Winter bird assemblages, species richness and relative abundance at a re-vegetated coal mine in the Middelburg district, Mpumalanga province, South Africa

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Winter bird assemblages, species richness and relative abundance were investigated at six re-vegetated sites within the Middelburg Coal Mine (Mpumalanga, South Africa) and compared with those for a site thought to be representative of un-mined biotope within the nearby Witbank Nature Reserve. Age of site since initiation of re-vegetation had little or no apparent effect on richness or abundance. Adjacency to currently active mining and variation in current land management practices appeared to have much more profound effects. Sites surrounded by active mining had lower richness and abundance. Those with 40% or more land left as fallow and strips of un-mowed grass as well as artificial ponds had higher bird richness and abundance.

Key words: bird assemblages, abundance, richness, re-vegetation, coal mining.

INTRODUCTION

Anthropogenic disturbances of natural vegetation due to agriculture and mining are widespread within South Africa (Tarboton 1997; Kritzinger & Van Aarde 1998; Jansen *et al.* 1999; Ratcliffe & Crowe 2001; Mangnall & Crowe 2003). Disturbance of grasslands is particularly important as these biotopes are ancient, complex and slow-evolving systems of diverse plant communities, that reproduce largely vegetatively rather than by seed production, with bulbous plants and climax grasses featuring strongly (O'Conner & Everson 1998). These systems include highland grasslands that are amongst the most threatened biotopes in southern Africa and have been assigned a high priority for conservation action (Macdonald *et al.* 1993). In total, 7750 km^2 of the grassland biome (2.2% of its total area) is currently formally conserved (Tarboton 1997). Grasslands generally lack the potential to recover after severe disturbance (Smit *et al.* 1997) and have been increasingly degraded by over-grazing with livestock (Tainton 1981; Hockey *et al.* 1988), extensive burning, forestry and invasion by alien plant species (Allan *et al.* 1997). Nevertheless, we know of no studies that have investigated the bird assemblages of degraded or re-vegetated South African grasslands.

Bird diversity and distributions are strongly influenced by vegetation composition and structure (Liversidge 1962; Wiens 1974; Folse 1982; Erdelen 1984; Knopf 1988). Therefore, investigation of avian diversity and abundance can provide an assessment of the status of rehabilitated sites, such as those that occur within areas previously exposed to coal mining (Morrison 1986). There are often a number of characteristic bird species within a biotope that are indicative of the status or stage of transformation of given biotopes (Wiens 1974). Since avian diversity is a key characteristic of natural ecosystems (Hoadley *et al.* 2002), identification of 'indicator' species can be used to assess the degree of recovery and level of change in habitat structure and/or functioning (Jansen *et al.* 1999). Further, Bibby (1999) maintains that birds are the clearest of all indicators of biodiversity trends.

In KwaZulu-Natal, South Africa, a study of the effects of re-vegetating coastal dunes after open-cast titanium mining near Richards Bay found changes in bird diversity with increasing age

