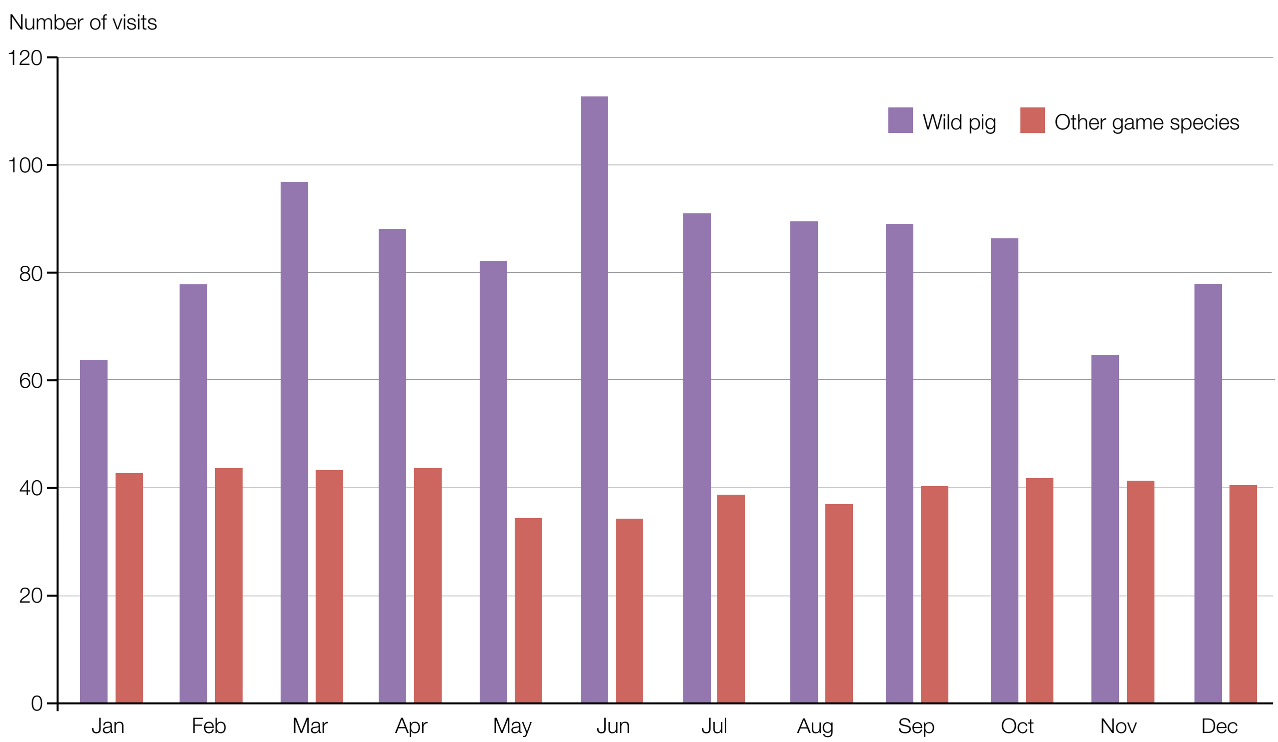

Figure 6: Average number of visits per month between 2014 and 2015

when it comes to managing the sustainable provision of ecosystem services and allocating scarce resources.

We also quantified the recreational hunting value of the Wenita forest estate using the company's recreational hunting permit database. Wenita offers recreational hunting access to registered hunters for a small fee that covers access to the hunting sites and administration costs. Wenita issues more than 200 hunting licences per year and more than half of the forest estate can be hunted.

Based on the Wenita's hunting database, around 3,000 recreational hunting visits took place in 2014 and 2015 (Figure 6), with pig hunting accounting for the majority of hunting visits. Pig hunters collected about 1,792 and 1,361 pigs from the forest estate in 2014 and 2015, respectively. Assuming each collected pig yielded an average of 20 kg of usable game meat for home consumption (and each kg has a value of about $7 based on the current price of pork chop at about $10–15/kg and the imputed hunter's meat processing cost of about $3–8/kg), the total meat value provided by the forest estate to hunters was $250,880 and $190,540 in 2014 and 2015, respectively.

