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Is *Ammophila arenaria* (Marram grass) a threat to South African dune fields?

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Abstract. *Ammophila arenaria* (marram grass) was introduced to South Africa from Europe as a means of stabilizing the Cape Flats in the 1870s, but was only successfully established in the 1890s as it was found that seeds from the first introductions did not readily germinate. By the end of the last century, it was successfully used as a dune stabilizing grass. It is now widely used in stabilization projects along the Cape coastline, being established by planting cuttings or whole plants. Because of problems experienced of marram becoming invasive, especially on the west coast of North America, and the fact that we have many invasive species which threaten our indigenous dune fields, studies have been initiated on this plant in South Africa. Most work to date has involved investigating the methods used to establish the plant in stabilization sites, and very little has been done on the biology of the species in this country. Marram is generally thought not to seed in South Africa, and thus its spread has been limited.

However, in the light of recent reports of successful germination of the seed, detailed studies on the phenology of seed production and establishment in natural areas will be undertaken. Studies on the natural control by fungal species and nematodes will be carried out in conjunction with work done in the Netherlands, so that a comparison of the biology of the species in South Africa can be made with that in Europe, where it is used extensively to stabilize dunes.

Keywords: Autecology; Invasive species; Stabilization; Vegetation history.

Nomenclature: Arnold & de Wet (1993) for vascular plants.

Introduction

At the recent Dunes '94 conference in South Africa fears were expressed that *Ammophila arenaria* (marram grass) could become a problem invasive weed in South African dune fields. This is the case in the Western United States, e.g. in Oregon (Wiedemann 1987; Wiedemann & Pickart in press) and in California, where the Californian chapter of the Society of Ecological Restoration (SERCAL) has implemented an eradication programme of marram (van Hook 1983; Pickart et al. 1990). Marram grass has been used extensively in South Africa in dune stabilization programmes, and is generally regarded as one of the most useful pioneer plants on the littoral foredunes. It is also used on rear dunes in some regions and sometimes in combination with other species (Avis 1989). Research on the use of marram grass as a stabilizer (Reyneke 1985) and on the history of the introduction of the species (Stehle 1981) have been undertaken in South Africa. However, studies on the biology of the species in this country are very limited, and it is therefore our intention to carry out more intensive studies. This will be done in conjunction with researchers in the Netherlands, who are looking at the reasons for die-back in the species once it has achieved its role as a stabilizer (van der Putten et al. 1989; cf. van der Putten & Peters 1995). We will also investigate which indigenous species could be used in stead of marram should it in fact be a problem plant.

Problems with aliens in dune stabilization

South Africa has a long history of problem invasive alien plants (Stirton 1978), the most problematic areas being in the Cape region on drift sands and in dune fynbos. Fynbos (derived from the Dutch fijnbosch, bush with fine, i.e. narrow leaves; Taylor 1978), is a highly specialized South African vegetation type of a shrubby heath or ericoid component, a shrubby proteoid (*Proteaceae*) component, and a shrubby 'grass' or 'reed' component ofrestioids (*Restionaceae*) (Cowling 1984). *Acacia* spp. (*A. saligna* and *A. cyclops*) were originally introduced to stabilize dune sands (Shaughnessy 1980; Avis 1989). These species all set seed prolifically and the seeds are attractive to birds of the natural coastal systems. This has facilitated spreading into many open spaces in the dune fields and dune fynbos vegetation (Castley 1992). Stirton (1978) states that the major danger of these species is their ability to form stands of dense, impenetrable tall shrubs or short trees (pole thicket) at the expense of the indigenous vegetation. This suppressive effect prevents the growth of indigenous

vegetation under the trees "thus resulting in areas which can be likened to ecological deserts" (Stirton 1978). Their strong competitive ability due to the lack of natural enemies gives them many advantages usually only attributed to annual weeds, as they are able to invade disturbed areas with ease (Avis 1989).

