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ASSESSING IMPACTS OF USING NATIVE SHRUBS ON THE SHEEP AND BEEF HILL COUNTRY FARMS IN NEW ZEALAND: A BIOECONOMIC MODELLING APPROACH

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Abstract

New Zealand hill country sheep and beef cattle farms contain lands of varying slope types, which influence herbage productivity and livestock carrying capacity. Unmanaged steep slopes are most vulnerable to soil mass movement, which negatively effects the environment and the socio-economy. Planting browsable native shrubs can potentially offer management options including erosion control, biodiversity restoration, supplementary fodder, and income from carbon credits. An established bioeconomic whole farm model was used to simulate an average East Coast region hill country sheep and beef farm with an area of 564 hectares (ha) of which, 60% was allocated to sheep. Native shrubs were planted on 10% of the farm (56.4 ha), on the steep slope on the land allocated to the sheep. A 20% annual planting rate was compared with the status quo of no native shrubs (0%) planted. Impacts on the sheep production system and the farm economics over a 50-year period were evaluated. Farm economic analysis was tested at two discount rates (5% and 7%). Planting native shrubs compared to the status quo, resulted in a 7.1% decrease in farm feed supply resulting in 11.6% reduction in annual average flock size. Reduction in flock size led to a 6.2% and 4.8% decrease in the status quo sheep flock annual mean income at 5% (NZ$ 29,464) and 7% (NZ$ 22,271) discount rates, respectively. On average, modelled shrub carbon income using the current carbon price of NZ$ 65 per New Zealand Emission Unit (NZU) was NZ$ 9,076 and NZ$ 6,599, which was 39.7% and 25.5% higher than the shrub establishment expenses at 5% and 7% discount rates, respectively. Overall, the combined flock and native shrub discounted cash operating surplus (COS) was 6.0% and 2.7% higher for native shrubs planting than the status quo at 5% (NZ$29,464) and 7% (NZ$ 22,271) discount rates, respectively. The Net Present Value (NPV) was higher for native shrubs planting at 5% and lower at a 7% discount rate, compared to the status quo. The study shows planting native on 10% of the farm on the steep slope, at a 20% annual planting rate, can be profitable.

Introduction

Hill country in New Zealand is defined as land below 1000 meters containing slopes greater than 15° and this land type account for approximately 37% of the farmed area (Kemp & Lopez, 2016). The slopes across hill country farms differ, but are generally a mixture of low (<7°), medium (8 to 20°) and steep (>21°) slope classes (Hodgson et al., 2005). Land use and productivity varies with slope; low and medium slopes are mainly planted with improved pastures, while less grazable steep slopes may be used for grazing or utilized for plantation forestry with the non-utilisable portions allowed to revert to native vegetation (Basher et al., 2016; Morris & Kenyon, 2014). Even with improved pastures, low herbage production on the steep slopes limits their use for grazing, often with a carrying capacity of less than eight stock units per hectare (Kemp & Lopez, 2016).

Native vegetation on the hill country sheep and beef farms represents approximately 12% of the national indigenous floral cover (Norton & Pannell, 2018). The low native vegetation cover resulted from clearance for pasture expansion in the early 1900s, which led to loss of native biodiversity and exposed some hill country to the vulnerability of soil mass movement and environmental degradation (Kemp & Lopez, 2016). Attempts to mitigate soil mass movement in hill country have utilized spaced exotic species such as poplars (*Populus* spp) and willows (*Salix* spp) (Eyles, 2010) and land use change to plantation forestry with radiata pine (*Pinus radiata*) (Basher, 2013). Poplars and willows are comparatively easy to establish, have deep and expansive roots that stabilize steep slopes (Basher, 2013; McIvor & Douglas, 2012), can supply valuable fodder (Kemp et al., 2003) and if well-spaced can provide carbon trade income (Ministry for Primary Industries, 2017), but they are deciduous and management intensive (Charlton et al., 2006). Plantation forestry can provide erosion control and income from carbon trade and sale of logs, but their monoculture limits biodiversity, understorey grazing, and can result in accelerated erosion during and after harvesting if not replanted (Basher et al., 2016).

An alternative to exotic species is the use of native trees and shrubs which are endemic and adaptable to New Zealand conditions (Norton & Pannell, 2018). Additionally, native plants are culturally valued, can enhance biodiversity restoration, control erosion, improve landscape aesthetics, provide income from carbon trade, and can be a potential source of fodder to livestock (Norton & Pannell, 2018). However, knowledge on the management of cultivated native shrubs in New Zealand and their role in erosion control, fodder production and their nutritive value for livestock, and the economics of establishing them on the hill country sheep and beef farms is lacking (Beef+Lamb NZ, 2018). Bioeconomic modelling of establishing native shrubs on the hill country sheep and beef farms using the limited literature data available can provide these insights.

