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Journal of Environmental Management 90 (2009) 384–395

Journal of Environmental Management

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Impact of land use on the biodiversity integrity of the moist sub-biome of the grassland biome, South Africa

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Received 8 September 2006; received in revised form 8 October 2007; accepted 30 October 2007
Available online 21 December 2007

Abstract

South Africa's moist grassland harbours globally significant biodiversity, supplies essential ecosystem services, supports crop and livestock agriculture, forestry and settlement, yet is poorly conserved. Ongoing transformation and limited opportunity for expanding the protected area network require instead that biodiversity conservation is 'mainstreamed' within other land uses. This exercise sought to identify the relative compatibility of 10 land uses (conservation, livestock or game ranching, tourism/recreation, rural settlement, dryland cropping, irrigated cropping, dairy farming, plantation forestry, and urban settlement) with maintaining biodiversity integrity. This was assessed using 46 indicators for biodiversity integrity that covered landscape composition, structure, and functioning. Data was integrated into a single measure per land use through application of the analytic hierarchy process, with supporting information gained from interviews with experts. The rank order of importance amongst indicators was landscape structure, functioning and composition. Consistent differences among land uses for all three categories revealed two clear groupings. Conservation, livestock or game ranching had the lowest impact and retained substantial natural asset, while that for tourism/recreation was intermediate. All other land uses had a severe impact. Impact on biodiversity integrity depended mainly on the extent of transformation and fragmentation, which accounted for the greatest impact on habitats and species, and impairment of landscape functioning. It is suggested that a strategic intervention for maintaining biodiversity integrity of moist grassland is to support livestock or game ranching and limit ongoing urban sprawl.

Keywords: Agriculture; Analytic hierarchy process; Ecosystem functioning; Forestry; Biodiversity indicator; Landscape; Livestock

1. Introduction

The grassland biome of South Africa harbours a rich species, community and ecosystem diversity (Reyers and Tosh, 2003). Its unique biodiversity features include globally significant centres of plant endemism (Cowling and Hilton-Taylor, 1997), half of the country's endemic mammal species, a third of its endangered butterfly species (Reyers and Tosh, 2003), and 10 of 14 of its globally threatened bird species (Lombard, 1995). Grassland is one of the most poorly maintained biomes in southern Africa because 23% is under cultivation, 60% is irreversibly transformed, only 2% is protected, and most of the remaining natural area is used as rangeland for livestock (Fairbanks et al., 2000). Although grasslands provide essential ecosystem services for economic development, this biome also supports a large human population whose resource demands have serious environmental implications that threaten its biodiversity (Reyers and Tosh, 2003).

Although the moist eastern region supports a greater share of the biome's biodiversity, it is also the region most transformed by agriculture, forestry, and urbanisation (Reyers and Tosh, 2003). Land uses in this region differ in their impact on plant (Venter et al., 1989; O'Connor et al., 2003; O'Connor, 2005; Walters et al., 2006) and animal (Rowe-Rowe, 1982;

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doi:10.1016/j.jenvman.2007.10.012

Samways and Moore, 1991; Samways and Sergeev, 1997; Armstrong et al., 1998; Davis et al., 1999) composition and diversity, and on ecosystem functioning (Du Toit and Du Preez, 1995; Dickens and Graham, 1998; Dye, 2000; Mills and Fey, 2004; Mills et al., 2005). These studies are insufficient for assessing the relative impact of different land uses because they have compared only a few land uses or a limited number of response variables.

Since South Africa's democratic elections in 1994, biodiversity conservation has been pursued against a backdrop of political and social change. Sustainable development was adopted as a guiding principle for environmental management through legislation (Environment Conservation Act, Act 73 of 1989) and the environmental rights of citizens have subsequently been included in the Bill of Rights in the Constitution of South Africa (section 24 of the Constitution, Act 108 of 1996). The National Environmental Management Act (Act 107 of 1998) and amendments to this Act currently provide the foundation for decisions regarding land use in this country.

