

Summary

The coastal dunes north of Richards Bay (28°38'S 32°20'E) have been mined by the mining company RBM (Richards Bay Minerals) for heavy metals such as zircon, rutile and ilmenite (Van Aarde *et al.* 1996a). The regeneration of mined dunes through a rehabilitation programme directed at establishing indigenous dune forests resulted in the development of patches of dune vegetation of known age, collectively representing a successional sere of indigenous dune vegetation. Apart from the mining process itself, other disturbance factors (e.g. burning, grazing, clearcutting and logging) in the region have resulted in a series of patches of vegetation ranging from relatively undisturbed dune forests to unmined regenerating dune vegetation and grasslands. Some areas have been severely disturbed through clearcutting and comprise of almost no understorey, while other patches consist of a mixture of poorly maintained exotic timber species. Each of these patches of vegetation support bird assemblages, some of which may be atypical for the region. Some of these assemblages may comprise of species endemic to the region or may occur at relatively low numbers as a consequence of these man-induced habitat disturbances.

The development of the bird community of regenerating dune forests in my study area was associated with changes from species typical of grasslands to species typical of woodlands. Based on an earlier study (Kritzinger & van Aarde 1998), trends in species richness, species diversity and species composition along an age gradient of spatially separated sites, the development of these bird communities are similar to those recorded elsewhere along successional gradients. The present study compares age related changes in species composition, species richness and species diversity of the bird community during instantaneous sampling five years after the 1993/94 study of Kritzinger & van Aarde (1998) and is based on information collected during 1998/99. It also addresses the intermediate disturbance hypothesis as an explanation for trends in community variables noted for the region and investigates the contribution of rehabilitating habitats to regional diversity.

Line transects surveys were conducted on 16 sites in the study area, these representing a disturbance regime from relatively undisturbed forests to severely disturbed plantations dominated by poorly maintained exotic timber species. The sites regenerating in response to dune rehabilitation represented an area of intermediate disturbance. Surveys were done along fixed line transects and the number of lines surveyed in a given site depended on the area of the site. Transects were at least 200 meters apart to improve the independence of observations. Furthermore, the starting points of the lines at a particular site were randomised and surveyed for about four hours from half an hour to one hour after sunrise when the birds are most active and conspicuous. Surveys were conducted on a monthly basis from June 1998 to February 1999.

Data from each line transect were analysed using the computer program DISTANCE (Laake *et al.* 1993) to obtain estimates of total bird density ha^{-1} for each sampled site. The relative densities for each species on each sampling site were obtained by using the equation $rD = rN/rV$, where rD is the relative density, rN is the relative number seen (the number of a specific species seen relative to the total number seen on the transect) and rV is relative visibility (Buckland *et al.* 1992). Bray-Curtis similarities of fourth-root transformed species relative densities were calculated between every pair of sampled sites (Clarke & Warwick 1994).

The species richness, total density ha^{-1} , Shannon diversity index and Pielou's evenness index were calculated for each of the sites as the mean values of the transect lines. Rank-abundance and rarefaction curves were constructed for each sampled site as described by Tokeshi (1993) and by James & Wamer (1982) respectively.

The community composition was analysed through multivariate analyses. Non-metric multidimensional scaling (ordination) was used to map inter-relationships between the sampling sites in order to differentiate between bird assemblages. Also, the typical species on each sampled site and discriminant species among the sampled sites were analysed according to Clarke & Warwick (1994).

Species richness, diversity and evenness increased with regeneration age for both study years (1998/99 and 1993/94). The absolute values of bird community variables increased with site regeneration age and values for the post-mined regenerating coastal

vegetation converge in similarity towards those of an unmined relatively mature dune forest. Differences in the derived community structure for the two study periods were small.

Ordination techniques showed that regenerating grassland sites and the intermediately aged regenerating sites form distinct assemblages, while the assemblages on the rest of the regenerating sites were more similar to each other and to those of the mature forest sites. Although the trends recorded through the measured multivariate techniques for the different study periods were the same, differences in the densities of species resulted from seasonal effects.

Species compositions also changed from species typical of grasslands (pioneers) with r-selective traits towards more specialist species (frugivores and non-passerines) with K-selective traits on the older woodland regenerating sites as predicted by successional theory (Pacala & Rees 1998). These species were illustrated by the typical and discriminant species recorded from each site.

