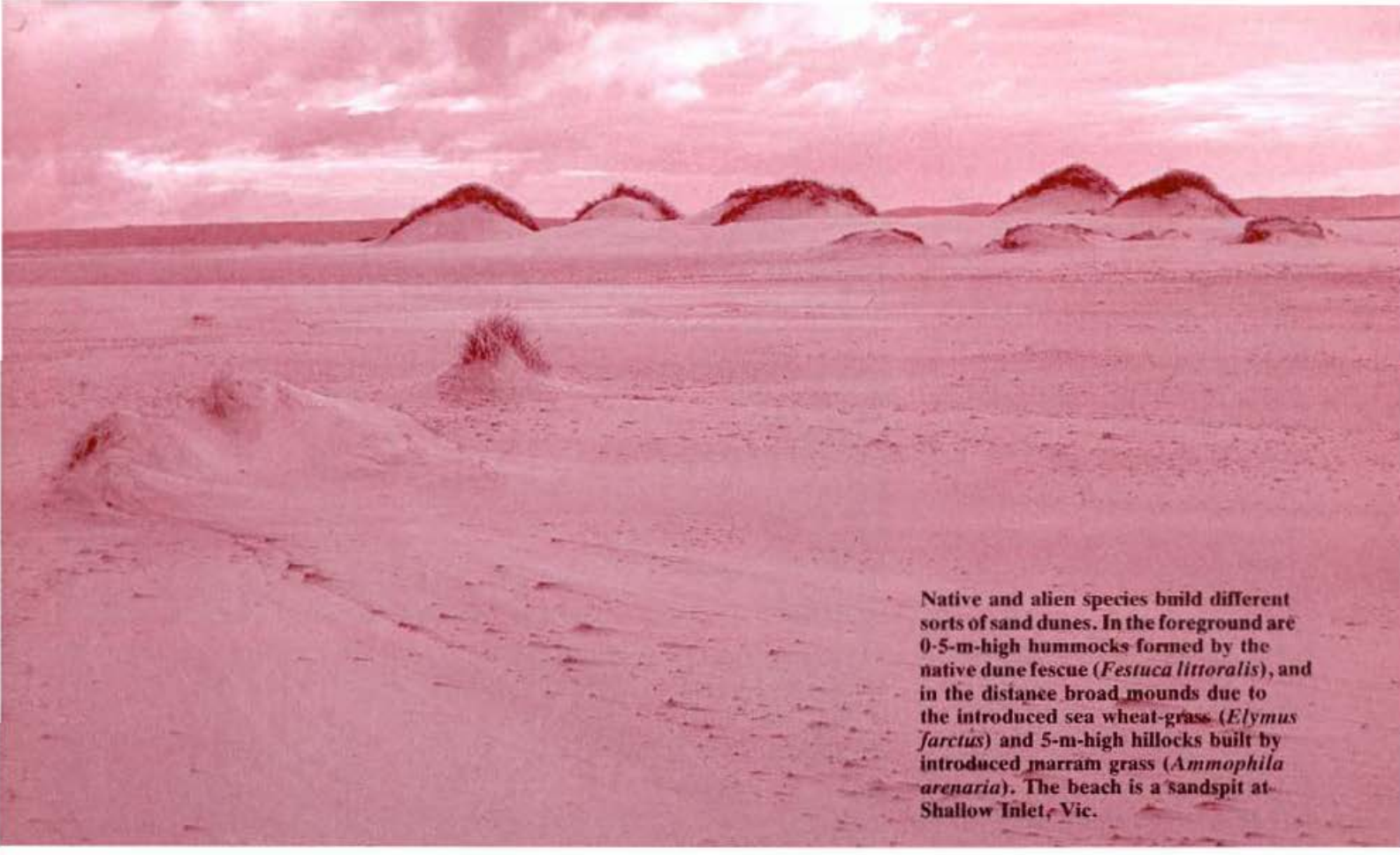


Native and alien species build different sorts of sand dunes. In the foreground are 0·5-m-high hummocks formed by the native dune fescue (*Festuca littoralis*), and in the distance broad mounds due to the introduced sea wheat-grass (*Elymus farctus*) and 5-m-high hillocks built by introduced marram grass (*Ammophila arenaria*). The beach is a sandspit at Shallow Inlet, Vic.