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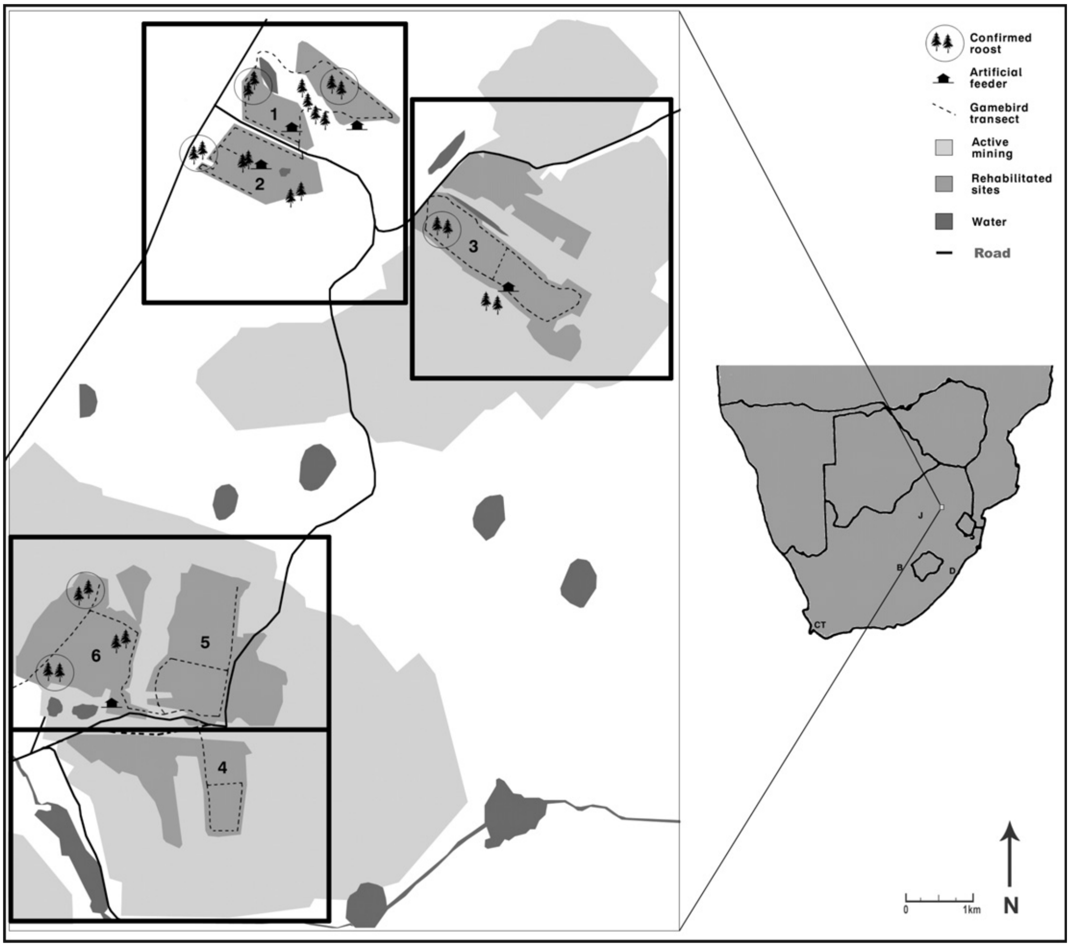

Fig. 1. Location of Middelburg Mine and study sites within the mine, including the relevant structural attributes of each.

since regeneration (Kritzinger & Van Aarde 1998). However, bird diversity and abundance did not necessarily increase with time, but rather there was a turnover in species as the vegetation progressed from grasses and shrubs through to mature coastal dune forest.

The present study is the first investigation at a South African coal mine of the effects on bird assemblages of re-vegetation following strip-mining. The primary objective of this study is to assess the effects of re-vegetation on winter bird species assemblages, species richness and relative abundance within re-vegetated sites mine at a coal in relation to those at an un-mined site within a nearby nature reserve.

Since the owners of the mine concerned are spending upwards of R20 million per annum on the re-vegetation of mined areas, it is desirable to assess the effectiveness of the current re-vegetation procedures using bird diversity as an indicator of habitat recovery. Furthermore, since up to 2000 km^2 of land on the Mpumalanga highveld could be subjected to coal mining, the future use of this vegetation type is uncertain.

METHODS

Study area

The primary study sites were within the Middelburg Coal Mine, situated between the towns of Witbank and Middelburg in Mpumalanga province, South Africa (Fig. 1). The mine covers an area of approximately 24 000 ha of which 4863 ha have been affected directly by mining activities. Initiation of open-cast coal mining in this part of South Africa dates back to the 1970s (Mentis 1999). The region receives an average rainfall of 720 mm per annum and lies at an altitude of

Table 1. Attributes of the six re-vegetated sites at Middelburg Coal Mine.

Site	Time since onset of re-vegetation	Estim. area (ha)	% Perimeter actively mined	No. of species observed	% Insectivores	% Granivores	% Shared with reserve
1	<6 years	80	0	36	45.16	72.22	70
2	>9 years	65	0	33	51.61	83.33	59
3	<4 years	100	90	26	35.48	66.67	47
4	>9 years	65	100	21	41.94	38.89	47
5	<3 years	60	100	16	38.71	22.22	34
6	<6 years	50	90	14	29.03	27.78	133
All	N/A	420	N/A	48	31	18	79
R	N/A	100	N/A	43	80.64	72.22	100

1500–1600 m above sea level. The predominant natural vegetation is Rocky Highveld Grassland (Low & Rebelo 1996) and Bankenveld interspersed with *Themeda* Veld (Acocks 1988).