The second part of the study examines the intermediate disturbance hypothesis as a factor forcing regional trends in habitat specific species diversity, density and evenness. Community variables increased monotonically with a decrease in the extent of disturbance. Only total density showed peaked values at the intermediate stage of local vegetation regeneration within the intermediately disturbed area. The intermediately disturbed habitats produced the highest number of rare species, while the lowest numbers were recorded from severely disturbed areas. Typical species also declined monotonically from undisturbed areas to severely disturbed areas. The occurrence of rare species was also affected by the state of disturbance within an intermediately disturbed area. The study does not support the intermediate disturbance hypothesis as an explanation for local and regional trends in the macro-parameters of bird assemblages in the study area. Regional trends may result from structural heterogeneity in habitat variables

The third part of the study examines the contribution of the bird assemblages on the post-mined regenerating dunes towards regional diversity. Data for this part of the study were obtained from post-mined regenerating sites, mature forests (Mapelane and

Zulti/Sokhulu), afforested areas (pine, gum and beefwood plantations), unmined sites of coastal dune indigenous woodlands (three sites) and the Cape Vidal/St. Lucia grasslands.

Four distinct assemblages (an assemblage occupying indigenous vegetation, one on exotic timber plantations and two different assemblages on grasslands) were identified when information for all the sites were combined. The exclusion of data from rehabilitated regenerating sites reduced the number of assemblages to three as one grassland assemblage (1-4 years old) disappeared. The exclusion of data from the rehabilitating sites had no influence on structural and compositional values for the region. Therefore, the rehabilitated regenerating area does not harbour bird assemblages atypical for the region and also do not contribute to the presence of rare or endemic species. Dune rehabilitation thus does not create habitats atypical of the region.

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Appendix 1 List of all bird species recorded from the total sampling area for both study periods during both seasons.

FAMILY	COMMON NAME	SCIENTIFIC NAME	AUTHOR
THRESKIORNITHIDAE	Hadeda Ibis	<i>Bostrychia hagedash</i>	Latham
ACCIPITRIDAE	Cuckoo Hawk	<i>Aviceda cuculoides</i>	Swainson
	Longcrested Eagle	<i>Lophaetus occipitalis</i>	Daudin
	Southern Banded Snake Eagle	<i>Circaetus fasciolatus</i>	Gurney
	African Fish Eagle	<i>Haliaeetus vocifer</i>	Daudin
	Steppe Buzzard	<i>Buteo buteo</i>	L.
	Crowned Eagle	<i>Stephanoaetus coronatus</i>	L.
	African Goshawk	<i>Accipiter tachiro</i>	Daudin
	African Marsh Harrier	<i>Circus ranivorus</i>	Daudin
	Gymnogene	<i>Polyboroides typus</i>	Smith
COLUMBIDAE	Redeyed Dove	<i>Streptopelia semitoquata</i>	Rüppell
	Tambourine Dove	<i>Turtur tympanistria</i>	Temminck
	Cinnamon Dove	<i>Aplopelia larvata</i>	Temminck
	Green Pigeon	<i>Treron calva</i>	Wagler
MUSOPHAGIDAE	Livingstone's Lourie	<i>Tauraco livingstonii</i>	Gray
	Purplecrested Lourie	<i>Tauraco porphyreolophus</i>	Vigors
CUCULIDAE	Emerald Cuckoo	<i>Chrysococcyx cupreus</i>	Shaw
	Klaas's Cuckoo	<i>Chrysococcyx klaas</i>	Stephens
	Diederik Cuckoo	<i>Chrysococcyx caprius</i>	Boddaert
	Green Coucal	<i>Ceuthmochares aereus</i>	Vieillot
	Burchell's Coucal	<i>Certhopus burchellii</i>	Swainson
TYTONIDAE	Barn Owl	<i>Tyto alba</i>	Scopoli
STRIGIDAE	Marsh Owl	<i>Asio capensis</i>	A. Smith
CAPRIMULGIDAE	European Nightjar	<i>Caprimulgus europaeus</i>	L.
COLIIDAE	Redfaced Mousebird	<i>Urocolius indicus</i>	Latham
	Spectacled Mousebird	<i>Colius striatus</i>	Gmelin
TROGONIDAE	Narina Trogon	<i>Apaloderma narina</i>	Stephens
HALCYONIDAE	Pygmy Kingfisher	<i>Ispidina picta</i>	Boddaert
	Brownhooded Kingfisher	<i>Halcyon albiventris</i>	Scopoli
MEROPIDAE	Little Bee-eater	<i>Merops pusillus</i>	Müller
BUCEROTIDAE	Trumpeter Hornbill	<i>Bycanistes bucinator</i>	Temminck
	Crowned Hornbill	<i>Tockus alboterminatus</i>	Büttikafer
CAPITONIDAE	Blackcollared Barbet	<i>Lybius torquatus</i>	Dumont
	White-eared Barbet	<i>Stactolaema leucotis</i>	Sundevall
	Redfronted Tinker Barbet	<i>Pogoniulus pusillus</i>	Dumont
	Goldenrumped Tinker Barbet	<i>Pogoniulus bilineatus</i>	Sundevall
INDICATORIDAE	Scalythroated Honeyguide	<i>Indicator variegatus</i>	Lesson
PICIDAE	Goldentailed Woodpecker	<i>Campethera abingoni</i>	A. Smith