With the Cape's wealth of species (Bond & Goldblatt 1984) it is important to control and inhibit the use of aliens as far as possible. Similarly, South Africa has a great heritage in terms of large mobile dune systems, which form an important part of our coastal region (Tinley 1985). Thus, this project is regarded as being an extremely important one, since we must not lose such dune systems. If *Ammophila arenaria* becomes invasive in South Africa, it may expand from the sites of its use for stabilization into natural and undisturbed sites. Marram expansion may threaten the natural plant species composition, possibly eradicating whole vegetation types such as the dune fynbos, and may also have a harmful impact on dune formation processes thus changing dune topography and dune landscape. At the Dunes '94 meeting it was resolved that the use of indigenous species should be favoured in stabilization programmes (G. Hellstrom pers. comm.). Whilst this may be desirable in terms of conservation, one has to consider the practicalities of stabilizing mobile sands where they are problematic for development, such as car parks or recreational areas, and also agricultural land (Cobby 1988).

History of the introduction of marram grass

It is not exactly known when *Ammophila arenaria* was introduced into South Africa. Towards the end of the 1860s government botanist Peter MacOwen brought a specimen plant to the Cape Town Botanic Gardens (Heywood 1894). In 1876 Joseph Storr Lister, then superintendent of plantations at the Cape, sowed seed onto the drift sands of Durbanroad (today Bellville) near Cape Town. The seed was derived from Lincolnshire in England, and apparently did not do very well in the South African drift sands. The sowing was a complete failure, and Lister abandoned marram grass in favour of the indigenous pypgrass, *Ehrharta villosa* (Heywood 1894; Stehle 1981). Another early attempt to establish marram in South Africa through seed was undertaken by the Port Alfred harbour authorities in the Eastern Cape in 1883, with unknown success (McNaughton 1895).

Only in 1892 did A.W. Heywood, government forester at Uitvlugt near Cape Town, try again with some 45 kg of a mixture of marram seed and seed of other dune species, which was sown onto the Eersterivier drift sands near Cape Town. On this occasion the marram seed was obtained from a French company. The outcome was slightly better than with Lister's experiments. Although the seed germinated only at the foot of the dunes, some 600 plant species survived to grow into sand binding plants that could be transplanted to other areas when 2 yr old (Heywood 1894). It was therefore concluded that marram grass does not germinate readily on open sand dunes and should rather be grown in nurseries to be transplanted onto the dunes only in a later stage.

In 1894 marram was grown successfully in nurseries in Tokai and Uitvlugt near Cape Town, and subsequently widely used for drift-sand reclamation throughout the Cape Colony, with one of Heywood's major supporters being government forester David Ernest

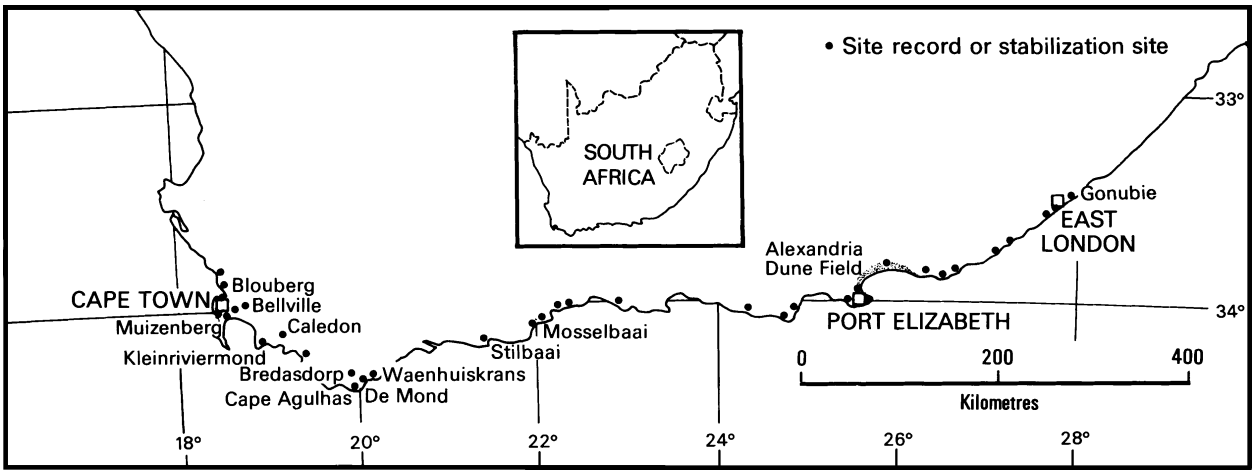

Fig. 1. Distribution of *Ammophila arenaria* in South Africa and regions where it is presently being actively used in dune stabilization.

Hutchins (Heywood 1894).