South Africa's grassland biome encapsulates much of what confronts biodiversity conservation in the developing world: ongoing land transformation to serve economic development and limited opportunity for increasing the area of protected land. An option is to 'mainstream' biodiversity conservation in production and development landscapes (Pimentel et al., 1992). This requires knowledge of the relative impact of different land uses which can assist in strategic conservation planning and decision-making regarding development applications in the context of the country's legislation. The aim of this study was to assess the relative impact of the main land uses in the moist grassland biome on its biodiversity integrity.

Table 1
Definition and description of the main land uses of the moist grassland sub-biome

Land use: definition	Description
Conservation estate: proclaimed reserves whose objective is biodiversity conservation.	Context. Derived mostly from livestock ranches over past 50 years. Norm. (i) Low stocking rate (Short et al., 2003). (ii) Fire used. Natural asset. All except infrastructure.
Livestock ranching: ranching of livestock (mainly cattle, also sheep) on extensive farms under private tenure.	Context. Historical norm since European settlement about 100 years ago. Norms. (i) Property comprises 70% natural grassland and 30% pastures. (ii) Rotational grazing at recommended stocking rate (O'Reagain and Turner, 1992). (iii) Fire used (Tainton, 1999). Remaining natural asset. Rangeland, wetland, and riparian.
Game ranching: ranching of wildlife on extensive farms under private tenure.	Context. Derived from livestock ranches over past few decades. Norms. (i) Pastures retained. (ii) Same stocking rate as livestock ranching. (iii) Selective grazers. Remaining natural asset. As for livestock ranching.
Tourism-recreation: private/public properties providing tourist and recreational facilities.	Context. Diverse land use derived mainly from livestock ranches over the past decade or so. Norms. (i) Greater amount of infrastructure and disturbance. (ii) Increased number of water impoundments. (iii) Less grazing and burning of natural asset. Remaining natural asset. Less than livestock or game ranching.
Rural settlement: areas under communal tenure used for living and subsistence agriculture.	Context. Settled over 100 years ago but people concentrated in 1960s under apartheid legislation. Norms. (i) Total area divided about a third each for housing, croplands, and rangeland. (ii) No services. (iii) Maize is the main crop. Little use of fertilizer or pesticides. (iv) Up to threefold higher stocking rates than commercial farms (Tapson, 1993). Remaining natural asset. Rangeland, riparian, permanent wetland.
Dryland cropping: rain fed crops grown for market plus livestock on unplanted areas.	Context. Practised if arable soils comprise a sufficient proportion of a property. Norms. (i) Maize is main crop. (ii) Extensive use of fertilizer, herbicides and pesticides. (iii) One crop per annum. Remaining natural asset. Non-arable grassland, often rocky, wetland and riparian.
Irrigated cropping: irrigated crops grown year round for market.	Context. Requires sufficient area of arable soils and access to perennial water. Norms. (i) Greater variety of crops than dryland cropping. (ii) Intensive use of fertilizer and poisons. (iii) Livestock not kept. Remaining natural asset. Non-arable grassland, often rocky, wetland and riparian.
Dairy farming: milk production for markets.	Context. Requires sufficient area of arable soils and access to perennial water. Norms. (i) Total area divided into 1/4 summer pastures, 1/3 irrigated winter pastures, 1/4 crops, and 1/5 remains natural. (ii) Grassland burnt annually and grazed heavily. (iii) Extensive dams or river abstraction for irrigation. Remaining natural asset. Non-arable grassland, often rocky, wetland and riparian fragments.
Plantation forestry: alien *Pinus*, *Eucalyptus* and *Acacia* species grown (corporate, private) for timber.	Context. Derived mainly from livestock ranches over past 30 years. Norms. (i)80% of property planted on a 5–25 year rotation. (ii) Slash burnt. (iii) Extensive road network. Remaining natural asset. Wetlands, poor soils, power-line servitudes and firebreaks.
Urban: settlement configured as an urban core and peri-urban fringe.	Context. Mostly expansion of historical nodes with some new nodes appearing. Norm. Town of about 50,000–100,000 inhabitants. Remaining natural asset. Untransformable habitats (wetlands, riparian, rugged hills).