(Appendix I continue)

	Cardinal Woodpecker	<i>Dendropicos fuscescens</i>	Vieillot
ALAUDIDAE	Rufousnaped Lark	<i>Mirafra africana</i>	Smith
HIRONDINIDAE	Black Sawwing Swallow	<i>Psalidoprocne holomélas</i>	Rüppell
	Lesser Striped Swallow	<i>Hirundo abyssinica</i>	Guérin-Méneville
CAMPEHAGIDAE	Black Cuckooshrike	<i>Campehaga flava</i>	Vieillot
	Grey Cuckooshrike	<i>Coracina caesia</i>	Lichtenstein
DICRURIDAE	Forktailed Drongo	<i>Dicrurus adsimilis</i>	Beckstein
	Squaretailed Drongo	<i>Dicrurus ludwigii</i>	A. Smith
ORIOOLIDAE	Blackheaded Oriole	<i>Oriolus larvatus</i>	Lichtenstein
CORVIDAE	Pied Crow	<i>Corvus albus</i>	Müller
PYCNONOTIDAE	Blackeyed Bulbul	<i>Pycnonotus barbatus</i>	Desfontaines
	Terrestrial Bulbul	<i>Phyllastrephus terrestris</i>	Swainson
	Sombre Bulbul	<i>Andropadus importunus</i>	Vieillot
	Yellowbellied Bulbul	<i>Chlorocichla flaviventris</i>	Smith
	Yellowspotted Nicator	<i>Nicator gularis</i>	Hartlaub & Finsch
TURDIDAE	Kurrichane Thrush	<i>Turdus libonyana</i>	Smith
	Spotted Ground Thrush	<i>Zoothera guttata</i>	Vigors
	Stonechat	<i>Saxicola torquata</i>	L.
	Natal Robin	<i>Gossypha natalensis</i>	A. Smith
	Cape Robin	<i>Cossypha caffra</i>	L.
	Starred Robin	<i>Pogonocichla stellata</i>	Vieillot
	Cape Rock Thrush	<i>Monticola rupestris</i>	Vieillot
	Bearded Robin	<i>Erythropygia quadrivirgata</i>	Reichenow
	Whitebrowed Robin	<i>Erythropygia leucophrys</i>	Vieillot
SYLVIIDAE	European March Warbler	<i>Acrocephalus palustris</i>	Bechstein
	Willow Warbler	<i>Phylloscopus trochilus</i>	L.
	Garden Warbler	<i>Sylvia borin</i>	Boddaert
	Yellowbreasted Apalis	<i>Apalis flavida</i>	Strickland
	Rudd's Apalis	<i>Apalis ruddi</i>	Grant
	Longbilled Crombec	<i>Sylvietta rufescens</i>	Vieillot
	Bleating Warbler	<i>Camaroptera brachyura</i>	Vieillot
	Fantailed Cisticola	<i>Cisticola juncidis</i>	Rafinesque
	Palecrowned Cisticola	<i>Cisticola brunnescens</i>	Heuglin
	Croaking Cisticola	<i>Cisticola natalensis</i>	A. Smith
	Rattling Cisticola	<i>Cisticola cheniana</i>	A. Smith
	Tawnyflanked Prinia	<i>Prinia subflava</i>	Gmelin
MUSCICAPIDAE	Dusky Flycatcher	<i>Muscicapa adusta</i>	Boie
	Spotted Flycatcher	<i>Muscicapa striata</i>	Pallas
	Bluegrey Flycatcher	<i>Muscicapa caerulescens</i>	Hartlaub
	Black Flycatcher	<i>Melaenornis pammelaina</i>	Stanley
	Pallid Flycatcher	<i>Melaenornis pallidus</i>	Müller
	Woodwards' Batis	<i>Batis fratrum</i>	Shelley
	Wattle-eyed Flycatcher	<i>Platysteira peltata</i>	Sundevall