Hill country sheep and beef farms are complex and dynamic systems consisting of biophysical, social and economic components, which interact and influence farm sustainable use and profitability (Farrell, 2020). Models integrating both biophysical and economic components, commonly referred to as bioeconomic models, are more robust in evaluating impacts of changing farming practices or applying a new intervention (Flichman, 2011). Therefore, the objective of this study was to use an existing bioeconomic whole farm model to simulate an average East Coast region hill country sheep and beef farm and compare the impacts of converting 10% of the farm on steep slope allocated to sheep to native shrub.

Methods

Model structure

A whole-farm system dynamics bioeconomic model (Fig 1) was developed in STELLA Architect version 1.9.3 to represent a North Island hill country sheep and beef enterprise in New Zealand based on the model of (Farrell et al., 2019). The model consisted of biological components (shrubs, feed, sheep), physical component (land) and economic component (sheep economics). The model simulations assessed changes in feed, sheep numbers, and cash flow dynamics for 50 years with and without a portion of the farm (up to 10%) planted in native shrubs over a 5-year period.

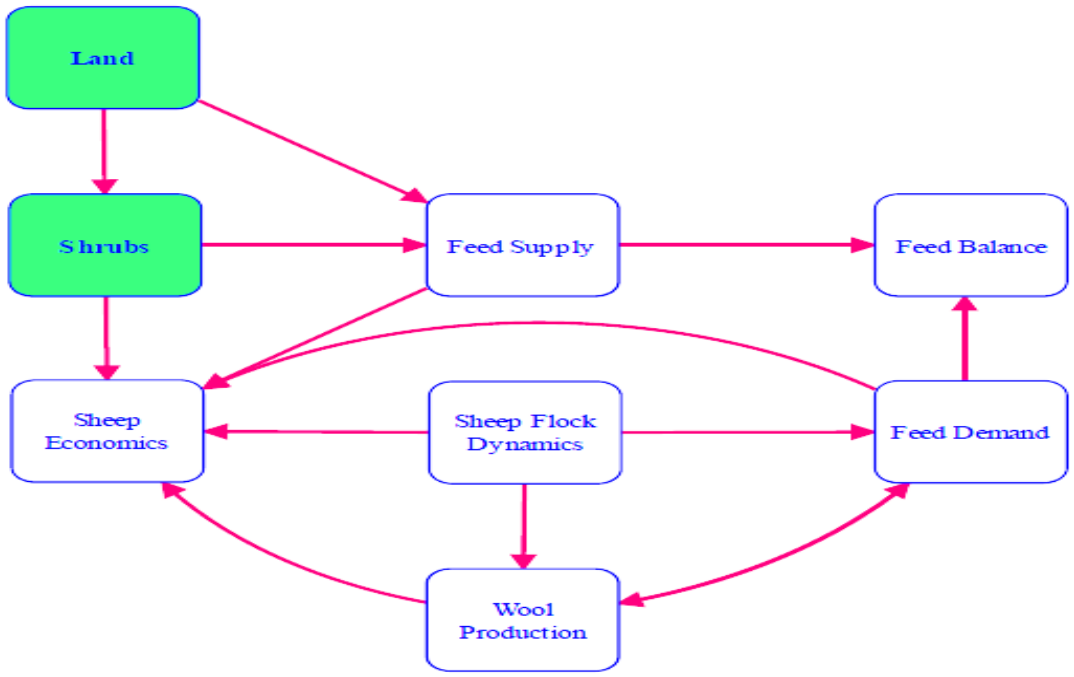

Figure 1. Simplified East Coast hill country sheep and beef whole farm bioeconomic model