Besides the early sites of the Bellville and Eersterivier drift sands, marram grass was used in vast amounts near Blouberg at the turn of the century and around Muizenberg in the 1920s and 1930s. It was used at Stilbaai and at Cape Agulhas in 1901-1902, in the Caledon/Bredasdorp region, and also near Kleinriviermond, De Mond and Waenhuiskrans. Marram was also planted further east in the vicinity of Mosselbaai and as far east as Port Elizabeth (Reyneke 1985). It is at present being used extensively in dune stabilization programmes all along the southern and southeastern Cape coasts and in isolated parts of the eastern Cape (Fig. 1; Avis 1989; Anon. 1993).

Use of marram grass in dune stabilization

Avis (1989) has reviewed the methods of large scale dune stabilization currently in practice in South Africa. In 1974 it was decided that alien species should be phased out, and only indigenous and non-invasive species should be used (Stehle 1981). Marram grass was considered to be a non-invasive species, and has consistently been used along the seaward margin of stabilization sites. Barriers of shade cloth are often used to create a large foredune. More often, marram grass is planted out directly in this region. Plants of marram grass are taken from established dunes and planted in bundles of 4 to 6 at intervals of about 50 cm. If planted during the rainy season, marram grass will become well established over extensive areas, often with very few indigenous species growing amongst the stands. Behind the marram grass, brushwood is cut and placed over the sand as evenly as possible. Seedlings of indigenous plants are planted, and seeds are sown in these areas, usually at a density of 150 to 200 kg/ha depending on species available. In the Eastern Cape the waxberry (*Myrica cordifolia*) has been successfully grown as seedlings which are planted extensively over the dune systems (Avis 1989).

Marram grass is thus an important species used in the dune stabilization programme, and although *Ehrharta villosa* was considered as an alternative species as long ago as the last century, studies have still not established this as a useful plant to replace marram. Marram grass responds well to irrigation and fertilization (Reyneke 1985), and until some alternative indigenous species can be found, it will continue to be used. Numerous projects on dune management (Anon. 1993) show how marram grass has been established over many hectares, especially in the Cape Peninsula regions. In these regions it is established under irrigation in the first year. By hydro-seeding indigenous species, it is hoped that marram will be replaced when it becomes moribund. However, marram grass persists for many years, and it is very difficult for indigenous species to replace it. Many other indigenous plants are available for dune stabilization (Lubke & Avis 1986), but detailed studies need to be undertaken on the biology of indigenous pioneer species, to find a suitable replacement as a primary stabilizer.

Distribution along the coastline

From its early introduction at Eerste Rivier in the Western Cape, *Ammophila arenaria* has been used at various localities all along the Cape coast. Being a temperate species, it has not been introduced into Natal along the North Coast of South Africa, where other stabilizing species were preferred (e.g. *Casuarina equisetifolia*). It is widespread along the coast (Fig. 1), but in all cases it appears to have been planted at each of these regions. At Bredasdorp in the Southern Cape, it produces seed which has been distributed to various regions, but generally germination is very low (less than 10 %), and thus it is more usually planted as cuttings or whole plants. Recently, studies in Gonubie (near East London, Eastern Cape) have shown that it can be germinated much more readily (S. Fergus pers. comm.) with a success rate of up to 80 %. It is now being planted in the Gonubie region, which is about as far east as the species grows satisfactorily.

Because of the stabilizing ability of marram grass and its degeneration following the lack of mobile sand (Ranwell 1972; Huiskes 1979; van der Putten & Troelstra 1990) the plants tend to disappear naturally from the system. This we have noted recently (October 1994) in the Alexandria dune fields where vast areas of dune were covered with *Ammophila arenaria* in 1986 (Fig. 2). Thus, there may be little need for concern, but this has to be substantiated by more extensive studies on the distribution and possible natural spread of the species.

Projected studies on marram grass and other dune stabilization species

Much work has been done on the autecology of the species in Europe (e.g. Salisbury 1952; Ranwell 1972; Huiskes 1979; van der Putten et al. 1989). It is thus not our intention to repeat this work in South Africa. However, it is important that we know the present distribution of the species and also where extensive stabilization projects are still in progress. These are mostly or more recently being undertaken by the Council for Scientific and Industrial Research (CSIR), Division of Earth,

Fig. 2. *Ammophila arenaria* (Marram grass) in abundance on the Alexandria dune fields in 1986. When the authors visited the same site in 1994, they found only a few isolated clumps of Marram grass in the vicinity.

