

(the main big animals on the dunes) slowed the increase outside somewhat. An overall increase in spinifex within the big enclosure compared with a decline outside supports this explanation. Cattle and sheep were seen browsing both marram and spinifex.

Within the rabbit enclosure, the greatest part of the vegetation increase was contributed by a burgeoning of marram, greater in magnitude than elsewhere. However, there were comparable increases in spinifex and *Coprosma acerosa* as well. All the other vegetation increased slightly. From this it is possible to conclude that rabbits are major browsers of marram, spinifex and *Coprosma acerosa* at Ocean Beach and that they eat other plants also, though to a lesser extent. Observations in the field bear this out.

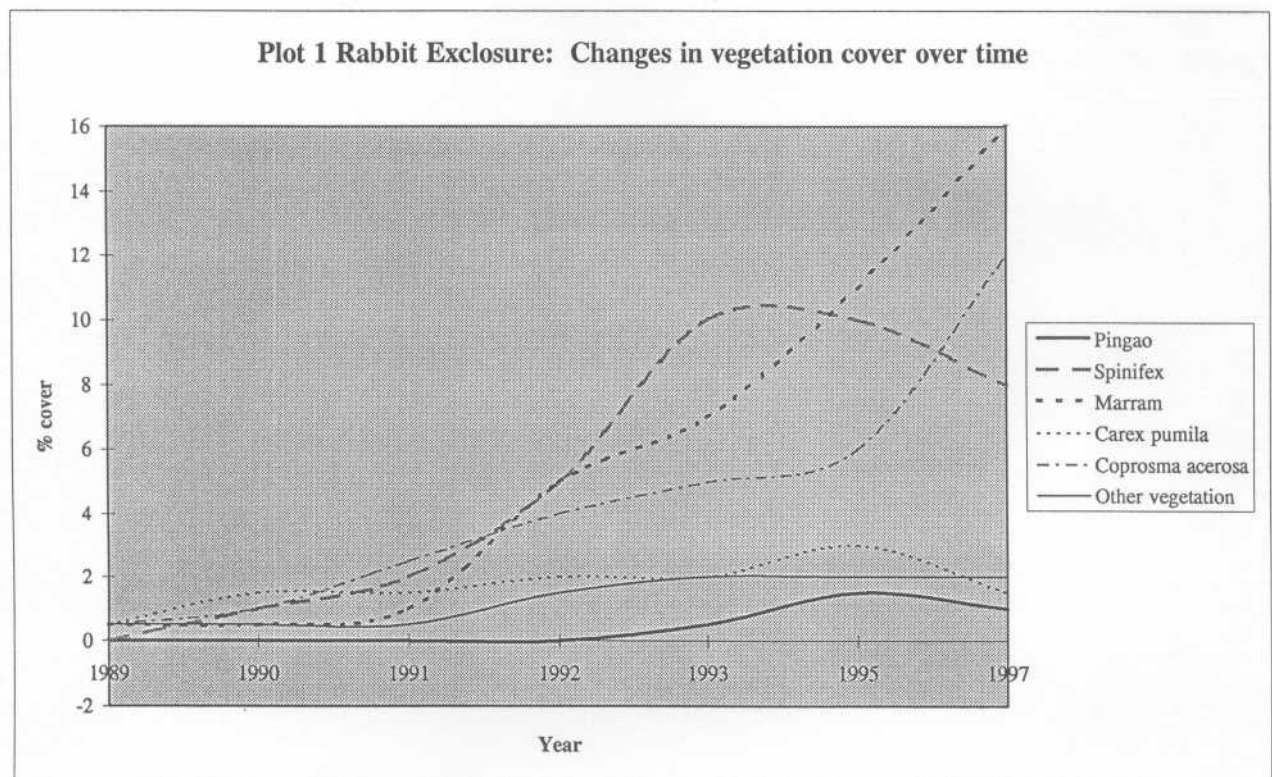


Figure 8. Changes in vegetation cover, rabbit enclosure, Plot 1.

4.1.2 Pingao

Because of a concern for pingao (Figure 24) at Ocean Beach, it was the subject of a particular focus. Living tufts of adult plants within the plot were counted at each measurement. So too were seedlings. The tuft counts show a trend of increase followed by decrease in all situations tested (Figure 9). This requires an explanation independent of browse. The obvious one is weed competition. I think it is necessary to look no further than that from marram grass, which increased dramatically in each situation, the decline in pingao corresponding to the burgeoning of the marram. The two plants overlapped in each place, the marram progressively invading the pingao's space.