Six sites of varying ages since the initiation of re-vegetation (pre-1995 up to 2001) and area (50–100 ha) were selected within the mine's boundaries (Table 1; Fig. 1). All sites have similar vegetation structure: grassland intermixed with bushes and, in some instances, trees. Hence visibility of birds was uniform across sites. All six sites (except site 2 that has never been mined) had been re-vegetated by leveling mined areas, replacing removed topsoil (400–1000 mm), fertilizing and re-seeding with a domesticated alien grass mixture: 22% Rhodes grass (*Chloris gayana*), 36% Smuts finger grass (*Digitaria eriantha*) and 42% Teff (*Eragrostis tef*). Once it was well established, this artificial grassland was mowed, bailed and sold by the mine. Sites 3–6 had active mining operations along at least three sides (Table 1). Site 3 had not been mowed recently and is predominantly mature seed-bearing grass. Site 4 had patches of unplanted land and strips of un-mowed grass creating edge habitat. All sites had trees (except sites 5 and 6), access to water, and patches of both mowed and fallow land. Of the re-vegetated sites, 1, 2, 3 and 6 had established trees, usually on slopes. Sites 1, 2 and 3 had considerably more (roughly 40–60% of area) land left as fallow land, while the remaining three sites had far less (roughly 25–40% of area). Sites 1 and 2 had artificial feeders to supplement the food of gamebirds.

To assess the extent to which bird diversity had developed, in the re-vegetated sites, towards that of typical un-mined vegetation, a site was chosen within the nearby Witbank Nature Reserve (Smit *et al.* 1997). The reserve is small (847 ha) and is situated on the transitional zone between the Rocky Highveld Grassland and the Moist Sandy Highveld grassland. Local birders and conservation officers advised that this site was the most appropriate habitat for the expected suite of bird species that would have occurred in undisturbed, un-mined biotope.

Bird surveys

Data collection was undertaken in mid-winter and thus cannot represent the situation for summer migrants and nomadic species. However, the data collected are relevant for taxa with a year-round reliance on the available resources (Tarboton 2001). Bird species sighted and abundance were recorded while walking fixed transects of 1.5–2.0 km in length through each study site, totaling 45 min of observer effort per transect. Waterbirds and raptors that were not directly utilizing the re-vegetated sites were excluded from counts. Line transects were chosen because of the topographical and vegetation uniformity and relatively large size (35–50 ha) of the sites (Mangnall & Crowe 2003). Weather conditions during surveys were stable (no rain, no severe winds or low temperatures) throughout the study period. Each site was traversed nine times: three times in the morning (before 10:00), midday (10:00–14:00) and afternoon (after 14:00), respectively. Birds were identified and counted on sight with the use of Zeiss 10 × 30 binoculars. Cloud cisiticola (*Cisticola textrix*) and wing-snapping cisticola (*Cisticola ayresii*) were lumped together due to difficulty in distinguishing these species from one another in the field. This same survey procedure was implemented at the un-mined site in the nature reserve. Assumptions discussed by Collinson (1985) were taken into consideration and methods suggested by Bibby *et al.* (1992) were used to avoid double

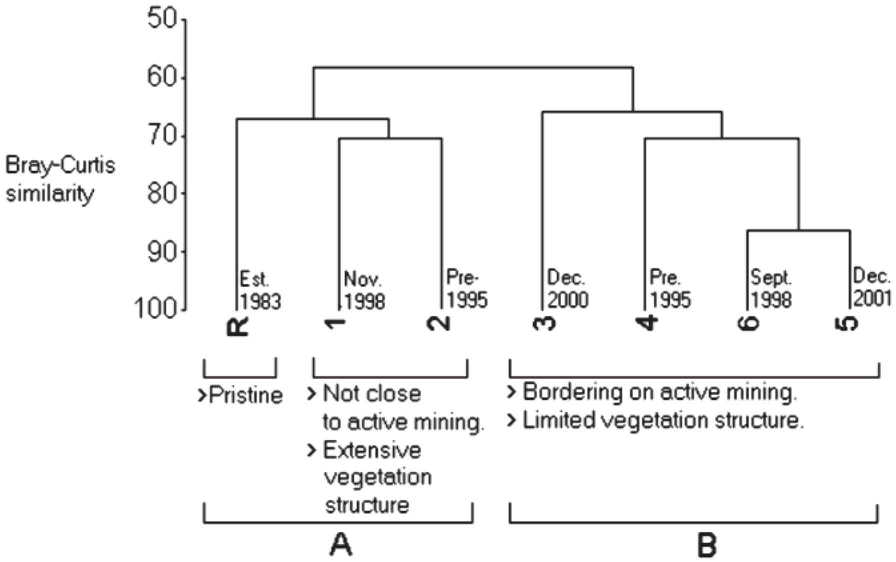

Fig. 2. Dendrogram of Bray-Curtis percentage similarities in bird assemblage structure between seven study sites. R is the reserve site, Witbank Nature Reserve, with conserved grassland. Dates of re-vegetation are indicated on the applicable branches.