Parameters used in model simulations

The parameters used to run the model simulations are shown in table 1. An average farm with an effective land area of approximately 564 ha in the East Coast region of New Zealand (Beef+Lamb NZ, 2020a) was used as the archetype for the North Island Hill country farm. The East Coast region of New Zealand was chosen due to the dominance of hill country terrains (Lambie et al., 2018), the region also accounts for approximately 50% of the North Island sheep population (Beef+Lamb NZ, 2020b) and was the base region for the existing bioeconomic model of (Farrell et al., 2019). Based on published data, the slope types of the modelled North Island hill country sheep and beef farm were grouped into; low (<12°), medium (13 to 25°) and steep (>25°) slope classes (López et al., 2003) to capture the critical slopes relevant to pastoral land use (Lynn et al., 2009) and pasture production (Burggraaf et al., 2018). Slope classes were apportioned as 8.7%, 45.9% and 45.4% in the low, medium, and steep slope classes, respectively, and were used to reflect the average slope mix of East Coast hill country farms (Saggar et al., 2015, Table 2). The percentage difference in pasture production on the medium and steep slopes, relative to low slope, were based on (Kemp & Lopez, 2016) and calibrated to ensure the medium and steep slopes pasture production was 52.1% and 38.1% of the low slope, respectively, to enable the modelled farm to support flock numbers similar to those for a class 4 hill country farm on the East Coast

region of New Zealand (Beef+Lamb NZ, 2020a). The model assumed that approximately 10% (56.4 ha) of the total effective land area of the farm would be used for planting native shrubs and was assumed to be part of the steep slope (>20°) portion of the farm.

An annual native shrub planting rates 20% was applied to mimic the likely land use change scenarios that can occur with establishment of native shrubs. The 20% planting rate assumed the 56.4 ha set aside for planting native shrubs was divided into five portions that were planted consecutively over five years. When no native shrubs were planted, a 0% native shrub was used in the model.

Table 1 Parameters used to run the model simulations.

Description	Parameter	Units
Farm characteristics	Productive farm size	564 hectares (ha)
	Flock size	2,747 Ewe
Slopes characteristics	Medium	45.9% (258.9 ha)
	Steep	45.4% (256.1 ha)
Livestock land use	Beef cattle	40% (225.6 ha) fixed
	Sheep	60% (338.4 ha)
Simulations	Annual shrub planting rate	0% and 20%
	Discount rate	5% and 7%
	Carbon price/ NZU	NZ$ 65.00
Browsing period	Start	5 years after planting
	End	5 years after start browsing

Results and Discussion

Farm feed supply

Annual feed supply in MJ ME remained constant for 0% native shrubs but had a staggered decrease in the 20% native shrub planting rates before levelling off after 14 years. The initial decrease in the 20% native shrub planting rates was highest due to the greater areas being removed per year from grazing. The long-term reduction in annual feed supply for both planting regimes (21.58 million MJ ME) compared to the base model (23.23 million MJ ME) was 7.1%. The lower mean annual feed supply for 20% planting rates, compared to the 0% rate was due to a reduction in pasture production area on the steep slopes and the restricted period of browsing for the shrubs between years 5 and 10 post planting. The reduction in feed supply resulted in 11.6% reduction in annual average flock size.

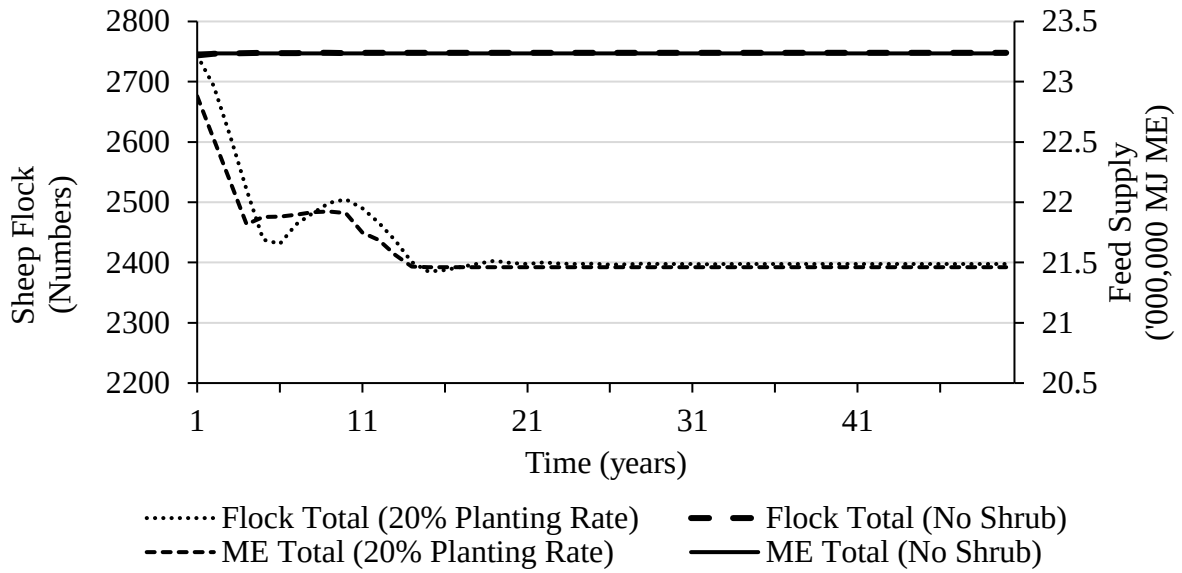

Figure 2. Annual feed supply for 50 years in metabolizable energy (million mega joules) and changes in flock numbers with native shrubs planted on 10% the modelled farm at 20% per year compared to status quo with no shrubs.

