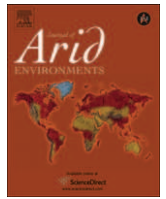




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## Below-ground carbon stocks in intact and transformed subtropical thicket landscapes in semi-arid South Africa

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## ABSTRACT

The feasibility of restoring subtropical thicket using carbon markets is largely a function of its carbon sequestration potential. We measured below-ground carbon stocks and analysed soil properties in intact, degraded and old agricultural landscapes in Baviaans Spekboom Thicket – a highly degraded thicket type earmarked for restoration. Soil and root carbon stocks to a depth of 110 cm in intact thicket were  $93 \pm 7$  (SE)  $\text{t ha}^{-1}$  and  $11 \pm 2 \text{ t ha}^{-1}$ , respectively. Degraded thicket had approximately one-third of the soil ( $31 \pm 2 \text{ t ha}^{-1}$ ) and one-quarter of the root ( $2.7 \pm 0.3 \text{ t ha}^{-1}$ ) carbon of intact thicket. Old agricultural lands had approximately half of the soil ( $42 \pm 4 \text{ t ha}^{-1}$ ) and quarter of the root ( $2.6 \pm 0.3 \text{ t ha}^{-1}$ ) carbon of intact thicket. Soil carbon stocks in topsoil were constrained at low concentrations of extractable K ( $<0.5 \text{ mmol}_c \text{ kg}^{-1}$ ), Mg ( $<1 \text{ mmol}_c \text{ kg}^{-1}$ ), Ca ( $<12 \text{ mmol}_c \text{ kg}^{-1}$ ) and extractable P ( $<40 \text{ mg kg}^{-1}$ ), suggesting that carbon sequestration will be strongly influenced by soil nutrient content. Restoration of Baviaans Spekboom Thicket stands to sequester  $70 \pm 8 \text{ t ha}^{-1}$  of below-ground carbon – an amount rivaling sequestration potentials in degraded mesic forests.

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### 1. Introduction

Despite a long association with large, indigenous herbivores, subtropical thicket in the Eastern Cape, South Africa is surprisingly sensitive to injudicious goat pastoralism (Midgley, 1991; Stuart-Hill, 1992). Heavy browsing by goats transforms the dense, closed-canopy shrubland into an open savanna-like system over a period possibly as short as a decade (Hoffman and Cowling, 1990; Lechmere-Oertel et al., 2005). Of the 16,942 km<sup>2</sup> of solid (unbroken canopy) thicket (with a *Portulacaria afra* component), 46% has been heavily impacted and 36% moderately impacted by domestic herbivores; while only 1.8% and 0.5% have been transformed by cropping and urbanization, respectively (Lloyd et al., 2002). The degradation of thicket results in loss of biodiversity (Moolman and Cowling, 1994; Lechmere-Oertel et al., 2005), large losses of ecosystem carbon stocks (Mills et al., 2005), a reduction in soil quality (Mills and Fey, 2004) and a reduction in plant productivity (and hence herbivore carrying capacity) (Stuart-Hill and Aucamp, 1993). Degraded thicket in semi-arid environments does not recover naturally if livestock pressure is reduced. The degradation

is, however, not irreversible because the dominant plant in many intact thicket types, *P. afra*, grows from cuttings and consequently can be used to restore the vegetation structure (Mills and Cowling, 2006).

Restoration of degraded Sundays Spekboomveld (SSV) using cuttings of *P. afra* has been shown to sequester a surprisingly large amount of carbon for a semi-arid area: approximately  $70 \text{ t C ha}^{-1}$  in soil carbon alone over a 27-year period (Mills and Cowling, 2006). This amount of carbon capture makes restoration of this vegetation type financially attractive at present prices of carbon credits on international markets (Mills et al., 2007). Apart from SSV, there are 11 other thicket types dominated by *P. afra* (Vlok et al., 2003), which are suitable for restoration via dense planting of *P. afra* cuttings. The feasibility of restoring these other thicket types cannot, however, at present be determined because the quantity of carbon that could potentially be sequestered by restoration in these landscapes is unknown. Baviaans Spekboom Thicket (BST) in the Baviaanskloof Nature Reserve has been earmarked by the local conservation authority as a potential thicket type for large-scale restoration. Approximately 30,000 ha of the original 64,191 ha have been severely impacted by goat pastoralism and agriculture, and another 15,800 ha have been moderately degraded. Restoration of BST in the Baviaanskloof Nature Reserve would be highly desirable for the local conservation authority because it would restore ecosystem

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