counting. Counts of birds around artificial feeders were recorded for assessment of their potential influence, but these data were not included in primary analyses.

Statistical analysis

Data were analysed using the package STATISTICA 6.0. Student *t*-tests ($P < 0.05$) were used to determine any significant differences between the respective sites in terms of observed total species richness. In order to discover overall patterns of between-site avifaunal similarity, multivariate analysis of the bird species assemblages encountered at the transect sites and nature reserve were performed using the cluster analysis (CLUSTER) and non-metric multidimensional scaling (MDS) programs in the software package PRIMER 5.0 (Plymouth Marine Laboratory, U.K.). Between-site similarity was assessed using the Bray-Curtis similarity coefficient (Bray & Curtis 1957) and a cluster analysis dendrogram reflecting the hierarchical relationships of sites was produced using group-average linking. A two dimensional MDS ordination plot was used to represent these similarities in a non-hierarchical manner (Jansen *et al.* 1999). SIMPER, the method used by Kritzinger & Van Aarde (1998) was used to assess dissimilarity between sites and to identify species typical of, and contributing most to difference between, sites.

RESULTS

The results of the bird surveys are summarized in Appendix 1. Seventy-four percent of the species observed in the site within the Witbank Nature Reserve were observed in at least one site at the coal mine. Bird richness and abundance were significantly ($P < 0.05$) lower in sites surrounded by active mining (Table 1). Sites 1 and 2 had higher values for richness, 36 and 32, respectively, and very high abundances of particular species including helmeted guineafowl (*Numida meleagris*) in both sites and the African quailfinch (*Ortygospiza atricollis*) in site 2 (Appendix 1). These two species contributed most strongly to inter-site dissimilarity between these two sites and the others according to the SIMPER analysis (Appendix 2). Sites 4, 5 and 6 had comparatively low species richness, 21, 14 and 16 species, respectively (Appendix 1).

Of the 123 bird species likely to occur in the area (Harrison *et al.* 1997a,b), 57 (46.34%) (Appendix 1) were observed over the study period within all sites at the mine, of these 43 (75.44%) were observed in the un-mined site in the nature reserve, while re-vegetated sites 1, 2 and 3 combined had 46 (80.70%) species and sites 4, 5 and 6 had only 22 (38.60%). Relatively species rich (group 'A') and depauperate sites (group 'B' in Figs 2 & 3) had 28 species (49.12%) in common. Of the remaining species, 29 (50.88%) were observed in rich sites only and of these 10 (17.2%)

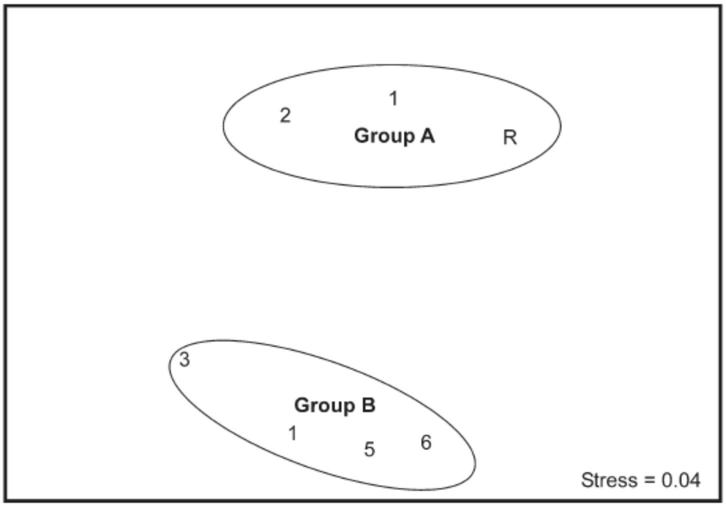

Fig. 3. Multidimensional scaling ordination between sites. R is the reserve site in the Witbank Nature Reserve, with conserved grassland.

