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Do ecological networks in South African commercial forests benefit grassland birds? A case study of a pine plantation in KwaZulu-Natal

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ABSTRACT

Grasslands in South Africa have been extensively transformed and fragmented, but are poorly protected. Commercial afforestation poses a particular threat to grassland biodiversity because areas suitable for forestry coincide with those supporting the greatest richness of endemic and threatened biota. To comply with international forestry standards, commercial timber growers leave "ecological networks" of interconnected open corridors within plantations: however, the value of these networks for conservation is unclear. This study investigated how bird community composition, richness and density were influenced by habitat extent, connectivity and quality in a grassland ecological network in a forestry plantation in KwaZulu-Natal, South Africa. We surveyed birds and measured local vegetation characteristics throughout the network. There were at least five open habitat types within the network and bird communities responded clearly to differences between these habitats: all network communities showed a distinct shift away from those typical of control grasslands. There were three distinct groups of species in the network: (1) grassland specialists, (2) habitat generalists and (3) non-grassland species. Grassland specialists were restricted to areas that are burned regularly and to large, contiguous open areas or wide grassland corridors. We found no evidence for the importance of physical connectivity among open habitats for birds in the study area. Instead, it appears that the establishment of so-called ecological networks at this scale has created much unsuitable habitat for grassland specialist species. We suggest consolidation of open areas and a rotational, biennial burning regime as a more appropriate management strategy for commercial plantations in these *Critically Endangered* montane grasslands.

1. Introduction

Grasslands in South Africa cover approximately 16.5% of the country's land surface, primarily on the high central plateau (Neke and du Plessis, 2004). Grasslands contain the majority of the country's human population as well as the most productive land for agriculture. As a result, they have been extensively transformed and fragmented. As of 2004, only about 53% of the biome remained in a "semi-pristine" state, contained mostly in livestock farms and rangelands (Neke and du Plessis, 2004). South Africa's grasslands harbour many threatened and endemic species, but they face increasing risk of transformation into pastures, crops and timber plantations (Reyers et al., 2001; O'Connor, 2005). Among the Global 200 ecoregions, South African montane grasslands are listed as *Critically Endangered* (Olsen and Dinerstein, 1998). Despite this, only 1.6% of the grassland biome in South Africa is formally protected (Neke and du Plessis, 2004).

Globally, commercial afforestation is a rapidly growing (and often overlooked) threat to biodiversity (Brokerhoff et al., 2008). This is especially true when it replaces unforested vegetation types such as grassland and steppe (Buscardo et al., 2008; Lantschner et al., 2008). Fragmentation of grasslands by artificial forests is of particular importance because of the impermeable nature of the forest matrix for non-forest species (Murphy and Lovett-Doust, 2004). Afforestation poses a special threat to South African grasslands because the country's regions of highest grassland biodiversity overlap extensively with the most suitable areas for timber plantations (Allan et al., 1997; Neke and du Plessis, 2004). As of 2004, approximately 11,500 km^2 of grasslands (about 3.3%) had been cleared and planted with exotic eucalypts and pines (Neke and du Plessis, 2004). The extent of this land use change has largely escaped international attention.

Most major South African timber growers are compliant with the international standards of the Forest Stewardship Council (FSC), which aims to minimise the impact of timber production on local biodiversity (Forestry Stewardship Council, 2003). However, these standards are designed to prevent the exploitation of natural forests and have limited application in open habitats. In the

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absence of formal guidelines for grassland conservation, timber producers in South Africa generally achieve compliance by leaving approximately one-third of plantation lands permanently unplanted in "ecological networks" of interconnected open corridors (Jackleman et al., 2006). So-called "open" corridors in South African plantations are often comprised largely of riparian zones (where planting is prohibited), firebreaks and power-line cuts instead of relict grassland habitat (J. Scotcher, pers. comm.). There has been little evaluation of the effectiveness of these networks and their contribution to grassland conservation remains poorly understood (Pryke and Samways, 2003).

The use of ecological networks in conservation has been recently debated (see Boitani et al., 2007). In theory, networks comprise core habitat patches surrounded by buffer areas and connected by corridors to allow movement of organisms between patches. This model has become popular as a method for reducing negative impacts of habitat fragmentation by increasing the connectivity of natural systems (Boitani et al., 2007). However, fragmentation and connectivity are notoriously difficult to measure or define (see Tischendorf and Fahrig, 2000; Fahrig, 2003; Lindenmayer and Fischer, 2006). Evidence that corridors have a positive effect is scant and largely derived from modelled populations (see Sheperd and Whittington, 2006; Hoyle, 2007; but see also Nasi et al., 2008). Recent reviews of empirical studies find little advantage of increased connectivity or corridors (Fahrig, 2003; Boitani et al., 2007), and some evidence indicates that managing for connectivity can sometimes be inappropriate (e.g. Weldon and Haddad, 2005; Pascual-Hortal and Saura, 2006; Koopman et al., 2007). Consequently, some authors recommend disregarding connectivity in favour of maximising the total amount of untransformed habitat (see Fahrig, 2003). An alternative, "habitat paradigm" discounts landscape-scale attributes altogether and recommends improving local habitat quality (Armstrong, 2005). The ecological network model is only appropriate if connectivity among habitat patches advances conservation objectives beyond what can be achieved by conserving habitat area or quality alone. Currently, no ecological network has been experimentally validated (Boitani et al., 2007). Grassland networks in plantations provide an excellent opportunity to test the relative importance of habitat amount, connectivity and quality in transformed environments.