Alien dune plants reshape our beaches

European immigration has greatly changed the face of Australia. To give added dimension to that change, several introduced plants — some through their own tenacity, others through use by well-meaning foreshore managers in stabilising coastal dunes — have proliferated and are altering the appearance of our coastline.

Bitou bush is an example that has made headlines (see the box), but according to studies by Dr Petrus Heyligers of the CSIRO Division of Wildlife and Rangelands Research, some grasses and herbs have an equally remarkable (albeit frequently overlooked) effect on the coastal scene.

Plants have a big influence on the type of dune formed. For example, at several locations along the Gippsland coast of Victoria, instead of low and wide foredunes characteristic of areas dominated by native grasses, hillocks 5 metres high are now found. The cause of this change is the introduced marram grass (*Ammophila arenaria*).

Dr Heyligers finds that about one-quarter of the 50 plant species that now occupy foredunes in south-eastern Australia are alien. 'The chance of finding a section of coast where foredunes carry only native vegetation is small indeed', he says.

Fortunately, some isolated patches still remain where the influence of introduced species is negligible. In some areas, patches dominated by native species lie within relatively short distances of others dominated by exotics. Dr Heyligers uses such areas, stretching from Wilson's Promontory in Victoria to Fowler's Bay in South Australia, to study how the local and foreign flora differ in their ecology and, in particular, their dune-building properties. This stretch of coastline ranges from temperate well-watered environments to semi-arid habitats, and provides a broad spectrum of floristic types.

Plants and dunes are part of a dynamic interplay. Certain plants help dunes form, and dunes create particular ecosystems for various other plants, which in turn affect the stability of the dunes. The process is a complex one involving wind, water, and sand supply, as well as the availability of suitable plant material; the ecological factors involved are not well understood. Wilson's Promontory provided an ideal natural laboratory, he found, with beaches that differed in these characteristics occurring close to each other.

Dr Heyligers' initial aim was to document the role of plants in initiating dune formation. He didn't expect to find that several introduced species, particularly European sea rocket (*Cakile maritima*), sea wheat-grass (*Elymus farctus*), and marram grass (*Ammophila arenaria*), could play such a dominant role in shaping our foredunes. It turned out that, due to their different ecology, they frequently established ahead of their native counterparts, in many cases building their own characteristic hillocks where none had existed before.

Small beginnings

Without vegetation, the upper beach would be largely flat and uniform, with sand shifting around according to the direction of the wind. Once a plant has established a toe-hold, however, a nucleus for a sand dune has been created.

The beginnings of sand dunes. *Right*, sand building up in the wind shadow of a marram grass tussock; *below right*, shadow dunes behind European sea rocket. The shape of an embryonic dune reflects the shape and growth habit of the plant behind which it forms.

We are talking here about foredunes, a term Dr Heyligers uses to characterise embryonic dunes. They are all those accumulations of sand between the high-water mark and the stable land forms further inland (which could include 'permanent' back-dunes). Full-blown foredunes start out as small piles of sand, and progress through ridges or terraces to grow into more-or-less stable structures (which coastal home-dwellers are so desirous of maintaining).

For a substantial foredune to eventuate, an ample supply of wind-borne sand is needed. The curtains of sand grains seen dancing over a still-wet beach are bound on an important mission. They settle at sites where the wind velocity falls below the pick-up threshold — behind an obstacle such as a piece of driftwood, article of flotsam, or a freshly germinated plant, for example.