Assuming that about half, or 15,000 ha, of the estate is classified as a pig hunting area, the value of pig hunting (based on meat value) is about $15/ha/year. This value corresponds well to the average game meat or bush meat value (converted to 2016 NZD) in the study by Naidoo and Rickets (2016). This value represents a conservative estimate of Wenita forest estate's game meat provisioning value.

In addition to the four ecosystem services described above for Wenita, other ecosystem services in the forest estate were identified, including general recreation, habitats for native birds, Māori cultural values and access to mānuka plots for honey production. This was done to acknowledge the other benefits that a planted forest estate provides to the general public and to demonstrate that the company is aware of, and responds to, its wider responsibility to society.

Conclusions and recommendations

We have observed a growing interest in integrating and using the ES approach by New Zealand government agencies, the forest industry and fellow researchers over the past five years. Government agencies at the national and local levels have recognised the importance of quantifying ES by commissioning Scion and other agencies to ensure those values get represented in policy discussions. The recent application of the approach to a forest estate is one of the first examples of a forest company of using an ES lens to view the multiple values provided by their production forest. The approach can be used as a tool to support planning that accounts for the environmental and community values in the forest estate to increase their recognition and inclusion in policy and investment discussions in the longer term.

The proportion of a forest's value derived from the production and sale of timber can be less than half of the total ES values provided by the forest. Estimated values from FIF for the Wenita forest estate suggest that the combined environmental value of carbon sequestration and avoided erosion is slightly higher than the sales profit from timber (Yao & Harrison, 2016). The Wenita forest estate also provides other important services including:

- Regulating services such as habitats for ecologically important species and pollination
- Cultural services that are valued by the forest users (recreational hunting and general recreation), the local and global communities (provision of habitats for native species), the iwi groups (Māori cultural values) and other industries (access to mānuka plots).

Taking into account that these other services have non-market values, the results suggest that overall the forest estate provides more non-market values (environmental and social benefits) than market values (economic benefits). This is consistent with the findings of other assessments of ES provided by forests (Dhakal et al., 2012; Grilli et al., 2015; Hein, 2011).

Estimating the value of non-market ES remains a priority. New spatial economic functions (e.g. avoided nitrogen leaching, biodiversity, recreation and water yield) are being developed for FIF, and future assessments of ES in existing and new forests will include estimates of those and other important values (Yao et al., 2016).

The recognition and representation of ES in policy and decision-making is vital given the role of ES in sustaining human society. Estimates or descriptions of the multiple values that an ecosystem provides will help in integrating social and environmental concerns with economic policy development. Quantified ES values, especially those that are less visible under current policy, can be better represented in cost-benefit analyses or the evaluation of different policy instruments (Barry et al., 2014). Decision-makers will be able to weigh the pros and cons of different courses of action and their impacts on the environment.

Incentives for afforestation is an apt example. There are various campaigns to plant more native and exotic trees on the part of New Zealand society and forest companies. Recognising and building on the multiple values which forests provide, and considering the recent increases in carbon and log prices, helps provide a strong case to support initiatives to increase the planting and replanting of trees. A successful campaign would contribute to sustained and enhanced ecosystem services from planted forests.

A fundamental change in the attitudes of individuals, organisations and society must occur for ES to become an integral part of economic modelling and policy. This fundamental change can be achieved by building on international, national and local ES initiatives as well as the growing interest to use the ecosystem approach. There is a need to effectively combine the most appropriate approaches and methods where the full value of an ecosystem can be adequately represented. With such a coupling, future ES research would be able to more effectively contribute to this shift in thinking where economics and policy consider the environmental, social, financial and cultural benefits and costs. Using an improved ES approach within policy that focuses on balancing the bottom lines of a mixture of land uses, including forestry, would contribute to more informed policy decisions that prioritise the need to maintain and sustain the provision of ecosystem services and become more aware about the limits of ecosystems across the landscape.

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