The fact that the pingao increased at all, and did so most markedly in the control plot, needs another explanation. This happened I think because fresh sand was blown into the plot area, providing "new ground" for the pingao to

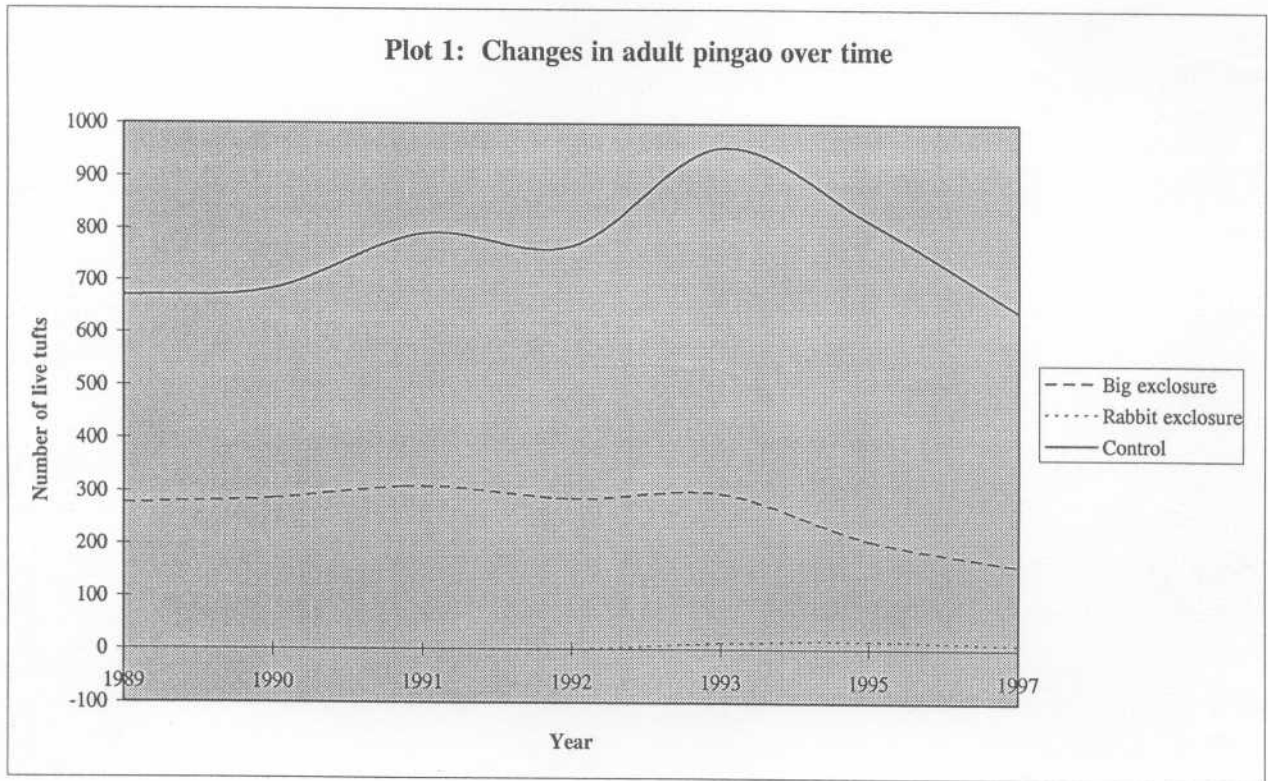


Figure 9. Changes in adult pingao in Plot 1 over time.

