Rate of Carbon Sequestration at Two Thicket Restoration Sites in the Eastern Cape, South Africa

Anthony J. Mills[1,2,3] and Richard M. Cowling[4]

Abstract

Ecosystem carbon storage in intact thicket in the Eastern Cape, South Africa exceeds 20 kg/m^2, which is an unusually large amount for a semiarid ecosystem. Heavy browsing by goats transforms the thicket into an open savanna and can result in carbon losses greater than 8.5 kg/m^2. Restoration of thicket using cuttings of the dominant succulent shrub *Portulacaria afra* could return biodiversity to the transformed landscape, earn carbon credits on international markets, reduce soil erosion, increase wildlife carrying capacity, improve water infiltration and retention, and provide employment to rural communities. Carbon storage in two thicket restoration sites was investigated to determine potential rates of carbon sequestration. At the farm Krompoort, near Kirkwood, 11 kg C/m^2 was sequestered over 27 years (average rate of 0.42 ± 0.08 kg C m^{-2} yr^{-1}). In the Andries Vosloo Kudu Nature Reserve, near Grahamstown, approximately 2.5 kg C/m^2 was sequestered over 20 years (0.12 ± 0.03 kg C m^{-2} yr^{-1}). Slower sequestration in the Kudu Reserve was ascribed to browsing by black rhinoceros and other herbivores, a shallower soil and greater stone volumes. Planting density and *P. afra* genotype appeared to affect sequestration at Krompoort. Closely-packed *P. afra* planting may create a positive feedback through increased infiltration of rainwater. The rate of sequestration at Krompoort is comparable to many temperate and tropical forests. Potential earnings through carbon credits are likely to rival forest-planting schemes, but costs are likely to be less due to the ease of planting cuttings, as opposed to propagating forest saplings.

Key words: biomass, carbon sequestration, *Portulacaria afra*, restoration, semiarid landscapes, soil carbon, thicket.

Introduction

Ecosystem carbon storage in the arid form of South African succulent thicket (Vlok et al. 2003), found in areas receiving 250–350 mm mean annual rainfall, exceeds 20 kg/m^2 (Mills, O'Connor, et al. 2003, 2005). This is an exceptional amount of carbon for a warm, semiarid region and is more akin to mesic forest ecosystems (Mills, Cowling, et al. 2005). In its untransformed state, xeric thicket has an almost complete cover of dense, relatively tall (3–4 m) evergreen vegetation and has a much higher biomass than would be expected under semiarid conditions (Lechmere-Oertel 2004; Mills, Cowling, et al. 2005; Lechmere-Oertel et al. 2005*b*). Much of the biomass comprises the succulent shrub *Portulacaria afra*, known locally as spekboom (Acocks 1953; Vlok et al. 2003). The vegetation has been used for farming goats since the early 1900s. Heavy browsing by goats has resulted in the loss of *P. afra*, which is highly palatable to livestock, and the transformation of thicket to an open "savanna." The transformed savanna comprises ephemerals and short-lived grasses (known locally as "opslag"), whose abundance tracks rainfall events, and scattered remnant trees (Hoffman & Cowling 1990; Lechmere-Oertel et al. 2005*b*). Approximately 45% of *P. afra*–dominated thicket in South Africa (5,519 km^2 out of a total of 12,624 km^2) has been altered in this manner (Lloyd et al. 2002).

Carbon lost as a result of degradation in the arid succulent thicket near Kirkwood, Eastern Cape was estimated to be approximately 4.0 kg/m^2 in soils to a depth of 500 mm and 4.5 kg/m^2 in biomass (above- and belowground) (Mills 2003; Mills, O'Connor, et al. 2005). Effective restoration of transformed thicket could be achieved by planting *P. afra* cuttings because this species propagates vegetatively in nature and takes root from cuttings rapidly (Swart & Hobson 1994). Restoration could potentially return greater than 8.5 kg C/m^2 to transformed sites, but the potential rate of return is unknown. Two lines of evidence suggest that return of carbon may occur faster than in other transformed semiarid systems. Lechmere-Oertel et al. (2005*a*) found that the leaf litter productivity of *P. afra* (0.45 kg m^{-2} yr^{-1}, dry matter [DM]) was similar to mesic forest systems, and Aucamp and Howe (1979) found that the net primary production of thicket was approximately 1.1 kg m^{-2} yr^{-1} wet aboveground biomass (0.45 kg DM m^{-2} yr^{-1} assuming a dry:wet ratio of 0.4). Benefits associated with restoration would include restoration of ecosystem services such as carbon sequestration, herbivore browse and flood control, the restoration of biodiversity, control of soil erosion, and the provision of jobs in

[1] Department of Soil Science, Stellenbosch University, Private Bag X01, Matieland 7602, South Africa.
[2] South African National Biodiversity Institute, Private Bag X7, Claremont 7735, South Africa.
[3] Address correspondence to A. J. Mills, email mills@sanbi.org
[4] Terrestrial Ecology Research Unit, Department of Botany, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa.