# DUNE FOREST SUCCESSION ON OLD LANDS: IMPLICATIONS FOR POST-MINING RESTORATION

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## Abstract

We investigated the effects of swidden agricultural disturbance in dune forest communities near Cape Vidal on the north-eastern coast of KwaZulu-Natal. Disturbed and undisturbed sites in the dune forest were identified from aerial photographs. Three communities in a successional sequence were identified: Acacia karroo woodland, Secondary dune forest and Climax dune forest. Species diversity was found to be highest in Climax dune forest, with 30% of the species found in the study being restricted to this community. Succession to climax dune forest was estimated to take 80 to 130 years post-disturbance with the possibility that certain species might not recover in the foreseeable future. In the light of these results, previous findings of successful rehabilitation after open-cast dune mining are questioned.

## 1. Introduction

This presentation focuses on the controversial issue of dune mining in the KwaZulu-Natal coastal dunes, and shows the results of a study undertaken at Cape Vidal, which examined recovery of dune forest after slash-and-burn agricultural disturbance. The findings of this study suggest the need to reassess the conclusions reached by previous rehabilitation studies, such as that by Mentis and Ellery (1994, 1998).

Dune mining has been continuing for some time in the dunes of Richards Bay. The company, Richards Bay Minerals (RBM), has been mining for ilmenite, zircon and rutile. This multi-billion Rand industry yields a large proportion of the world's supply of these minerals.

## 2. Mining and rehabilitation processes

The extraction process involves the creation of a large opencast mine in the dune system, including the clearing of vegetation and flattening of the topography. A dredge pool is created in the dune cordon, from which the minerals can be extracted. As the dredge pool slowly advances along the dune cordon, so the area recently mined is rehabilitated. The topography is then restored and the top of the dune re-vegetated.

RBM are committed to rehabilitation and strive to achieve this. Topsoil is saved from before the destruction of the vegetation and is re-laid after mining. The dunes are rapidly stabilised using grass species and ***Acacia karroo***, as it is believed that ***Acacia karroo*** woodlands will lead to dune forest. However, there is no consensus about whether or not ***Acacia karroo*** does in fact lead to climax dune forest, nor whether this occurs in a reasonable timeframe.

## 3. Role of *Acacia karroo* in rehabilitation

Proponents of the ***Acacia karroo*** scheme say that ***Acacia karroo*** occurs naturally in the dunes as an early seral stage. Opponents of the scheme say that succession does not necessarily advance beyond this early stage and this involves a high species loss as ***Acacia karroo*** woodlands can be extremely species-poor. The role of ***Acacia karroo*** in the dune systems is therefore not yet clear.

Some recent work (von Maltitz ***et al.,*** 1996) indicates that there are two successional pathways in these dune communities, one involving bush clumps of forest species leading to climax forest, and the other involving ***Acacia karroo*** and leading to less speciose communities. There is some debate, therefore, whether RBM are rehabilitating or revegetating these dune systems by using ***Acacia karroo*** as their sole strategy.

Rehabilitation studies (CSIR Environmental Services, 1993; Mentis & Ellery, 1994; Lubke ***et al.,*** 1996) have been conducted to test this question. They suggest that succession has been relatively rapid post mining disturbance, reaching a climax plot in about 40 years. Impact is considered to be moderate to low in the medium to long term, and rehabilitation is seen as progressing to a desirable end-point. These findings indicate that the impact of mining is not that severe and that succession is progressing satisfactorily. However, there is not great consensus about this. Due to the heavily destructive nature of the opencast mines, there has been some unease about whether or not climax dune forest will ever be restored. In fact, a closer examination of these rehabilitation studies indicates that there seem to be certain areas of contention in these studies.

## 4. Problems with previous rehabilitation studies (Mentis & Ellery, 1994, 1998)

1) Comparisons between successional trajectories on mined and unmined land were used to indicate acceptable ecosystem recovery after mining. However, the unmined lands selected as a control were also heavily disturbed, having undergone "bulldozing for industrial or urban development" (Mentis & Ellery, 1998). This leads to a comparison of disturbed versus undisturbed successional tracks, which heavily weights the chances of congruence in forest development.

2) Mentis and Ellery (1994, 1998) used species richness as their main measure of ecosystem recovery. However, a measure of species richness, by not identifying the type of species involved, does not discriminate between species of primary forest and weeds of recently disturbed lands. Comparisons of species composition are much more appropriate measures when the objective is to recover a community resembling the primary community in composition.

3) Mentis and Ellery (1994, 1998) measured successional progress towards a "climax" by comparing sample plots with plots they considered to be successional endpoints. The outcome of such an analysis clearly depends on the choice of endpoints. In this regard, the inclusion of ***Acacia karroo*** woodlands as a successional end point is unjustified. Previous work has shown ***Acacia karroo*** woodlands to be early precursors in a lengthy successional sequence after disturbance (Weisser & Marques, 1979; Weisser, 1980). Indeed it has been questioned whether ***Acacia karroo*** woodlands are in fact natural states in the dune forest community (MacDevette & Gordon, 1991). Nevertheless, three primary forest plots and three ***Acacia karroo*** woodlands were used by Mentis and Ellery (1994) to create a goal endpoint for succession in a distance analysis. Their use of endpoints is also not consistent. In analyses involving time since disturbance, climax forest plots were excluded, as their exact disturbance histories were unknown, and the ***Acacia karroo*** woodlands were used as the sole endpoints. Since mining produces ***Acacia karroo*** woodlands, this choice of endpoint biases the results towards indicating successful rehabilitation.

We felt we could add to the debate by addressing some of these issues in the dune forests.

## 5. Cape Vidal study

### 5.1 Background

The study conducted at Cape Vidal (West, 1999) was originally structured as an initial attempt to examine the effects of human disturbance (slash-and-burn or swidden agriculture) in KwaZulu-Natal ecosystems. Slash-and-burn agriculture is a low-impact disturbance compared to opencast mining, and is relatively small-scale, so one would expect that a good seed source would be available from surrounding vegetation, and that nurse trees were often left in fields, which could accelerate bush clumps. The situation should thus be relatively favourable for a speedy recovery post-disturbance. Therefore, one would expect recovery from swidden agriculture to be faster than from opencast mining. However, comparing the results to previous findings (Mentis & Ellery, 1998) indicated that recovery was in fact slower post slash-and-burn disturbance. We felt that the data suggested that this was a good opportunity to test previous claims about dune forest recovery.

### 5.2 Research methods

We sampled tree and shrub vegetation in 39 sites of varying ages since disturbance. These sites were identified by examining aerial photographs of the area from 1937, 1960, 1975, 1988 and 1996 and locating areas within the forest that had been cleared for cultivation by swidden farmers. We were able to determine at which period the sites started to revegetate from the sequence of photographs. We labelled three ages of disturbance: 1) lands abandoned between 1937–1960 (1960), 2) abandoned between 1960-1975 (1975), and 3) abandoned between 1975-1988 (1988). Thus, assuming at least five years were required to form a canopy that is recognisable on aerial photographs, we sampled sites with minimum (and possible maximum) post-disturbance ages of 42 (60), 27 (36) and 14 (21) years.

We identified two control groups. The first control group consisted of sites that were topographically similar to the disturbed sites (i.e. in the dune slacks) but showed no sign of agricultural disturbance in any of the aerial photographs. These sites were labelled slack controls (SCs). It is possible that these sites were farmed at some time in the past. However, if this were the case, the minimum age of the stands would be well in excess of 60 years as they were covered by mature forest in the 1937 aerial

photographs. We reasoned that these slack controls might well represent the climax state of anthropogenically disturbed forest.