were observed only in the protected site. Only two species, brown snake eagle (*Circaetus cinercus*) and mountain chat (*Oenanthe monticola*), (3.45%) were observed exclusively in depauperate sites (Appendix 1). Age of site seemed to have little or no effect on bird richness or abundance (Table 1; Figs 2 & 3). Sites re-vegetated prior to 1995 were located in both the depauperate ('B') and rich groups ('A'). Similarly, each of the two groups contained sites re-vegetated since 1998. The two most recently re-vegetated sites (3 & 5) both fell within group 'B'. They are most dissimilar in terms of species composition and abundance according to Bray-Curtis similarity analysis (Figs 2 & 3).

Sites 1 and 2, within which there were artificial feeders nearby the transects (Fig. 1), had relatively high counts for nine of the observed species and, on two occasions these species were seen at feeders only during that particular transect (Appendix 1).

Species richness was significantly ($P < 0.05$) higher in sites 1–4 than in sites 4–6. This supports the results reflected in the multivariate analyses, with a 58% similarity shown between groups 'A' and 'B' according to the Bray-Curtis similarity coefficient (Fig. 2).

DISCUSSION

Bird assemblages

As yet, there is no evidence to suggest temporal succession of bird assemblages within the associated habitat following re-vegetation at the Middelburg Coal Mine. This differs from the findings of Kritzinger & Van Aarde (1998) at a re-vegetated titanium mine in KwaZulu-Natal. Prevention of the establishment of natural grassland habitat may be hindered by competition from the fast-growing, alien grasses planted on re-vegetated sites, thus preventing re-colonization by birds common to undisturbed grassland (Mentis 1999). Furthermore, the succession of natural grasslands is a slow process that is extremely sensitive to anthropogenic disturbance (Acocks 1988). These results are not confounded by habitat structures such as water, trees and feeders as these are present on depauperate sites (Fig. 1) and presence/absence analysis (Appendix 2) reveals the same relationship as found when including abundance in the analysis.

The distinguishing factors that characterize the sites in terms of species richness, composition and relative abundance appear to be the proximity to active mining and physical management of the site. Key beneficial management features are dams and trees as well as the creation of edge habitat by leaving strips of tall grass and fallow land within, e.g. sites 1, 2, 3 and 4 (Table 1). Sites 4–6 are surrounded by active mining and harboured the lowest avian diversities. The overriding effect here is that large tracts of actively mined areas could act as deterrents to bird movement within and between these sites.

The current re-vegetation process may adversely affect insect populations/densities; this is reflected in the difference in insectivore species

Table 2. The typical species and those contributing most to the dissimilarity between the respective study sites. Sites 1 and 2 were re-analysed without helmeted guineafowl and African Quailfinch in order to assess the contribution of other species.

Reserve Typical spp.	Sites 1 and 2 Typical spp.	Site 3 Typical spp.	Sites 4,5 and 6 Typical spp.
Spike-heeled lark Long-billed pipit African quailfinch Cape clapper lark	Helmeted guineafowl Long-tailed widowbird African quailfinch (2) Crowned lapwing (1) Namaqua dove (2)	Orange-breasted waxbill African quailfinch Southern red bishop	Cape longclaw African stonechat Brown-throated martin
Contributors to dissimilarity	Contributors to dissimilarity	Contributors to dissimilarity	Contributors to dissimilarity
Southern red bishop Long-tailed widowbird	Helmeted guineafowl African quailfinch (betw. 1 and 2)	Orange-breasted waxbill African quailfinch	
Orange-breasted waxbill	*Analysis without helmeted guineafowl or African quailfinch* Southern red bishop Orange-breasted waxbill (2) Crowned lapwing (1) Common waxbill (1)		

presence between mine sites (25.81–51.61%) and the reserve site (80.64%). Insect numbers appear to be further depleted by the presence of active mining surrounding the given sites and acting as a barrier, this can be seen in Fig. 1 with sites 1 and 2 revealing the highest numbers of insectivores within the mine sites (45.16% and 51.61%, respectively) (Table 1). This could, however, be confounded by the high percentage of area left as fallow land in these sites. The high abundance of granivorous species at site 3 (Appendix 1), with the most abundant species being orange-breasted waxbills (*Sporaeginthus subflavus*), African quailfinches and southern red bishops (*Euplectus orix*) is perhaps a consequence of the nomadic nature of granivorous birds. This site had the highest proportion of un-mowed grasses and thus had an abundance of mature, seed-bearing grasses serving as an attraction for these birds (Ward 1971). The grouping of the sites into two assemblages (Figs 2 & 3) is supported by the low within-group dissimilarity values obtained in the SIMPER analysis (Appendix 2). These groupings are in accordance with proximity to active mining as well as vegetation structure and biotope diversity (Fig. 1).