Previous work in plantation networks has focused on arthropods. For example, grassland networks function as habitat and movement corridors for butterflies (Lepidoptera), depending on their width and quality (Pryke and Samways, 2001). The level of disturbance in the networks (e.g. by cattle and non-native plants) also seems to be crucial in determining a corridor's suitability as butterfly habitat (Pryke and Samways, 2003). Bullock and Samways (2005) show that associations between arthropod communities and their host plants are maintained throughout grassland networks, and conclude that even narrow corridors have a high biodiversity conservation value. However, any real evaluation of a network's conservation value must account for multiple taxa operating at a variety of spatial scales and trophic levels.

Birds represent a useful taxon for evaluating the conservation value of grassland networks. At a broad scale, bird communities in South Africa are highly sensitive to changes in land use (Okes et al., 2008) and the responses of avian communities to afforestation have been particularly marked (Allan et al., 1997; Fairbanks, 2004). Species richness (Herkert, 1994; Hamer et al., 2006), abundance (Winter and Faaborg, 1999; Johnson and Igl, 2001) and reproductive success of grassland birds (Winter and Faaborg, 1999; Perkins et al., 2003) may all increase with increasing habitat patch size. However, the diversity and reproductive success of grassland specialists has been shown to decrease near habitat edges, suggesting that fragmentation may be more influential than patch area *per se* (Winter et al., 2000; Hamer et al., 2006). Other studies suggest that local habitat characteristics are most important for grassland birds (Bakker et al., 2002; Koper and Schmiegelow, 2006). In this study of an ecological network, we consider the relative importance of habitat area, connectivity and quality for grassland birds in an artificially afforested landscape in South Africa's mistbelt grasslands. Specifically, we address the question of whether this network satisfies its conservation aims and, if not, how its efficacy could be improved.

2. Methods

The study was conducted in Mondi-Shanduka's Gilboa Estate (29°25′S 30°30′E) and the adjacent Karkloof Nature Reserve in the midlands of KwaZulu-Natal (KZN), South Africa. Gilboa lies in the upper catchment of the Karkloof River, 1400–1800 m a.s.l. The plantation covers an area of approximately 5241 ha, about 1746 ha (33.3%) of which is designated conservation land making up the open area (ecological) network. Much of Gilboa's open area network consists of riparian zones, roads, firebreaks and power-line cuts. However, one larger patch of continuous grassland remains on Gilboa and is interconnected with the rest of the open area network. This large grassland patch is referred to as the Gilboa control site (Fig. 1).

The area receives high annual rainfall (800–1280 mm), mostly during summer, and temperatures range between −2 and 38 °C (Sandwith, 2002). The vegetation is classified as Drakensberg Foothill Moist Grassland (Mucina et al., 2005), and is characterised by patches of indigenous forest in a matrix of grasslands dominated by Red Grass (*Themeda triandra*) and containing an unusually high diversity of forbs (Sandwith, 2002).

We collected data during the breeding season (October and November) of 2007. Because of local differences in habitat structure, we were forced to use three different techniques for quantifying bird density. We used line transects wherever possible, this being the most efficient survey method in open areas where bird densities are low (Bibby et al., 2000; Buckland, 2006). A single observer using 10 × 25 binoculars walked at a slow, even speed for a distance of 100 m and recorded the species, group size and perpendicular distance to every bird seen or heard. Transect lines ran lengthwise along the centre of narrow corridors in the network, and, in more open control areas, were spaced at least 150 m apart to minimise pseudo-replication. Habitats that were heavily invaded by bramble (*Rubus cuneifolius*) were essentially impenetrable and could not be surveyed with line transects: in these habitats we used 10-min semi-circular point counts from the edge of the patch (see Fox and Hockey, 2007). In instances where bramble made line transects impossible but patches remained semi-accessible, we used point counts from the centre of the patch. All birds seen or heard at any distance from point count locations were recorded. Point counts were preceded by a 5 min relaxation period in which birds were allowed to habituate to the presence of the observer. We are fully cognisant that a mixed sampling design such as this is less than ideal. However, given that the majority of areas sampled were open (where transect sampling is appropriate), yet bramble patches of varying penetrability (where point counts are appropriate) were distinct elements in the landscape, we felt justified in adopting a mixed sampling approach and our analyses attempt to correct for potential biases emanating from this approach.

We surveyed birds between 07:00 h and 17:00 h on clear and overcast days when wind was mild or moderate. Care was taken to eliminate any sampling time bias within habitats, and there was no significant difference in sampling time across habitat types (one-way ANOVA, df = 4, $P = 0.18$). We placed transects opportunistically, choosing areas that were structurally homogenous and