USING AN ECOSYSTEM SERVICES APPROACH TO ASSESS THE COST OF SOIL EROSION AND HOLISTIC VALUE OF SOIL CONSERVATION IN HILL COUNTRY

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Abstract
Resource management in many countries is exploring more closely the use of an ecosystem services approach to inform policy development and engage community. This paper describes a methodology to operationalize a natural capital-ecosystem service framework to:

- quantify and value the ecosystem services lost from a sheep and beef grazed pasture following a land slide erosion event,
- characterise the recovery of the provision of ecosystem services in the years following the land slide,
- quantify and value the ecosystem services from a grazed pasture following the introduction of wide-spaced trees as part of a soil conservation scheme to limit erosion.

It then uses this methodology in a study area located on the East Coast of New Zealand, the Hawke's Bay that was affected by a heavy rain storm in April 2011, resulting in widespread shallow land sliding on hill slopes along a 250km coastal strip. Overall 43 km^2 (4,300 ha) of bare ground was found in the total area of 5900 km^2, largely in permanent pasture grazed by sheep and cattle.

The total value of the ecosystem services provided by a grazed sheep and beef pasture on uneroded flat and rolling land and steep land was $5,085 and $3,717/ha/yr, respectively. Following an erosion event, the total value of the services provided by the steep land dropped by 64%. Recovery of services after the erosion event was slow. After 50 years, recovery was at approximately 61% (in dollar value) of the uneroded land. Planting conservation trees to reduce the risk of soil erosion increased the total value of the services, 20 years after planting, of the resulting tree-pasture system by 23%. This approach provides new information to inform decision makers of the wider implications of an erosion event.

A traditional cost benefit analysis of soil conservation shows planting trees isn't profitable unless the trees are harvested for timber, and low discount rate (<5%) is used. Inclusion of the value of the extra provision of ecosystem services provided by the trees, in addition to the reduced risk of soil erosion, resulted in the Net Present Value of the investment greatly positive regardless of the discount rate (0-10%). This study addresses a real conservation issue and shows how an ecosystem services approach can be integrated to advance existing governance frameworks and to provide a more complete economic analysis for decision makers.

Introduction

In New Zealand, Regional Councils are responsible for the management of natural resources and are increasingly under pressure from the general public to deliver high environmental standards. Soil loss and degradation from farm land is still a significant issue in a number of regions of the country. Over the last 50+ years, investment from central regional government, in soil conservation has run into billions of dollars, with considerable amounts of resource invested in research, land resource inventories, plant materials, preparation of soil conservation farm plans, provision of information on sustainable land management practices and advice, encouragement for self-regulation by farmers, through to financial incentives to facilitate uptake and adoption of sustainable practices on erosion-prone land. Soil conservation policies aim to reduce the risk of soil erosion in hill and steepland country, the downstream costs associated with nutrients losses and sediment loadings to waterways, and damage to productive farmland and towns.

Current evaluation of soil conservation policies by councils has a strong focus on quantifying the reduction in the amount of erosion and sediment lost and the impact on productive capacity and downstream community. Hawke's Bay Regional Council, is examining more holistic frameworks to quantify the effectiveness of their soil conservation investments and to inform future policy directions and investments.

In April 2011, the Hawke's Bay region was affected by a heavy rain storm which provoked landslides on hill slopes along a 250 km coastal strip. Following that storm, Hawke's Bay Regional Council used satellite imagery to estimate the proportion of land affected by landslides. Overall 43 km^2 of bare ground was classified from a total area of 5900 km^2, including 86% new (Jones et al. 2011). The cost to the Council of storm recovery was put at NZ$39 million. This included repairs for damage to infrastructure and land, personal and commercial damage claims. Following this event, the Council decided it was time to take their soil conservation policies to the next level, using the Kyoto protocol and carbon credits as an incentive for sheep and beef farmers on hill country to enter the scheme. However after carbon prices collapsed, this scheme was delayed until further information became available. As part of a wider analysis, the Hawke's Bay Regional Council then decided to commission AgResearch through an Enviro-link medium grant project to investigate an ecosystem services approach to estimate the environmental cost of the April 2011 storm, to evaluate the wider environmental and social benefits of soil conservation policy and finally, to assess the cost-efficiency of future investments into soil conservation through agro-forestry.

The study is based on a theoretical framework specifically developed to inform the provision of ecosystem services from soils (Dominati et al. 2010). Dominati et al. (2010) framework brings together Soil Science and Ecological Economics concepts to inform the connection between soil natural capital stocks, land use, management and the provision of ecosystem services (Daily et al. 1997; Barrios 2007; Palm et al. 2007; Robinson & Lebron 2010; Robinson et al. 2012; Wall 2012; Robinson et al. 2013; McBratney et al. 2014). That framework was combined with above ground ecosystem services frameworks (MEA 2005; TEEB 2010) to cover all aspects of soil conservation. The ecosystem services studied include the provision of food, wood and fibre, the provision of support for human infrastructures and farm animals, flood mitigation, the filtering of nutrients and contaminants, the decomposition of wastes, net carbon accumulation in soils and trees, nitrous oxide regulation, methane oxidation, pollination and the regulation of pests populations.