Certain assemblages could be influenced by the presence or absence of trees within sites. These include birds such as various doves, chinspot batis and red-throated wryneck. For this reason it is suggested that the presence of established structure in the form of trees be encouraged within sites. These are also important roost sites for guineafowl.

Characteristic species

In natural systems, with the close association between avian assemblages and vegetation composition and structure, it is often found that a number of specialized species appear to be sensitive to disturbance of pristine habitats and surrounding areas (Jansen *et al.* 1999). Spike-heeled lark (*Chersomanes albofasciata*), long-billed pipit (*Anthus similis*), African quailfinch and Cape clapper lark (*Mirafra apiata*) emerged as the characteristic species of the reserve site (Table 2). These species are considered grassland specialist bird species (Harrison *et al.* 1997a,b) and were found only within well-re-vegetated (= rich) sites within the mine. Ten other species were found only in the reserve site; these include rufous-naped lark (*Mirafra passerina*), lazy cisticola (*Cisticola aberrans*), Shelley's francolin and Barrow's korhaan (*Eupodotis barrowii*). These species are all grassland specialists and were found at very low abundances within the reserve.

Sites 1 & 2 had helmeted guineafowl as both the typical species and the most contributing species to the dissimilarity of these sites compared to all other sites. This may stem from the moderate fragmentation within these sites and the presence of water and trees, essential requirements for guineafowl population success (Ratcliffe & Crowe 2001). Furthermore, the populations within these sites benefited from the presence of artificial gamebird feeders. With the removal of guineafowl from the analysis, the southern red bishop emerges as the most important contributing species with orange-breasted waxbill being of importance in site 2 only and crowned lapwing (*Vanellus coronatus*) and common waxbills (*Estrilda astrild*) of importance in site 1. The fact that three of the most contributing species within these two sites are granivorous is possibly due to the extensive edge habitat created by strips of tall grass. These sites are often mowed and have open bodies of water either in or around them that serve as a further attraction for these species. Sites 4, 5 and 6 were dominated by orange-throated longclaws (*Macronyx capensis*), stonechats (*Saxicola torquata*) and brown-throated martins (*Riparia paludicola*) (Appendix 2). These species were common to all sites and can be considered as robust within the analyses (Appendix 2). The reasons for this are unclear and would probably be a consequence of these three species not being sensitive to habitat transformation or generalist feeders not reliant on a specialized habitat.

CONCLUSIONS

The current re-vegetation programme is effective in resuscitating some, relatively low-level ecological processes that can attract and sustain a limited assemblage of birds. Once active mining ceases around the currently depauperate sites and land is managed with both habitat composition and structure in mind it is expected that they will improve considerably with regards to avian diversity and abundance. Currently, the post-disturbance land management practices influence system functioning and faunal diversity strongly. The formation of patches of burnt and unburned areas with varying levels of grazing form a fine-scale grassland mosaic that provides suitable habitat for a range of grassland species and thus encourages avian richness and abundance (Mentis & Bigalke 1981). Furthermore, areas with extensive edge habitats, due to this mosaic management, support greater avian species diversity than those without edge habitat (Ratcliffe & Crowe 2001). In addition, vegetation structure and the availability of different biotopes similarly support higher avian species diversities (Little & Crowe 1994).

However, it is unlikely that these areas will return to climax grasslands through oldfield succession. According to Roux's model, this will take many decades and will only commence once soil fertility within sites is diminished (Mentis 1999). Other potential future uses of this land are uncertain and are expected to be very limited due to soil compaction that occurs during replacement of topsoil. Suggested measures for the improvement of avian diversity within poor sites for future encouragement of diversity include the retention of grass and fallow land edges/strips within sites (as seen in site 1), encouragement of tree growth and establishment of new biotopes, such as dams. This increase in vegetation structure provides a structurally more complex habitat that can, potentially, accommodate a wider species assemblage and perhaps a greater abundance of individual bird species (Little & Crowe 1994; Ratcliffe & Crowe 2001).

