Is soil disturbance really necessary to ensure the success of bare patch restoration in sandy soils in the Nama Karoo?

Introduction
Rangelands in the Nama Karoo are primarily used for extensive livestock farming with sheep and goats. Poor grazing management is regarded as one of the most important causes of land degradation in South Africa (Hoffman and Ashwell 2001) and has resulted, together with periodic droughts and physical and chemical processes in the soil, in vast areas of the Nama Karoo being totally denuded of any vegetation (Cowling et al. 1986, Kellner and Bosch 1992). This has a large impact on the availability of fodder for livestock as well as on the livelihoods of the people making a living in the area from extensive livestock farming.

Often the veld degrades to a point beyond which vegetation cover, plant density and species composition can recover, despite removal of the animals and their grazing impact (Curtin 2002, Snyman 2003, van den Berg and Kellner 2005). In such cases restoration interventions become necessary to assist with the re-establishment of vegetation.

The general view is that mechanical disturbance of the soil is necessary because of the clayey soils of bare patches that form an impenetrable crust that leads to a high degree of soil compaction. Although one does not find that kind of compaction in sandy soils, there is a degree of crust formation on the bare soil that influences germination in a negative way (Van der Merwe and Kellner 1999).

Objective
The objective of this study was to test the hypothesis that, in the long term, soil disturbance is not the only intervention that will allow for the successful restoration of vegetation on sandy soils in the Nama Karoo.

Materials and Methods
Study area
The study was conducted in the bossieveld of the Gamka Karoo (Mucina and Rutherford 2006) on a bare patch of approximately 1 ha on the farm Montana in the Beaufort West district, Western Cape Province. The area receives an average annual rainfall of 215 mm and the soils are sandy-loam and nutrient-rich, but with a low organic carbon content of 0.24%. A detailed description of the site is given in Visser et al. (2004).

Treatments
The study started in November 1999 and 6 treatments with 3 replications were applied, following a randomized block design. Each treatment plot was 12x12 m in size. The treatments were Seeding (S), Seeding+Brush-packing (SB), Tilling (T), Tilling+Seeding (TS) and Tilling+Seeding+Brush-packing (TSB) and a control (C).

The soils in the tilled plots were cultivated once to a depth of 150-200 mm using a tine implement. The rows were about 150-200 mm apart. Branches from nearby Acacia karroo trees were cut and used in the brush-packing treatments. Seeds of five indigenous species were sown-in in the seeded plots at a seeding rate of 15 kg.ha⁻¹. A seeding rate of 3-5 kg.ha⁻¹ is normally recommended (Esler and Kellner 2001), but this high seeding rate was used to ensure that available seed is not the limiting factor. The species included in the seed mixture were Cenchrus ciliaris, Chaetobromus dregeanus, Atriplex semibaccata, Pteronia membranacea and Tripteris sinuata. The experimental area was fenced off to exclude large herbivores but smaller herbivores such as hares could freely access the site for the study period.
Vegetation surveys
Vegetation surveys were done annually in December from 2000 until 2004 and again in February 2010. For each plot all plants encountered within each of 10 randomly located 1x2 m quadrants were counted and identified. The growth stage of each plant, which is seedling, reproductive or vegetative was also recorded. The presence or absence of the different growth stages is an indication of the success of establishment of a particular species (Brown 1957).

Results and Discussion
The number of species present and the plant density increased drastically from 2000 to 2010. The number of species present increased from a maximum of 14 species in the T and TSB-treatments in 2000 to 31 species in the SB-treatment and 27 species in the TSB treatment respectively in 2010. The plant density increased from <6 plants/m-2 to >60 plants.m-2 during the same period (Figure 1a and b).

Figure 1a
Figure 1a: Number of species and plant density (plants.m-2) in the different treatments in (a) 2000 and (b) 2010 at Montana.
Only three of the sown-in species were present in the treatments, namely *Atriplex semibaccata*, *Cenchrus ciliaris* and *Chaetobromus dregeanus*. *Cenchrus ciliaris* was the most common species and was found in all the treatments except the Seeding only (S) treatment. *Cenchrus ciliaris* is a summer-growing grass species that prefers to grow in sandy soil, explaining its dominance (van Oudtshoorn 1999). Other species present, that are readily grazed, includes *Pentzia incana*, *Felicia muricata* and *Eragrostis lehmanniana* (only in SB treatment), but there were still mainly pioneer species present and accounting for the largest numbers, namely *A adscencionis*, *A lindleyi* and *C virgata*.