Method

To quantify the provision of ecosystem services from sheep and beef farms on hill country, information from existing tools supporting planning in the region was used, including monitored soil quality indicators (Taylor et al. 2010), land use capability classes maps (Lynn et al. 2009) and the OVERSEER® Nutrient budget (https://secure.overseer.org.nz/live; Wheeler et al., 2008). Neoclassical economic valuation techniques, including market prices, defensive expenditures, replacement cost and provision cost methods, were used to determine the economic value of each service (Hanley & Spash 1993; Pearce et al. 2006; Farley 2012). The study covered different aspects of soil conservation through the following steps:

- Quantification and economic valuation of the provision of ecosystem services from a typical East Coast hill country sheep and beef operation, to assess the baseline flows of ecosystem services under current land use, based on information from existing planning tools. The assessment was done for rolling and steep landscape units.
- Quantification and valuation of the provision of ecosystem services from eroded land to evaluate the loss of services compared to intact pastures on the steep landscape unit.
- Characterisation of the recovery profile of the provision of ecosystem services in the 20 years following a landslide based on soil recovery data (Lambert et al. 1984; Rosser & Ross 2011), to assess how far the provision of ecosystem services recovers, for the steep landscape unit.
- Assessment of the provision of ecosystem services over 20 years from the steep landscape unit planted with wide-spaced poplars for soil conservation, to see how trees impact on the provision of services.
- Cost-benefit analysis of an ecological infrastructure investment in soil conservation on steep hill pasture prone to erosion using an ecosystems services approach, to assess the return on investment from the soil conservation policy (Pearce et al., 2006) for the steep landscape unit.

Results and Discussion

The total value of the ecosystem services provided by a grazed sheep and beef pasture on uneroded flat and rolling and steep land was $5,085 and $3,717 /ha/yr, respectively (Figure 1). Regulating services, which are usually not considered in decision making, had an economic value four-times that of the provisioning services for the rolling landscape unit and almost six-times greater for the steep landscape unit (Figure 1).

Following an erosion event, the total value of the services provided by the steep landscape unit dropped by 64% to $1,299/ha/yr. Recovery of ecosystems services after the erosion event was slow. After 20 years, the provision of ecosystem services recovered 52% of uneroded levels, and up to 62% (in dollar value) after 50 years.

Planting conservation trees on pasture on Land Use Capability (LUC) Class 6 and 7 land to reduce the risk of soil erosion increased the total value of the services by 23% from $3,717/ha/yr to $4,568/ha/yr after 20 years (Figure 1).

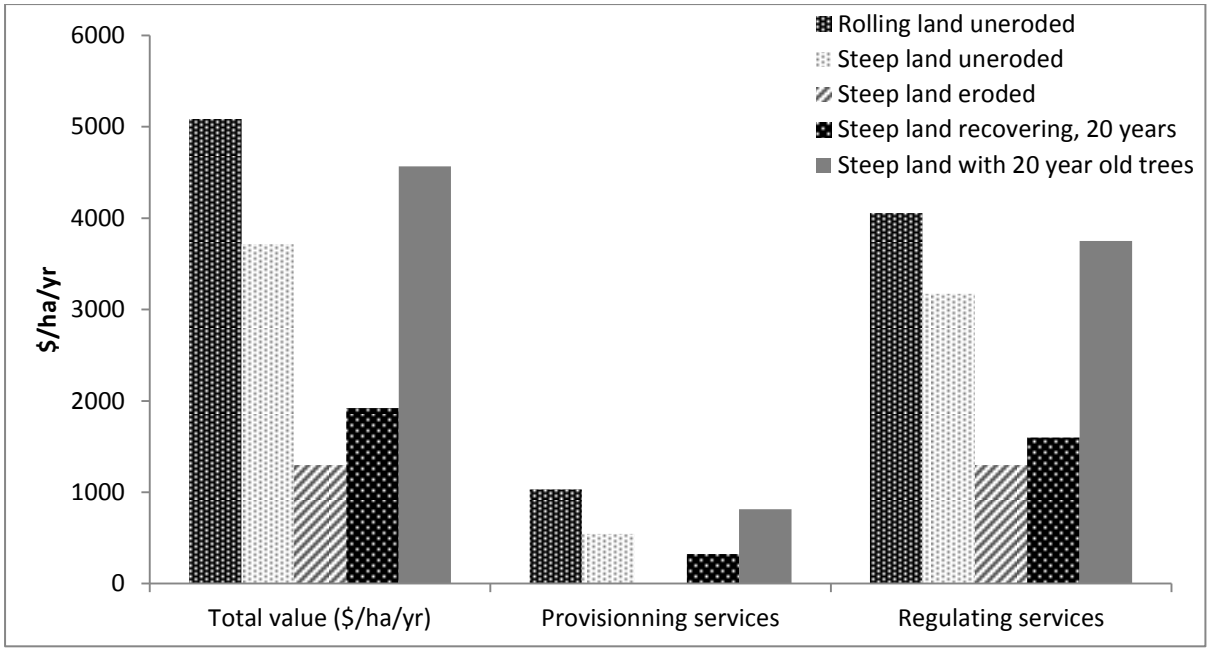

Figure 1: Value of annual flow of ecosystem services ($/ha/yr) for a sheep and beef operation before erosion, immediately after erosion, following 20 years of recovery, and with 20 years old wide spaced trees.

A traditional cost benefit analysis of soil conservation shows planting trees isn't profitable unless the trees are harvested for timber, and low discount rate (<5%) is used. However, inclusion of the value of the extra provision of ecosystem services provided by the trees, in addition to the reduced risk of soil erosion, the Net Present Value of the investment is greatly positive, regardless of the discount rate (0-10%).

Conclusions

This study shows how an ecosystem services approach can be **integrated and used on the ground to advance existing governance frameworks** to solve resource management challenges. Understanding how current investments in built capital and current and future investments in ecological infrastructure are likely to change the flow of ecosystem services from managed landscapes is critical to assess the efficiency, cost-effectiveness and sustainability of resource management policies, and to increase political and public awareness of the value of land.

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