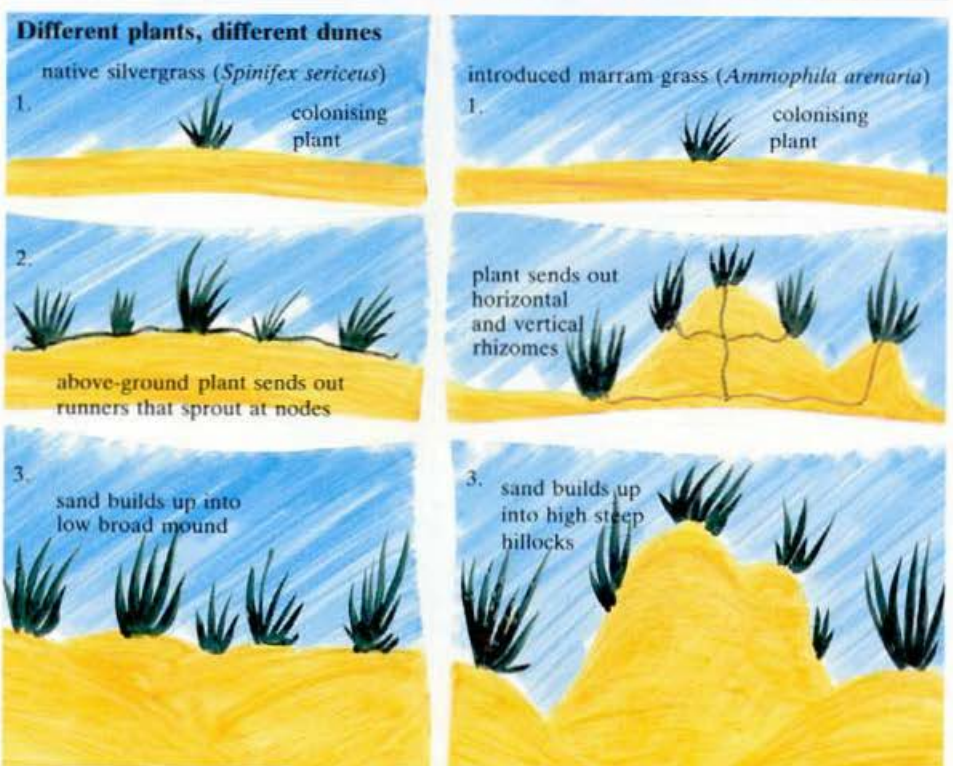
In this way, a 'wind-shadow dune' is created in the wake of the obstacle. If the obstacle is a plant, then a unique self-sustaining process can take place: the plant, and the dune, can grow.

The dune expands with the growth of the plant and, as Dr Heyligers emphasises, the growth habit of the plant — including its height, width, flexibility, and shoot density — and environmental factors together determine the ultimate shape of the foredune. The shape of a shadow dune bears the imprint of the plant type — if not the plant species — behind which it has formed.

Low horizontally spreading plants generally build low wide dunes, whereas tussocks and upright bushy plants tend to construct isolated high dunes. As the most widespread introduced grass, marram grass, forms tussocks, and the most common native grass, silvergrass (*Spinifex sericeus*), spreads horizontally, the embryonic dunes built by these two sand-dwellers have different shapes.

Moreover, since the introduced plants grow faster, in general, than their native

Both these species are good at trapping wind-blown sand. But whereas the native plant spreads horizontally, its introduced counterpart extends vertically as well. Our southern beaches are changing because of it.



Marram grass grows so fast vertically that it can construct sand dunes with very steep sides — steeper than the angle of repose of bare sand (about 30°). These hummocks are on the Victorian coast opposite Gabo Island.

The three introduced species mentioned earlier stand out as prolific colonisers that are dune-builders *par excellence*.

European sea rocket is undoubtedly the most common pioneer of the upper beach. It tolerates salt spray, sand-blasting by ferocious winds, and partial burial. Its growth habit gives rise to a congregation of irregular low dunes usually less than 0·5 m high.

The plant gained a foothold in Western Australia in the 1890s, probably as a stowaway on a ship that emptied its ballast tanks near Fremantle. It spread east, presumably on ocean currents, reaching South Australia in 1918 and Victoria 4 years later. In the early 1960s it appeared on the southern coast of New South Wales.