The total plant density in the SB-treatment in 2010 was significantly more than in all the other treatments except TSB ($F_{4.99}$; $p=0.015$). The increase in total plant density from 2000 – 2010 ($F_{4.64}$; $p=0.018$) and from 2004 to 2010 ($F_{4.77}$; $p=0.017$) was significantly more in the SB-treatment than the rest, except for the TSB-treatment. The total plant density showed significant time x treatment interactions, with significantly higher plant density in the SB-treatment in 2010 than all the other treatments and years ($F_{5.15}$; $p=0.0005$) (Figure 2).

It is evident that there were a high number of seedlings present in 2010, especially in the SB and TSB treatments (Figure 3). More than half of the total number of individuals present was seedlings. This can be ascribed to rainfall received in the area about two weeks before the surveys were done. The other
treatments, except T, did not have a high number of seedlings with less than 5 plants/m². There was no significant difference between treatments in 2010, but when comparing the number of seedlings present in 2010 with the other years, there were significantly more seedlings in 2010 than in the other years ($F_{3,44}^{34.44}; p<0.0001$). There were, however, no significant differences between treatments.

The same were found for the Reproductive and Vegetative stages. There were significantly more plants in flower or seed in 2010 than in the other years ($F_{12,34}^{12.34}; p=0.0002$), with the highest number of individuals in the SB treatment. The differences between the treatments were however not significant. It was the same for the plants in a vegetative stage ($F_{3,1.91}^{31.91}; p<0.0001$). The SB and TSB treatments have high numbers of all three growth stages present, which is a sign of success. According to Wiedemann and Cross (2000) the restoration effort can be seen as a success when > 5 plants.m⁻² have established.

Seeding+Brush-packing and TSB-treatments were the most successful treatments ten years after the initial work was done. No grazing took place, except for small game that could get through the fence and there were some signs of grazing. The success of these two treatments in the longer term

Figure 3: The plant density (plants.m⁻²) of the different growth stages in the different treatments in 2000, 2004 and 2010 at Montana.
is mainly because of brush-packing. This treatment provides shade that decreases topsoil temperatures which can reach temperatures of 65°C on the bare areas (Snyman 2003). It traps soil, plant litter and seed (Milton 1995) and reduce water run-off and wind and water erosion (Ludwig and Tongway 1996; Brady and Weil 1999), which, together, resulted in the highest plant density and highest species richness in the SB treatment.

Cost-Benefit:
From the costs of the different treatments, it is obvious that brush-packing is very expensive at R802.ha⁻¹. This, however, depends on the availability of brush materials and distance from the restoration site (Visser et al. 2004), which was the reason for the high cost in this study’s case. In this case it seems that tilling alone would be more efficient than TS and TSB treatments due to its lower input costs, but sometimes one does not have the implements for tilling and branches are readily available, and brush-packing is over the longer term more effective than tilling alone.

Conclusion
From the data it is evident that the hypothesis can be accepted. In the long term, soil disturbance (tillage) is not the only intervention that will allow for the successful restoration of vegetation on denuded sandy soils in the Nama Karoo. Brush packing that provides shade, protects the plants from grazing and provides organic matter, resulted in the highest plant density and highest species richness in the Seeding+Brush-packing treatment. Although brush-packing can be an expensive treatment, if the branches are not readily available, it is very useful in nature reserves and game farms to keep the animals out of the area being restored, especially where one does not want to camp off a site for aesthetic reasons.

Since it is an arid area, rainfall is the major limiting factor and can influence the success of any restoration or rehabilitation project and post-treatment management is critical to prevent the area from becoming bare again.

Figure 4: Comparison of plants established.ha⁻¹ in 2010 and the Cost/ha⁻¹ for the different treatments at Montana. (Costs/ha adapted from Esler and Kellner (2001) and Witbooi (2002).
References


