Soil carbon and nitrogen in five contrasting biomes of South Africa exposed to different land uses

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Accepted 12 November 2003

Stocks of soil C to a depth of 50 cm in untransformed, indigenous veld ranged from 21 t ha^{-1} in karoo to 168 t ha^{-1} in thicket and stocks of N ranged from 3.4 t ha^{-1} in karoo to 12.8 t ha^{-1} in grassland. Mean soil C in thicket (5.6%, 0-10 cm) was approximately five times greater than expected for a semi-arid region. Removal of vegetation due to cultivation, grazing or burning reduced soil C and N at all sites. Soil C under intact thicket was greater than at sites degraded by goats (71 vs 40 t ha^{-1}, 0-10 cm). Restoration of thicket could potentially sequester ~40 t C ha^{-1}. The sale of this sequestered carbon to the international market may make restoration of thousands of hectares of degraded thicket financially feasible. Soil C under plant cover was greater than in exposed soil in renosterveld (28 vs 15 t ha^{-1}) and in karoo (7 vs 5 t ha^{-1}). Parent material was also related to soil C content. In grassland, soil C was greater in dolerite-derived than sandstone-derived soils (54 vs 27 t ha^{-1}); and in bushveld it was greater in basalt-derived than granite-derived soils (28 vs 14 t ha^{-1} in unburnt plots). Annual burning in bushveld reduced soil C, particularly at the surface. Soil C in the 0-1 cm layer of unburnt plots was 2 to 3 times greater than in burnt plots.

Keywords: land use, sequestration, soil carbon, soil nitrogen, South African biomes

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Introduction

The increase in atmospheric CO_2 and associated concerns of global warming have turned the world's attention towards the global C cycle (Lal, 2001). Sequestering C into biomass or soil could buy time to address the problem but the production of biomass in a mostly semi-arid country such as South Africa is limited by available water. Consequently stocks of soil C per unit area in South Africa are typically lower than in temperate, mesic regions (Du Preez & Snyman, 1993; Du Toit & Du Preez, 1995; Schulze, 2000). Soil with a cover of vegetation tends to have more C than exposed soil because plants recycle C and they may suppress mineralisation by releasing antibacterial exudates (Theron, 1951; 1963), and reduce mineralisation catalysed by wetting and drying of the soil (Birch, 1958) by shading and cooling and by intercepting rainfall. Removal of vegetation by ploughing, grazing, browsing or burning reduces soil organic matter. Declines in C due to cultivation have been recorded in grasslands of the highveld (Du Toit *et al.*, 1994; Nel *et al.*, 1996) but the extent to which land use affects soil C in other South African regions is largely unknown. In this paper, soil C is examined in five contrasting biomes and stocks of soil C under vegetation, in open, bare soils and in soils exposed to a variety of land use practices (including cultivation, livestock husbandry, pastures, forestry and veld burning) are compared.

Materials and methods

Study areas

The study sites (Figure 1) were named after the characteristic natural vegetation types for each area as defined by Low & Rebelo (1996) and included: West Coast Renosterveld (renosterveld), Central Nama Karoo (karoo); Xeric Succulent Thicket (thicket); Moist Upland Grassland (grassland); and Mixed Lowveld Bushveld (bushveld). A summary of geographic features including climate, vegetation, geology, soils, and land uses is presented in Tables 1 and 2.

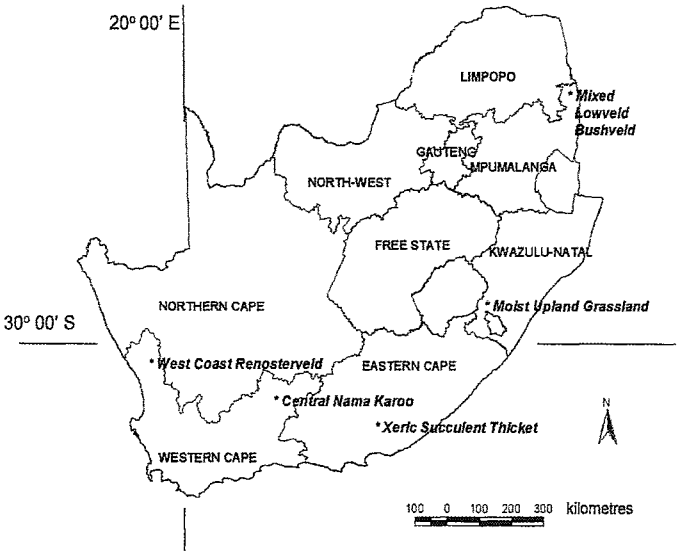

Figure 1 The location of the five study sites.

Sampling

Composite samples, comprising 15-20 subsamples, were taken at least 10 m apart with an auger to a depth of 10 cm as described below:

(a) **Renosterveld** - Dwyka sediment-derived soils were sampled from (i) open renosterveld i.e., on bare ground outside of bush clumps; (ii) below renosterbos bushes (*Elytropappus rhinocerotis* [L.f.] Less.); and (iii) old wheatlands planted to medic (*Medicago* spp.); and (iv) cultivated wheat fields. Dolerite-derived soils were sampled from (i) virgin veld and (ii) cultivated wheat fields. All sites were at least 500 m apart.