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Appendix 1. Bird species (Sinclair & Ryan 2003) and total counts over the study period within each site. Values in brackets indicate counts directly associated with artificial feeders in sites 1 and 2. Groups A and B refer to Bray Curtis clusters (Fig. 2).

	Site							
Feeding guild / Species	R	1	2	3	4	5	6	Group
Carnivores								
Secretarybird, *Sagittarius serpentarius*	–	1	1	–	–	–	–	A
Black-shouldered kite, *Elanus caeruleus*	1	1	–	2	1	–	–	A & B
Brown snake-eagle, *Circaetus cinereus*	–	–	–	2	–	–	–	B
Kestrel, rock, *Falco rupicolis*	2	–	–	–	–	–	–	A
Marsh owl, *Asio capensis*	1	2	–	1	–	–	–	A & B
Omnivores								
Shelley's francolin, *Scleroptila shelleyi*	3	–	–	–	–	–	–	A
Swainson's spurfowl, *Pternistis swainsonii*	–	6	–	–	–	–	–	A
Helmeted guineafowl, *Numida meleagris*	24	406 (518)	457 (522)	–	–	–	–	A
Insectivores								
Hadeda ibis, *Bastrychia hagedash*	1	3	–	–	–	–	–	A
Barrow's korhaan, *Eupodotis barrowii*	2	–	–	–	–	–	–	A
Crowned lapwing, *Vanellus coronatus*	11	30	12	–	–	8	6	A & B
Blacksmith lapwing, *Vanellus armatus*	2	23	8	–	–	–	–	A
Red-throated wryneck, *Jynx ruficollis*	1	–	–	–	–	–	–	A
Rufous-naped lark, *Mirafra africana*	4	–	–	–	–	–	–	A
Cape clapper lark, *Mirafra apiata*	5	–	5	–	–	–	–	A
Spike-heeled lark, *Chersomanes albofasciata*	10	3	–	–	–	–	–	A
Red-capped lark, *Calandrella cinerea*	–	1	–	–	–	–	–	A
Brown-throated martin, *Riparia paludicola*	5	2	1	4	29	14	7	A & B
Mountain wheatear, *Oenanthe monticola*	–	–	–	1	7	1	–	B
Capped wheatear, *Oenanthe pileata*	–	–	1	–	–	–	–	A
Ant-eating chat, *Myrmecocichla formicivora*	1	1	1	–	1	–	–	A & B
African stonechat, *Saxicola torquata*	20	15	20	11	19	24	22	A & B
Zitting cisticola, *Cisticola juncidis*	22	17	36	14	18	14	11	A & B
Cloud cisticola, *Cisticola textrix*								A & B
Wing-snapping cisticola, *Cisticola ayresii*	31	14	27	21	18	3	4	A & B
Wailing cisticola, *Cisticola lais*	3	2	–	–	3	–	–	A & B
Levaillant's cisticola, *Cisticola tinniens*	26	7	–	3	11	3	1	A & B
Lazy cisticola, *Cisticola aberrans*	2	–	–	–	–	–	–	A
Neddicky, *Cisticola fulvicapilla*	2	–	–	–	–	–	–	A
Tawny-flanked prinia, *Prinia subflava*	3	6	–	1	2	2	–	A & B
Chinspot batis, *Batis molitor*	1	–	–	–	–	–	–	A
Cape wagtail, *Motacilla capensis*	–	–	1	–	–	–	–	A
Pipit, african, *Anthus cinnamomeus*	14	34	27	6	17	10	6	A & B
Long-billed pipit, *Anthus similis*	5	3	4	–	–	–	–	A
Cape longclaw, *Macronyx capensis*	34	31	40	25	24	27	17	A & B
Common fiscal, *Lanius collaris*	12	14	6	10	12	13	7	A & B
Bokmakierie, *Telophorus zeylonus*	1	–	–	–	–	–	–	A
Red-winged starling, *Onychognathus morio*	–	–	2	–	–	–	–	A
Granivores								
Speckled pigeon, *Columba guinea*	2	2	8	–	–	–	–	A
Red-eyed dove, *Streptopelia semitorquata*	–	7 (8)	–	–	–	–	–	A
Cape turtle-dove, *Streptopelia capicola*	28	7 (8)	9 (10)	1	3	3	8	A & B
Laughing dove, *Streptopelia senegalensis*	36	16 (43)	19 (28)	11	14	13	13	A & B
Namaqua dove, *Oena capensis*	–	2	11	3	–	–	–	A & B
Cape sparrow, *Passer melanurus*	10	4 (29)	36	4	3	7	2	A & B