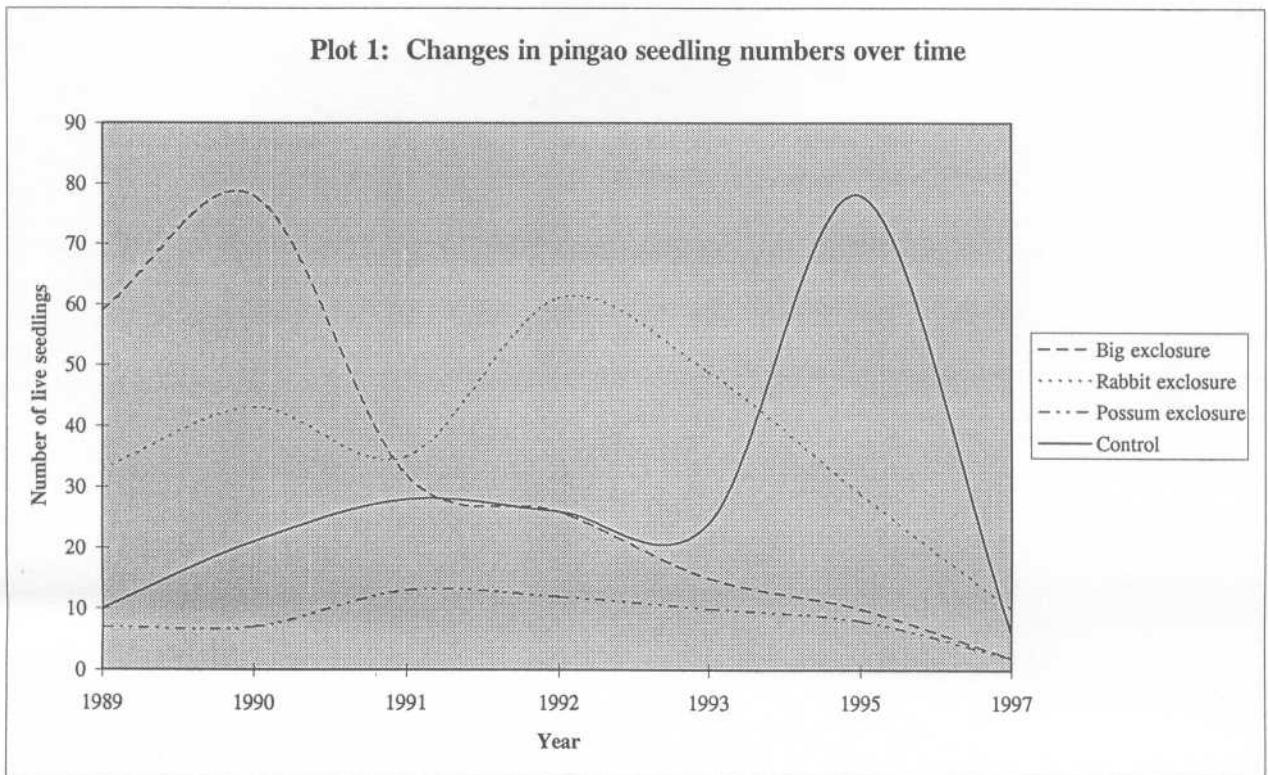


Figure 10. Changes in pingao seedling numbers in Plot 1 over time.

travel into and an injection of substrate and nutrients as a stimulus to growth. Unfortunately for the pingao, these conditions also encouraged the marram grass, which then began winning out. Over the next decade, unless there is some intervention, I would expect the marram to progressively dominate the pingao on the study site. The adult pingao will only persist on the newly drifted sand.

The pattern in the numbers of pingao seedlings (Figure 10) is fascinating. The trends with time scarcely correspond, except for those within both the rabbit enclosure and the possum enclosure, in which there was an increase followed by a substantial decline after 1992. In these two enclosures, the seedling densities were much higher than in the larger plots. They were initially located where they were for that reason, but the survival rates for their seedlings were also much higher. The figures alone suggest that rabbits, far more than possums, are responsible for preventing pingao seedlings persisting and maturing into adulthood at Ocean Beach. The visual confirmation of this was overwhelming. Seedlings alongside the rabbit enclosure were decimated by rabbits (Figure 25), whereas those a few centimetres away but protected from rabbits (but not possums) were unscathed and grew rapidly into adult plants (itself a contributor to the decline in the number of seedlings present!). Although even heavily browsed seedlings did recover, they were set back severely. Repeated browsing killed them.

The peaks in the graphs of the numbers of seedlings in the big enclosure, rabbit enclosure and control indicate "flushes" of seedlings that appeared for a while and were gone soon after. This was clearly not solely the result of rabbit browsing. Pingao seedlings are initially tiny things with a single fine leaf. They are very vulnerable and their environment is a harsh one (Figure 26). If they fail to send their roots down quickly enough to where the sand is moist they are doomed. If they get buried by drifting sand or undermined by wind deflation they are unlikely to survive for long. They also suffer from competition for moisture, nutrients and light from other plants. The best sites for them to germinate and grow are dune hollows or flats that are just too dry for other vegetation but provide sufficient stability and moisture for the seedlings to persist. So for most of the new seedlings that appear, often as a delicate green haze in a patch in the dunes, their future is curtailed by largely natural processes. This conclusion is supported by the fact that the seedling numbers declined overall in every situation. However, I believe that rabbit browsing is responsible for almost entirely preventing pingao seedlings being recruited into the adult population on the Ocean Beach dunes.