(Appendix I continue)

	Bluemantled Flycatcher	<i>Trochocercus cyanomelas</i>	Vieillot
	Paradise Flycatcher	<i>Terpsiphone viridis</i>	Müller
MOTACILLIDAE	Grassveld Pipit	<i>Anthus cinnamomeus</i>	Rüppell
	Cape Wagtail	<i>Motacilla capensis</i>	L.
	Pied Wagtail	<i>Motacilla aguimp</i>	Dumont
	Yellowthroated Longclaw	<i>Macronyx croceus</i>	Vieillot
LANIIDAE	Fiscal Shrike	<i>Lanius collaris</i>	L.
	Lesser Grey Shrike	<i>Lanius minor</i>	Gmelin
MALACONOTIDAE	Southern Boubou	<i>Laniarius ferrugineus</i>	Gmelin
	Puffback	<i>Dryoscopus cubla</i>	Shaw
	Gorgeous Bush Shrike	<i>Telephorus quadricolor</i>	Cassin
	Orangebreasted Bush Shrike	<i>Telephorus sulfureopectus</i>	Lesson
	Blackcrowned Tchagra	<i>Tchagra senegala</i>	L.
STURNIDAE	Blackbellied Starling	<i>Lamprotornis corruscus</i>	Nordmann
NECTARINIIDAE	Purplebanded Sunbird	<i>Nectarinia bifasciata</i>	Shaw
	Grey Sunbird	<i>Nectarinia veroxii</i>	A. Smith
	Scarletched Sunbird	<i>Nectarinia senegalensis</i>	L.
	Olive Sunbird	<i>Nectarinia olivacea</i>	A. Smith
	Collared Sunbird	<i>Anthreptes collaris</i>	Vieillot
ZOSTEROPIDAE	Cape White-eye	<i>Zosterops capensis</i>	Swainson
PLOCEIDAE	Thickbilled Weaver	<i>Amblyospiza albifrons</i>	Vigors
	Forest Weaver	<i>Ploceus bicolor</i>	Vieillot
	Spectacled Weaver	<i>Ploceus ocularis</i>	A. Smith
	Lesser Masked Weaver	<i>Ploceus intermedius</i>	Rüppell
	Yellow Weaver	<i>Ploceus subaureus</i>	A. Smith
	Weavers	<i>Ploceus spp.</i>	-
	Redshouldered Widow	<i>Euplectes axillaris</i>	A. Smith
ESTRILDIDAE	Green Twinspot	<i>Mandingoa nitidula</i>	Hartlaub
	Bluebilled Firefinch	<i>Lagonostica rubricata</i>	Lichtenstein
	Blue Waxbill	<i>Uraeginthus angolensis</i>	L.
	Common Waxbill	<i>Estrilda astrild</i>	L.
	Grey Waxbill	<i>Estrilda perreini</i>	Vieillot
	Bronze Mannikin	<i>Spermestes cucullatus</i>	Swainson
	Redbacked Mannikin	<i>Spermestes bicolor</i>	Fraser
VIDUIDAE	Pintailed Whydah	<i>Vidua macroura</i>	Pallas
FRINGILLIDAE	Yelloweyed Canary	<i>Serinus mozambicus</i>	Müller
	Cape Canary	<i>Serinus canicollis</i>	Swainson
	Bully Canary	<i>Serinus sulphuratus</i>	L.

Appendix 2 The rare species recorded from each level of disturbance (✓) and each level of disturbance within the intermediately disturbed area (✓✓).

