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WILL REMOVAL OF GRAZING INCREASE SOIL CARBON STOCKS ON MULGA LANDS?

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ABSTRACT

Soil carbon and ground cover were measured in 2005 on two sets of 24-year-old multiple grazing exclosures at "Croxdale", a Queensland Department of Primary Industries & Fisheries (QDPI&F) research station near Charleville in south-west Queensland. Each trial consisted of three plots: (1) fully exclosed; (2) domestic stock exclosed and macropods able to graze; and (3) domestic stock and macropods able to graze. Total ground cover had changed little since measurements in 1985, although grass cover had significantly declined. The dominant component of total ground cover was mulga litter with small contributions from grasses and cryptogams. Soil carbon contents, to a depth of 30 cm, significantly differed between sites. More soil carbon was present in the fully exclosed sites than in areas grazed by macropods or macropods and domestic stock. The average soil carbon content in the fully exclosed plots was 8.2 t/ha greater than in plots exposed to grazing from macropods and domestic stock with much of the change being confined to one replication. The increase in soil carbon mainly occurred at depths between 10 and 30 cm. Simulation modelling suggests that the magnitude of measured changes may be due to a combination of reduced grazing and ongoing soil erosion in continuously grazed areas.

INTRODUCTION

Recently, management of carbon stocks and biodiversity have become key issues for the Mulga lands, not only in Queensland but across Australia. There is, for example, the possibility that increases in carbon content, as a result of modifying management of these grazing systems, may be traded as carbon credits and thus represent a new source of income for landholders (Harper et al. 2003). Any changes in carbon stocks due to de-stocking need to be quantified before assessing any economic value to be gained by carbon trading or including changes in grazing land management in national carbon accounts.

In 1981 two grazing exclusion sites were established on hard mulga sites on the Department of Primary Industries' (DPI) Croxdale research station located near Charleville. This was a component of a project, Mulga Lands Condition Study. The original aim of the experiment was to provide objective evidence of the effects of livestock and macropods on the stability of hard Mulga lands. In this paper we report on changes in carbon content after 24 years.

METHODS

In October 2005 each of the three plots at two sites were sampled for cover, tree basal area and soil carbon, 24 years after initial exclosure. Each site has three plots 50mx 50m with the following treatments: (1) complete exclosure (1.8m marsupial netting with no grazing allowed); (2) partial exclosure (5 plain wire fence, excluding sheep and allowing grazing by macropods); and, (3) control (un-exclosed, normally grazed by sheep and macropods). The two exclosure sites on Croxdale were labelled X1 and X2 with X1 being furthest from the Charleville to Quilpie road. Treatments were labelled NONE (no grazing), ROO (macropods but no domestic stock, ALL (all animals graze). In each plot, five (east to west) transect lines parallel to the fence were established at 5, 15, 25, 35 and 45 m from the northern fence line of each plot. Cover components were estimated at 50 points along each transect line using a line intercept method for under storey cover components and a GRS densitometer for determination of over storey foliage cover. Means and standard errors were calculated for each of the six plots. Stand level tree basal area (at 1.5 m) was determined for each plot using an optical wedge at 10-15 locations. A large factor wedge was used to avoid including stems from trees outside the plots. Tree biomass was calculated using the stand biomass to stand basal area ratio calculated by Burrows (1976). Leaf litter was collected from 10 randomly placed 0.25 m^2 quadrats in each plot and bulked to a single sample for mass and carbon content determination. Litter included all components, including sticks of diameters less than 25 mm. Samples were dried at 65°C for 48 hours for moisture determination.

Soil samples were collected at 5 points in each transect line and were collected at 4 depths, nominally 0-5 cm, 5-10 cm, 10-20 cm and 20-30 cm using a 50 mm diameter core sampler hammered into the ground for the first three depths and a standard soil auger for the 20-30 cm increment. For the sample depth of 20-30 cm complete sampling by corer or auger was impossible due to the large number of rocks in the 5->100 mm size range and samples were taken to 30 cm only where possible. Soil core samples were bulked for each transect and depth increment. All soil samples were weighed and sieved to 2 mm and sub-sampled for soil-moisture determination at 105°C. Rock, roots and charcoal not passing the 2mm sieve were collected, weighed and sampled for soil moisture. Bulk density, rock (%), root (%) and soil moisture contents (%) were calculated for each sample increment with bulk density for 20-30 cm being estimated from rock content and bulk density of the layers above. Carbon and nitrogen analysis were determined by the Dumas combustion method using a Leco elemental analyser following fine grinding of a sub-sample to 0.5 mm. Carbon amounts were calculated from bulk density and carbon concentration. Carbon dynamics of the site were simulated using the CENTURY model Version 4.4 (Parton *et al.* 1987) with the model being calibrated to the fully exclosed treatments. Parameters for modelling Mulga growth were obtained from Burrows (1976).

RESULTS

In 2005 there was little grass-based ground cover in any treatment due to prolonged drought (Fig. 1). Litter cover from mulga was similar to amounts recorded three years after the trial commencement (Fig. 2). Grazed plots had the least litter cover indicating removal of tree litter by grazing animals, with 1315, 1230 and 940 kg/ha for NONE, ROOS and ALL treatments. Mulga recruitment occurred only in the ungrazed plots indicating that both macropods and sheep can remove mulga seedlings. Significant tree death was seen in the ungrazed plots and was probably due to drought following thickening of the mulga stand.