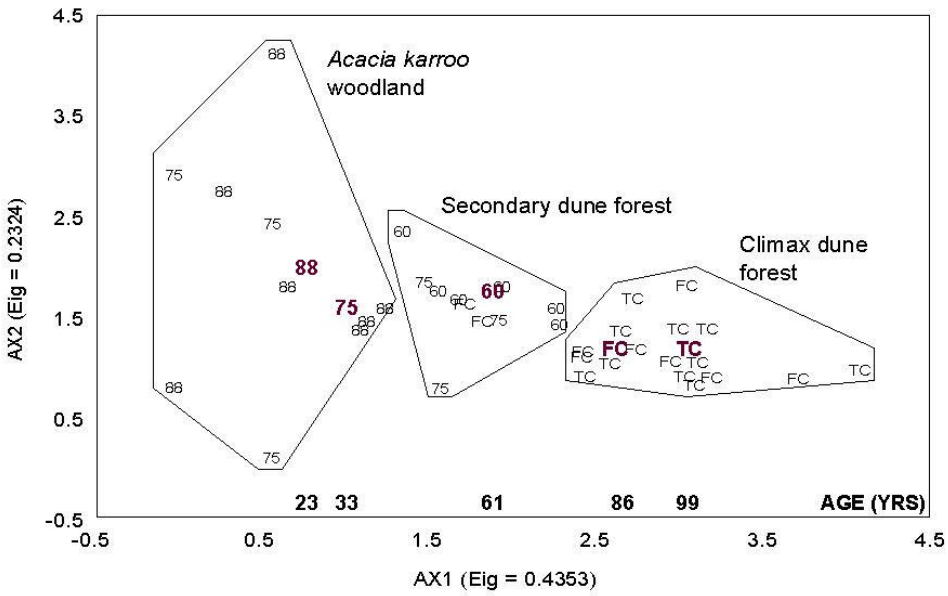
The second control group was chosen in order to control for any form of agricultural disturbance, however ancient. These topographic controls (TCs) were located on flat ground on the tops of dunes, as opposed to the dune slacks where all other sites were located. We reasoned that these sites would be least likely to have experienced any agricultural disturbance, due to their topographic isolation, and would thus provide an effective comparison to the slack controls.

Thirty-nine plots (50 m x 15 m) were laid in the five different categories of disturbance (7 x 1988, 6 x 1975, 6 x 1960, 10 x SCs, 10 x TCs). The species name, diameter at breast height (dbh) and number of stems of all woody plants over two meters tall, rooted in the plot, were recorded.

## 5.3 Results

The methods of Mentis and Ellery were followed to allow comparison between the two studies. These methods were: 1) Community analysis, 2) Analysis of succession and 3) Timing of the successional sequence. A DCA ordination of the transects (Figure 1) indicates three different communities, which are almost identical to those shown by Pablo Weisser and others (Weisser, 1980), namely ***Acacia karroo*** woodland, secondary dune forest and climax dune forest. The ***Acacia karroo*** woodlands had low diversity (only 34 species were recorded), while secondary dune forest had 56 species and climax dune forest had 74 species. Figure 1 shows that ***Acacia karroo*** woodlands are at best in an early seral stage and are compositionally different from dune forest proper.

Figure 1: DCA of transects with centroids and calculated age




Another important result is that of species endemism in these communities (Figure 2). Thirty percent of all woody species sampled at Cape Vidal occurred solely in the climax vegetation. Thus, if succession does not advance to climax stage, up to 30% of species in the area could be lost.

To compare our results to those of Mentis and Ellery (1994) we performed a direct distance analysis of all plots from a putative successional end-point (Figure 3). The end-point selected in this study was derived from the average climax dune forest plot, compared with the ***Acacia karroo*** woodlands selected by Mentis and Ellery (1994). This analysis was run twice, once including only common species and once including all species. This had a profound effect on the result. With the inclusion of rare species the successional trajectory does not reach the end-point and the $R^2$ drops considerably from 0.903 for common species only to 0.174. Thus, if one is concerned about the recovery of rare species, succession from ***Acacia karroo*** woodlands does not seem to be adequate.

Figure 2: Proportion of total flora endemic to each successional community and those shared between communities