Species	Relatively undisturbed	Intermediately disturbed	Severely disturbed
Barn Owl	✓		
Blackbellied Starling	✓		
Blackcrowned Tchagra			✓
Blackeyed Bulbul		✓	
Bluemantled Flycatcher	✓		
Brownhooded Kingfisher		✓	✓
Bully Canary			✓
Burchell's Coucal		✓	✓
Cape White-eye		✓	
Cardinal Woodpecker		✓	
Collared Sunbird			✓
Crowned Hornbill	✓		
Cuckoo Hawk		✓	
Dusky Flycatcher		✓	
Emerald Cuckoo		✓	
European Nightjar	✓		
Fiscal Shrike		✓	
Forest Weaver		✓	
Gorgeous Bush Shrike		✓	
Goldenrumped Tinker Barbet		✓	✓
Green Coucal	✓	✓	
Green Pigeon	✓		
Greenspotted Dove			✓
Grey Sunbird			✓
Hadedda Ibis	✓		
Klaas's Cuckoo	✓		
Lesser Masked Weaver	✓	✓	
Lesser Striped Swallow			✓
Livingstone's Lourie			✓
Longbilled Crombec		✓	
Longcrested Eagle	✓		
Narina Trogon		✓	
Natal Robin		✓	
Puffback		✓	
Purplebanded Sunbird		✓	
Purplecrested Lourie	✓		✓
Pygmy Kingfisher			✓
Rattling Cisticola		✓	
Redeyed Dove		✓	✓
Rudd's Apalis	✓		
Sombre Bulbul		✓	
Southern Boubou		✓	
Spectacled Weaver			✓
Squaretailed Drongo		✓	
Tambourine Dove		✓	✓
Tawnyflanked Prinia		✓	
Thickbilled Weaver	✓		
Trumpeter Hornbill	✓		

(Appendix 2 continue)

Whitebrowed Robin	<i>Erythropygia leucophrys</i>		✓	
Yellowbellied Bulbui	<i>Chlorocichla flaviventris</i>			✓
Yelloweyed Canary	<i>Serinus mozambicus</i>		✓	
Yellowspotted Nicator	<i>Nicator gularis</i>	✓	✓	

Species		Least disturbed	Intermediately disturbed	Severely disturbed
Blackeyed Bulbul	<i>Pycnonotus barbatus</i>	✓✓	✓✓	
Brownhooded Kingfisher	<i>Halcyon albiventris</i>	✓✓		
Burchell's Coucal	<i>Cenrtopus burchellii</i>		✓✓	
Cape Canary	<i>Serinus canicollis</i>			✓✓
Cape White-eye	<i>Zosterops capensis</i>	✓✓	✓✓	
Cardinal Woodpecker	<i>Dendropicos fuscescens</i>	✓✓		
Collared Sunbird	<i>Anthreptes collaris</i>		✓✓	
Common Waxbill	<i>Estrilda astrild</i>			✓✓
Cuckoo Hawk	<i>Aviceda cuculoides</i>	✓✓		
Dusky Flycatcher	<i>Muscicapa adusta</i>	✓✓		
Emerald Cuckoo	<i>Chrysococcyx cupreus</i>	✓✓		
Fiscal Shrike	<i>Lanius collaris</i>		✓✓	✓✓
Forest Weaver	<i>Ploceus bicolor</i>		✓✓	
Georgous Bush Shrike	<i>Telephorus quadricolor</i>		✓✓	
Goldenrumped Tinker Barbet	<i>Pogoniulus bilineatus</i>		✓✓	
Green Coucal	<i>Ceuthmochares aereus</i>		✓✓	
Lesser Masked Weaver	<i>Ploceus intermedius</i>		✓✓	
Little Bee-eater	<i>Merops pusillus</i>			✓✓
Longbilled Crombec	<i>Sylvietta rufescens</i>	✓✓	✓✓	
Narina Trogon	<i>Apaloderma narina</i>		✓✓	
Natal Robin	<i>Gossypha natalensis</i>		✓✓	
Palecrowned Cisticola	<i>Cisticola brunnescens</i>			✓✓
Pintailed Whydah	<i>Vidua macroura</i>			✓✓
Puffback	<i>Dryoscopus cubla</i>		✓✓	
Purplebanded Sunbird	<i>Nectarinia bifasciata</i>	✓✓		
Rattling Cisticola	<i>Cisticola cheniana</i>	✓✓		
Redeyed Dove	<i>Streptopelia semitoquata</i>		✓✓	
Scarletched Sunbird	<i>Nectarinia senegalensis</i>			✓✓
Sombre Bulbul	<i>Andropadus importunes</i>		✓✓	
Southern Boubou	<i>Laniarius ferrugineus</i>	✓✓	✓✓	
Squaretailed Drongo	<i>Dicrurus ludwigii</i>		✓✓	
Tambourine Dove	<i>Turtur tympanistria</i>	✓✓		
Tawnyflanked Prinia	<i>Prinia subflava</i>	✓✓		
Whitebrowed Robin	<i>Erythropygia leucophrys</i>	✓✓		
Yelloweyed Canary	<i>Serinus mozambicus</i>		✓✓	✓✓
Yellowspotted Nicator	<i>Nicator gularis</i>		✓✓	