The soil carbon content in the de-stocked treatment was higher than in the grazed plots and averaged 5.2 t C/ha more than plots grazed by macropods only and 4.5 t C/ha greater than plots grazed by domestic stock and macropods. However, there was significant variability in the grazed treatments as indicated by the large standard errors (Fig. 3). Soil carbon content was variable between sites and some of the variability may have been due to differences in soil texture with site X1 being less clayey than site X2 (13% vs. 16% clay). Soil carbon change (NONE – ALL) was greatest, at 4.1 t C/ha, in the 10-20 cm layer; and 2.4 t C/ha at 20-30 cm. There was with little difference in the top 10cm. If other below ground C stocks (coarse charcoal and root material from grass and trees) are also considered, the difference between treatments is greater with the NONE treatment containing 8-9 t C/ha more carbon than the grazed treatments.

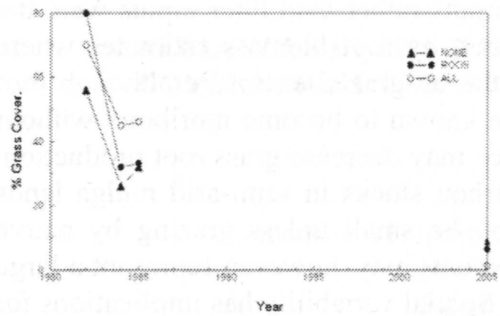

Figure 1: Change in grass cover 1982-2005

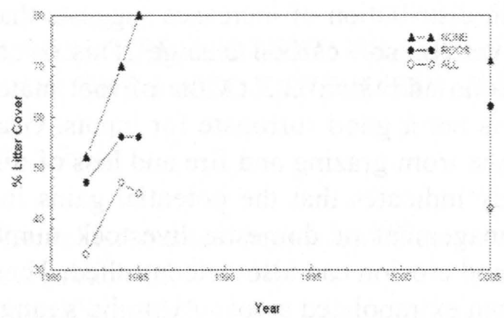

Figure 2: Change in litter cover 1982-2005

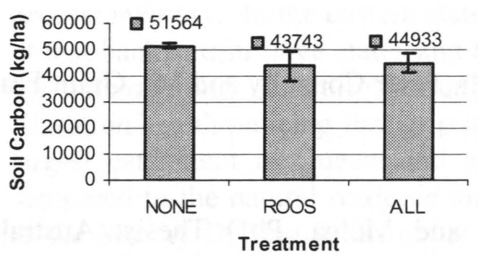

Figure 3: Average soil carbon (0-30cm) by treatment and standard errors

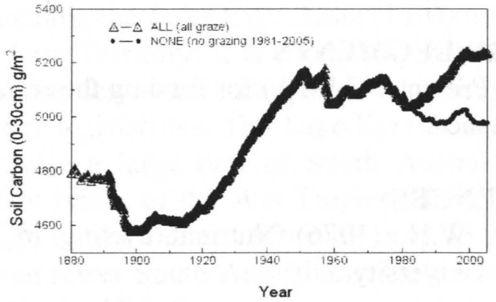

Figure 4: Simulation of soil carbon in NONE and ALL treatments of exclosure 1

Simulation modelling suggested that maximum soil carbon gains in the top 30 cm due to reduced grazing are in the order 2.0-2.4 t C/ha and are similar in magnitude to decadonal variability (Fig. 4). However, these changes are less than the simulated trends due to fire reduction and woodland thickening, which are about 8 t C/ha for soil carbon and 10 t C/ha of tree carbon over 100 years. The measured changes in soil carbon content due to change in grazing regime is similar in magnitude to those occurring following tree clearing. Average losses for mulga clearing at 8 sites was 3.7 t C/ha (Harms *et al.* 2005). Losses after clearing may be partly attributed to an increased proportion of primary production being consumed, loss of mulga litter cover and canopy cover causing soil warming, and changes in the fine root stock collected with the soil. If we hypothesise that the major effect of clearing is increased consumption of primary production and loss of surface cover, then it could be inferred that removal of grazing and re-growing mulga in cleared mulga lands could store from 2 to 4 t C/ha of soil carbon to a depth of 30 cm.

DISCUSSION

There is little reported information of the impact of grazing on soil carbon contents in the mulga lands of Queensland. Reports by Mills *et al.* (1989), Dawson (1982) and a symposium "The Mulga Lands" (Sattler, 1986) do not specifically address issues of soil carbon in the landscape. Mills (1989) reports the relative carbon and nitrogen contents to a depth of 1 cm in eroded and non eroded soils, these being 39% and 45%, respectively. There is no quantification of what this means in terms of mass at the landscape scale where presumably some carbon is being stored in sediments deposited in drainage lines. Reports from a series of domestic livestock exclosures established between 1966 and 1984 that simply excluding domestic livestock did not lead to significant regeneration of desirable species or a reduction in shrubs still seems to hold true. Variability between plots in our study is significant with the X2 plots having on average 8.3 t C/ha more C than plot X1.

The depth distribution of increases suggests that root inputs rather than litter inputs were the main driver for soil carbon change. This is corroborated by root biomass estimates where there was an additional 3.3 t C/ha of root material in the un-grazed exclosure although root biomass is not a good surrogate for inputs. Grasses are known to become moribund without disturbance from grazing and fire and loss of disturbance may decrease grass root production. This study indicates that the potential gains in soil carbon stocks in semi-arid mulga lands from management of domestic livestock numbers may be small unless grazing by native animals and erosion can also be controlled. These increments may, however, represent a large value when extrapolated across Australia's rangelands. Spatial variability has implications for project scale accounting as sampling needs to account for repositioning of carbon in the landscape, and the costs of adequately sampling changes in carbon may outweigh the value of this new commodity.

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