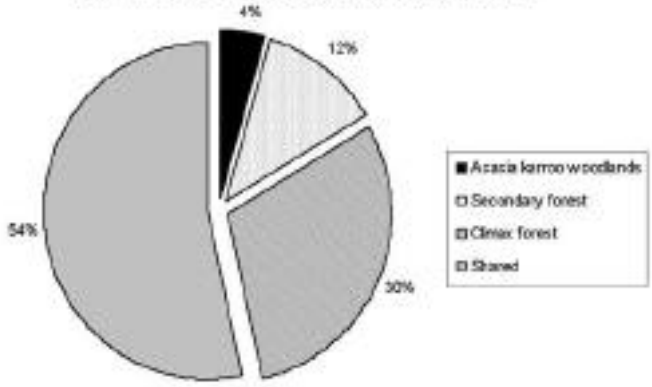
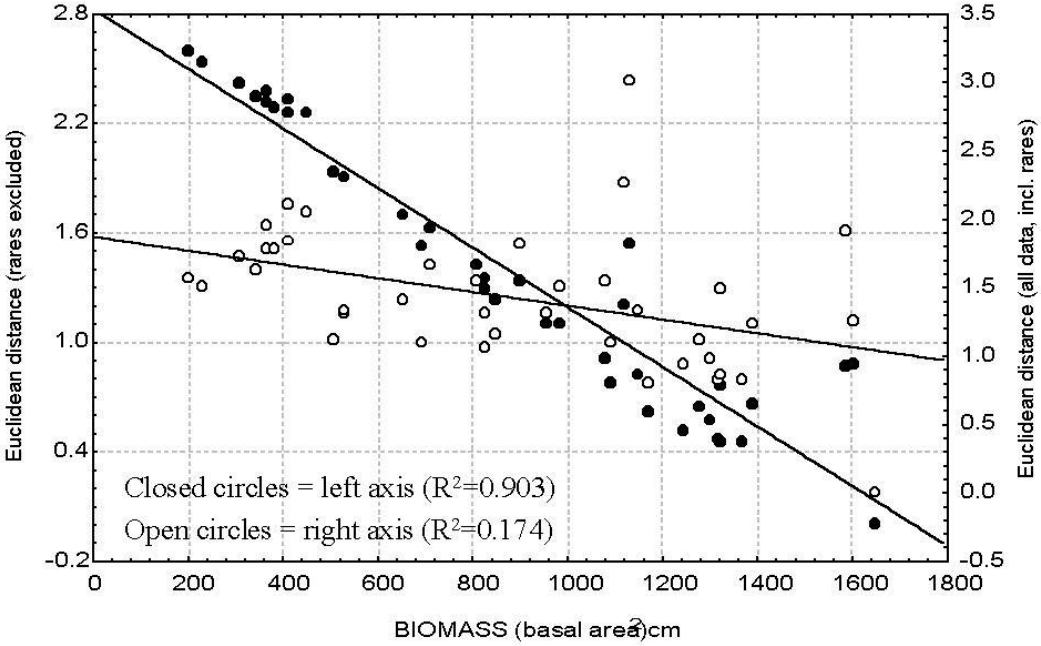



Figure 3: Euclidean distance from putative climax plot vs. total plot biomass




In an attempt to relate time to the successional sequence, the centroids of the known aged sites were regressed and extrapolated along the ordination axis (Figure 1). This shows that climax dune forest only begins to establish up to 80 years after slash-and-burn disturbance. We feel that due to the low impact nature of the slash-and-burn agriculture, this is a very conservative estimate for recovery. More severe disturbances may well cause a much lengthier rehabilitation time.

Thus, it would seem that ***Acacia karroo*** woodlands are not the goal of succession in the dune forest community. At best they are the precursor of a lengthy successional series that requires at least 80 years in order to recover up to 30% of the total woody flora. We feel that this estimate of succession represents a best-case scenario for recovery, considering the relatively low-impact disturbance (i.e. swidden agriculture) the sites have undergone. If one is dealing with mining disturbance, where the effects are much larger, the system could well take longer to recover.

## 6. Conclusions

Previous studies of the value of ***Acacia karroo*** woodlands as a rehabilitation species for dune mining are questionable in terms of end-points of succession and measures of rehabilitation and need to be reviewed. ***Acacia karroo*** woodlands may follow a different successional pathway, or at least severely reduce the number of species present. Genuine rehabilitation will be lengthy and species loss is potentially severe.

It is important for stakeholders and conservation officials to realise the impact of disturbance in the dune forest communities. Disturbance is certainly a part of these communities, and has been for many centuries, but recovery from disturbance seems to be relatively slow.

A key point is that the position of ***Acacia karroo*** woodlands in the successional trajectory is not completely understood, because in some areas ***Acacia karroo*** woodlands have been in stasis for up to 60 years without advancing into climax dune forest. We feel that the evidence from this study, involving low-impact disturbance, has implications for the dune-mining debate and effectively adds to previous rehabilitation studies. It also shows that if dune forest rehabilitation is to be achieved, it must be targeted in a more effective manner, using all available techniques. Leaving recovery to nature may not be enough.

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