Continued on p. 22

Appendix 1 (*continued*)

Feeding guild / Species	R	1	2	3	4	5	6	Group
Grey-headed sparrow, *Passer diffusus*	–	3 (9)	2 (5)	–	–	–	–	A
Cape weaver, *Ploceus capensis*	10	8	1 (29)	–	–	–	–	A
Southern masked weaver, *Ploceus velatus*	12	22 (29)	7 (89)	2	2	–	2	A & B
Red-billed quelea, *Quelea quelea*	–	–	5	7	–	–	–	A & B
Southern red bishop, *Euplectes orix*	99	8 (13)	73 (96)	34	8	–	–	A & B
Yellow-crowned bishop, *Euplectes afer*	10	–	4	4	–	–	–	A & B
Red-collared widowbird, *Euplectes ardens*	8	–	4	4	–	–	–	A & B
Long-tailed widowbird, *Euplectes progne*	78	19	21	24	1	9	2	A & B
Common waxbill, *Estrilda astrild*	–	27	–	–	–	–	–	A
African quailfinch, *Ortygospiza atricollis*	18	–	169	96	–	–	–	A & B
Orange-breasted waxbill, *Sporaeginthus subflavus*	30	12	43	319	–	–	–	A & B
Black-throated canary, *Serinus atrogularis*	5	–	–	–	4	–	–	A & B
Total counted	**591**	**286**	**493**	**610**	**197**	**151**	**108**	
Total species	**43**	**35**	**32**	**26**	**21**	**16**	**14**	

Appendix 2. SIMPER analysis results illustrating dissimilarity values between sites and those species contributing to these dissimilarities. Values in bold indicate significant differences in abundances between the sites.

Site	Average dissimilarity (presence/ absence)	Average dissimilarity Excl. 'A' & 'B'	Average dissimilarity (abundance)	Most contributing species	% Contrib.	*t*-test abundance
R & 6	43.66	68.58	70.45	Southern red bishop	19.96	**0.000694**
R & 5	44.55	61.42	63.59	Southern red bishop	20.84	**0.002344**
R & 4	38.33	57.66	59.9	Southern red bishop	19.16	**0.006955**
R & 3	41.42	61.42	62.85	Orange-breasted waxbill	38.13	0.968885
R & 2	34.88	35.99	57.19	Helmeted guineafowl	46.71	0.397391
R & 1	36.36	51.39	66.74	Helmeted guineafowl	50.67	0.615442
6 & 5	16.03	23.55	23.55	Cape longclaw	16.39	0.444664
6 & 4	32.45	39.02	39.02	Brown-throated martin	18.49	0.150148
6 & 3	34.67	74.6	77.99	Orange-breasted waxbill	56.96	0.134568
6 & 2	48.11	62.13	83.05	Helmeted guineafowl	48.57	0.062566
6 & 1	41.12	58.24	80.47	Helmeted guineafowl	66.16	0.146350
5 & 4	26.58	29.89	29.89	Brown-throated martin	14.42	0.500276
5 & 3	33.76	69.02	72.93	Orange-breasted waxbill	57.48	0.172547
5 & 2	49.77	58.55	80.61	Helmeted guineafowl	48.21	0.076223
5 & 1	42.16	49.4	75.2	Helmeted guineafowl	67.8	0.171132
4 & 3	35.59	66.53	70.51	Orange-breastedwaxbill	56.06	0.220618
4 & 2	48.12	55.7	78.4	Helmeted guineafowl	47.7	0.093209
4 & 1	40.18	46.49	72.69	Helmeted guineafowl	67.1	0.200697
3 & 2	43.7	53.78	62.45	Helmeted guineafowl	44.76	0.482184
3 & 1	45.29	65.85	80.07	Helmeted guineafowl (**B**)	43.86	0.678528
2 & 1	29.12	43.43	29.31	African quailfinch (**A**)	30.51	0.821980