Before it arrived and spread, botanists frequently reported incipient foredunes formed by the native dune fescue (*Festuca littoralis*). Since the '60s, however, such reports have been rare, and European sea rocket has probably become more common than its native competitor ever was. The one consolation is that the shapes (although not the sheer numbers) of both sorts of foredunes are about the same.

Such cannot be said for other introduced grasses, which give 'foreign takeover' an entirely new meaning. They have remarkable dune-building abilities: a single individual of marram grass, for example, can build up a steep-sided hillock 4–5 metres high.

Marram's rapidly growing rhizomes, and the sand-trapping dense tufts that shoot up from them, can keep a dune rising at rates of up to 1 m per year. Because of wind funnelling — the process whereby air speeds up around obstacles — gullies between the hillocks are maintained, keeping the hillocks isolated from one another. Since the plant needs fresh water for optimum growth, it frequently appears as a secondary coloniser, taking over shadow dunes started by salt-tolerant pioneer species.

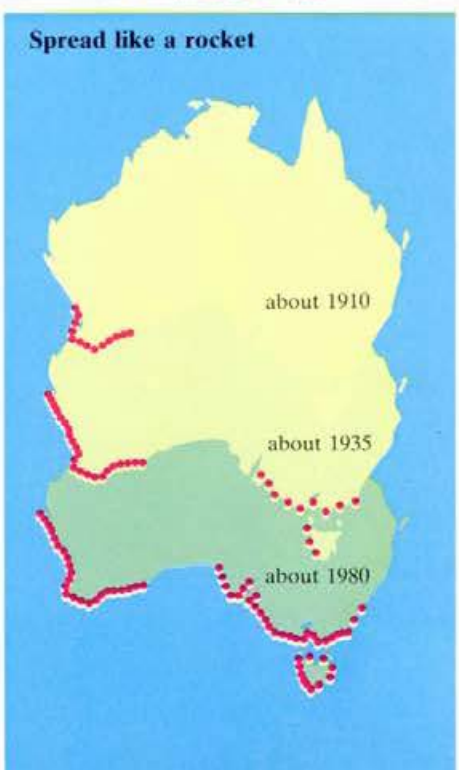
Marram grass originated from Europe and North Africa, and was introduced in Victoria in 1883 to fix the sand drifts near Port Fairy. It is still commonly used for dune restoration, especially in temperate high-rainfall areas. Planted or spontaneous, the vigorous plant can now be found in the south-west of Western Australia, and from Eyre Peninsula in South Australia to southern Queensland.

If it weren't for European sea rocket, there'd probably be no dunes here. A beach at Cape Jaffa, S.A.

counterparts, they can trap sand at a faster rate, and create much larger dunes.

Beach colonisers

Dr Heyligers has studied the growth habits of some dozens of foredune species, both indigenous and imported. Many of them perform only an auxiliary role in dune-building, either because they act more as stabilisers than builders, or because they are not abundant enough to dominate a dune on their own.



How the European sea rocket has invaded our beaches, as reconstructed from herbarium records.

Counter-offensive on bitou bush

Bitou bush — also known as Higgins' curse — at Moruya, on the New South Wales south coast.

Bitou bush, boneseed, jungle weed, South African star bush, Higgins' curse — they're all common names for *Chrysanthemoides monilifera*. This particularly aggressive exotic plant was widely used from about 1950 to 1970 for sand-dune stabilisation and got out of control; it has now become the scourge of the New South Wales coastline. The plant is turning vast stretches of foreshore into impenetrable thickets, and choking out native plants such as banksias, wattles, tea trees, grasses, and heaths.

Unlike marram grass, sea wheat-grass, and European sea rocket, discussed in the main story, bitou bush is not a pioneer species, or dune-builder, and so doesn't alter the physical shape of our coastline. It takes over during the later stages of plant succession, and hence is more likely to occupy the back-dunes rather than the foredunes.

Moreover, its invasion of the colder southern coastlines (that have been the main focus for Dr Heyligers' studies) has been somewhat more restrained.