Farm economic analysis of establishing native shrubs

The modelled farm economic analysis undertaken focused on the sheep enterprise, because it was assumed that investing in native shrubs on 10% of the farm only affected sheep feed supply, hence flock size causing changes in sheep enterprise cashflow. In the model, capital used to invest in the establishment and maintenance of the native shrubs was sourced internally from the sheep enterprise proceeds. Reduction in flock size led to a 6.2% and 4.8% decrease in the status quo sheep flock annual mean income at 5% (NZ$ 29,464) and 7% (NZ$ 22,271) discount rates, respectively. On average, modelled shrub carbon income using the current carbon price of NZ$ 65 per New Zealand Emission Unit (NZU) was NZ$ 9,076 and NZ$ 6,599, which was 39.7% and 25.5% higher than the shrub establishment expenses at 5% and 7% discount rates, respectively.

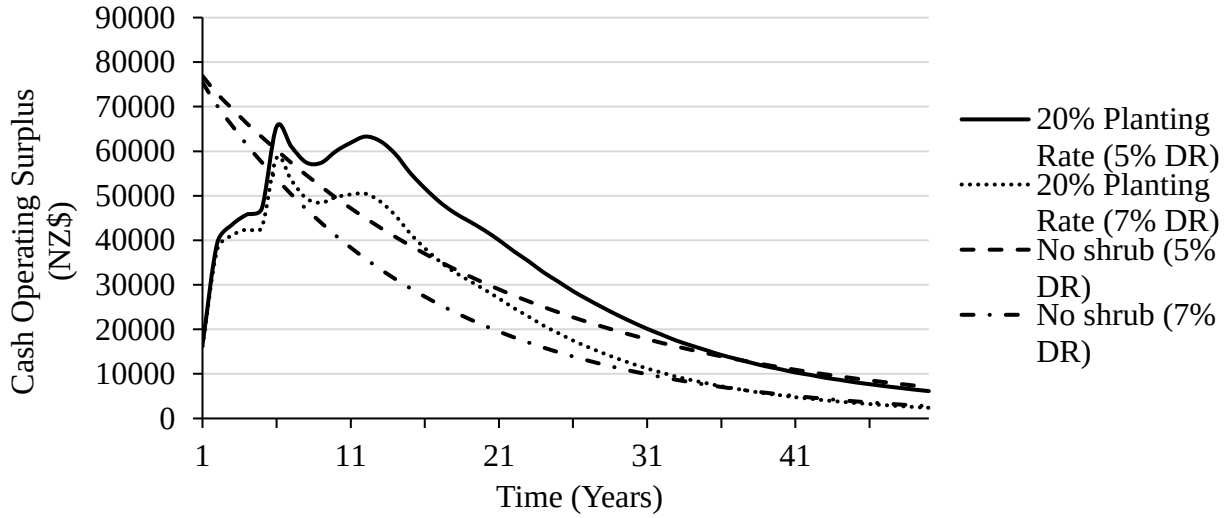

Figure 3. Annual farm cash operating surplus at 5% and 7% discount rates (DR) with and without conversion of 10% of farm to shrubs at 20% annual shrub planting rate.

Overall, the combined flock and native shrub discounted cash operating surplus (COS) was 6.0% and 2.7% higher for native shrubs planting than the status quo at 5% (NZ$29,464) and 7% (NZ$ 22,271) discount rates, respectively. The Net Present Value (NPV) was higher for native shrubs planting at 5% and lower at a 7% discount rate, compared to the status quo.

Conclusion

Planting browsable native shrubs on 10% of the farm on the steep slope caused a decrease in feed supply and disproportionate reduction in flock size. The decrease in feed supply led to reduction in flock size which caused a lowered flock income. However, the lowered income from sheep enterprise was compensated and exceeded by native shrub carbon trade income at the modelled price of NZ$ 65. Therefore, planting native on 10% of the farm on the steep slope, at a 20% annual planting rate, can be profitable.

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