Marine and Atmospheric Science Technologies (EMATEK), where problems of dune movement have been recognized. A survey of the distribution of marram grass will include mapping of the marram communities and their sampling for density and species diversity. A comparison will be made with the marram grass communities in Europe, where the plant occurs naturally. On a few selected sites more detailed investigations will be carried out on the population biology of the marram communities and on succession patterns within these communities. A preliminary observation in both South Africa and Europe (Lubke pers. observ.) is that marram grass forms monospecific stands in South Africa with little potential for other pioneer species to invade. Because of the unavailability of suitable grass and herbaceous species to grow under such conditions, a variety of secondary colonizers do not invade into the dense grass community. The main mechanism of plant succession on natural dune communities in South Africa is autogenic, and Avis (1992) showed that the Facilitation Model of Connell and Slatyer (1977) best described these successional changes. Our observations on marram grass suggest that in these communities the Inhibition Model may also apply. If this is the case, then a self-perpetuating natural plant community will not be the end product. This can be a problem in dune stabilization, since marram grass may die out without leaving species to replace it. Another focus will be on the reproduction of *Ammophila arenaria*. In Southern Africa it is said to spread almost entirely vegetatively, but recent discoveries of seedlings prove this to be wrong.

No work has been done on the vesicular-arbuscular mycorrhiza (VAM) of introduced or indigenous dune pioneer species in South Africa. VAM have been shown to be important in controlling the spread of pioneer plants and also aid in the uptake of nutrients by dune plants (Ernst et al. 1984). Thus it is important that we initiate a programme looking at the availability of VAM species in the dune soils along our coastline, and also along profiles from pioneer to climax communities. Similarly, studies on nematodes have shown that they can be responsible for the decline in pioneer plants (van der Putten et al. 1989, 1993; van der Putten & Troelstra 1990), and this type of study also needs to be extended to South African dune systems. Should some marram grass have been introduced from cuttings, the nematode and VAM species may well have been introduced from Europe, as is the case with many of the fungal mycelia found on trees such as *Pinus* spp. (Levin et al. 1985).

The use of marram on foredunes has been very successful in the Cape and no indigenous species has yet been found to be as useful as a stabilizer species. The study is intended to provide information on the autecology of indigenous dune pioneer plants and to find a

suitable alternative to marram grass for the purpose of dune stabilization in South Africa. *Agropyron distichum* (*Thinopyrum distichum*), or sea wheat, is supposedly an introduced species but occurs naturally all along the Cape coast almost reaching East London. This species is very often the pioneer of the foredunes in the southern Cape, with marram grass growing behind on the next dune ridge. The species seeds readily and young plants and seeds are known to wash up and germinate on the strandline (P. Reyneke pers. comm.; R. Lubke pers. observ.). We feel that this species is more likely an indigenous, widespread cosmopolitan species which grew naturally in the temperate regions of the Cape. It should be investigated in more detail as a possible pioneer in stabilization regions, with the potential of breeding up more vigorous strains. On the rear dunes *Myrica cordifolia* (waxberry) has been the most successful plant used in dune stabilization work (Cobby 1988; Avis 1989). *Ehrharta villosa* var. *maxima* is a species commonly found in these regions, occurring in a number of dune habitats, including foredunes (Lubke 1993). It has been the subject of a number of autecological and ecophysiological studies (Hoare 1994) and more emphasis needs to be placed on the cultivation of the plant in dune stabilization. Along the Natal coast *Scaevola plumieri* is the primary colonizer but this species is very difficult to cultivate either from seeds or from cuttings. It invades naturally into the foredunes of mobile dune systems. Because of the lack of extensive dune fields in Natal and the presence of natural dune stabilizing species, there seems little reason to extend studies on indigenous species to be used in these regions.

Conclusions

As yet, it is unknown whether *Ammophila arenaria* is a problem species in South Africa. However, because of the concern which has been expressed, it is important that a detailed study be made of the species and its use in dune stabilization. As yet we have no evidence of marram grass becoming established in any area where it was not previously planted. We need to establish the extent and present distribution of populations of marram grass around the Cape coastline, and determine how and when these were established. Changes in these communities over time, including the seed production and reproduction of marram, will be studied. A comparison with the behaviour of the plant in northwestern Europe will also be made.

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