Nevertheless, the way it has now come to dominate more than 200 km of the New South Wales coast dramatically illustrates how easily coastal-zone ecology can be disturbed. Along with the other exotics that have proliferated after dune-stabilisation programs introduced them, it makes us consider what price we place on keeping frontal dunes 'stable' in an environment that, by its very nature, is dynamic.

Currently, bitou bush is completely absent on only 40% of the New South Wales coastline. It occurs on 80% of the State's headlands, and grows in at least 12 national parks and nine nature reserves. Potentially, it could almost completely dominate the entire coastline of the State, and perhaps extend its range to Townsville, Adelaide, and tens of kilometres inland.

Because its rate of spread outpaces all standard efforts at control, the CSIRO Division of Entomology has begun a search for biological control agents. Preliminary surveys revealed that bitou bush was not generally seen as a pest in its native South Africa, largely due to a complex of insects and fungi that were found to attack it.

Since the beginning of 1987, Dr John Scott of the Division has been working at the University of Cape Town in a study of the natural enemies of the plant. The project is supported by the Council of Nature Conservation Ministers (CONCOM) with funding from CSIRO, State National Park Services, and the New South Wales Soil Conservation Service.

The program is a co-operative venture between CSIRO and the Keith Turnbull Research Institute (KTRI) of the Victorian Department of Conservation, Forests and Lands. Dr Scott will survey the weed in South Africa and send promising agents to KTRI, which will carefully test them to ensure they are sufficiently specific to bitou bush to be safely released.

So far, a number of likely natural enemies have been identified. They include stem-borers, root-borers, leaf-eaters, and seed-attacking insects. Since bitou bush produces much more seed here than in its homeland, scientists favour releasing seed-attacking agents first. The work has just started, but it's possible the first agent could be imported for testing in 1988.

Bitou bush and boneseed. *Proceedings, National Conference on* Chrysanthemoides monilifera, *Port Macquarie, August 1984.*

A case in point

Dr Heyligers can give numerous examples of how exotic species have changed the Australian sand-scape. One impressive case concerns Waratah Bay, at the base of Wilson's Promontory, where a vast sand spit, about 3·5 km long and up to 1 km wide, separates Shallow Inlet from the ocean.

When the inlet was first surveyed in 1841, the spit was mapped as 'drift sand'. Until the early 1960s, the spit remained bare sand, undergoing at least one and possibly two episodes in which it was washed away (and re-formed).

Then, Dr Heyligers surmises, some fragments of sea wheat-grass were washed onto the spit and changed the course of events. This hardy sand-colonising plant, indigenous to the Mediterranean, was accidentally introduced (probably via ship's ballast) to Port Phillip Bay in the early 1920s. It is steadily increasing its territory, having now spread as far afield as South Australia, where, within relatively few years, it has become prominent on beaches around Adelaide.

Because of its extreme hardiness and salt tolerance, it is a colonising species without equal among the native flora. In the late 1950s the Soil Conservation Authority of Victoria happened to use it in dune reclamation trials at Picnic Point, only 20 km from the spit.

This undertaking was the most likely source of fragments that started dune formation on the spit, as we have aerial photographs taken in 1965 that show the first low mounds. The mounds, and their *E. farctus* cover, are still there today, but haven't they grown! The dunes are 6 m high, 800 m long, and about 200 m wide.

This remarkable feat of dune-building has been helped in its later stages by our acquaintance, marram grass, as well as native silvergrass and dune fescue. Without the two alien plants, the spit would have remained bare or, at best, would have formed low dunes with dune fescue as coloniser. Because the dunes now present are so huge, Dr Heyligers believes they are 'permanent', in the sense that even a violent storm would not wash them away — the neck of the spit may be consumed, but the dunes will remain as islands.

Andrew Bell

More about the topic

The impact of introduced plants on foredune formation in south-eastern Australia. P.C. Heyligers. *Proceedings of the Ecological Society of Australia*, 1985, **14**, 23–41.