Adult pingao was seen to be relatively resistant to rabbit browse, although fresh new growth on runners was frequently browsed very hard (Figure 25). Sheep, horses, goats and cattle were all recorded browsing adult pingao (rarely seedlings, which I presume are too small to be targeted). Of them, cattle were by far the most damaging (Figure 27). They chew the leaves into a fibrous mass, then lift their heads, still chewing, which rips whole stem sections out of the sand and either breaks them off or leaves their roots exposed. Their great oafish hooves are capable of considerable damage to pingao runners too. Possums, although frequenting the dunes, were detected browsing pingao very rarely. I suspect their impact on the dune vegetation is relatively minor and that they seek out mainly pasture grasses and leguminous herbs.

Hares were present, but in such low numbers I could get no sense of their impact.

Physical damage to both adult and seedling pingao by off-road machines (quads, trail bikes and 4WD vehicles) was observed at Ocean Beach (Figure 28). The adult runners on dune faces were most badly affected, being frequently broken or ripped out. Flower heads were often flattened when run over. In total, the impact of these machines on the pingao during the study was much less than that of cattle and rabbits, but it was severe enough locally to cause the demise of plants in marginal situations and to set off episodes of destructive wind erosion through disturbance.

Wind appeared to have a substantial influence on pingao during the study. The photopoints showed this best (Figure 29). Whole areas of apparently healthy adult pingao progressively lost vigour and crumbled, eventually dying and being blown away. I believe that this is largely a natural process, and that pingao is a plant that goes with the flow of the sand on dunes, but that wind isn't the only factor. Pingao's healthiest new growth is invariably on new-built sand. Once it is well established as a clump or patch, the sand it clasps becomes relatively stable. Presumably the pingao progressively extracts the nutrients and moisture it requires, growing until the limits to the capacity of that bit of the dune to sustain it are reached. Then it loses thrift and dies back. Meanwhile, at its extremities the pingao flourishes, so long as there is new sand to colonise. Thus individual pingao plants move around the dunes according to conditions. It is possible therefore that some of the plants on the dunes are truly ancient - as old as any plants on earth.

The final influence on pingao that was observed during the study was that of competition. The main potential competitors were spinifex and (as already mentioned) marram grass, since they all occupied much the same niche.

Spinifex was found growing with pingao in many places. In each case the pingao continued to thrive for years, as did the spinifex. Spinifex was documented several times sending runners into pingao clumps. Again, both pingao and spinifex remained healthy.

By contrast, wherever marram grass and pingao occupied the same space (Figure 30) the pingao lost vigour and died back. The graphs in Figures 6-8 illustrate the effect on a larger scale as the marram has burgeoned and the pingao has declined. This is an interaction that has been documented elsewhere (Partridge 1991). The marram is considered to outcompete the pingao for available moisture; possibly also nutrients. There is no doubt in my mind that marram grass is a very serious weed of the Ocean Beach dune system.

Other plants (notably *Coprosma acerosa*, hare's tail, various pasture grasses, rosette plants and leguminous herbs) certainly grew with pingao in the study area. They were almost invariably among mature stems and old roots of adult pingao that had begun to decline for the reasons described earlier as a consequence of the maturing process. I found no evidence of significant competition from these other plants: they were simply taking advantage of the relative stability provided by the old pingao.

4.1.3 Spinifex

Not so spectacular as pingao, spinifex (Figure 31) is the quiet native sandbinding expert, so to speak, running about and clothing the naked sand with great ease.

The graph of changes (Figure 11) strongly suggests that spinifex is quite palatable to browsing mammals and is adversely affected by them. The basic evidence is that spinifex increased overall in both exclosures, whilst suffering a slight decline in the control plot. This is backed up by observations that were made of browsing of both adults and seedlings by domestic stock, goats and rabbits. Figures 6-8 illustrate a latter decline in spinifex, echoing that of pingao, that coincided with the rapid increase in marram grass - hence the conclusion that marram is a serious competitor with spinifex and therefore a weed in the Ocean Beach context.

Spinifex demonstrated a remarkable ability to take advantage of the changing patterns of sand in the dune system, even more so than pingao. Its "tumbleweed" seedhead that can blow all around the dunes is the obvious example of that. Less obvious is its stunning growth rates. I recorded runners extending more than five metres in just a year: growth to make any plant opportunist proud. What this meant was that spinifex could very rapidly colonise new sand nearby, retreat from unfavourable conditions or survive even deep inundation. The only conditions it couldn't handle well were those of major sand deflation by wind and competition with marram grass. It was less prone to vehicle and cattle damage than pingao, and better able to recover after such damage.

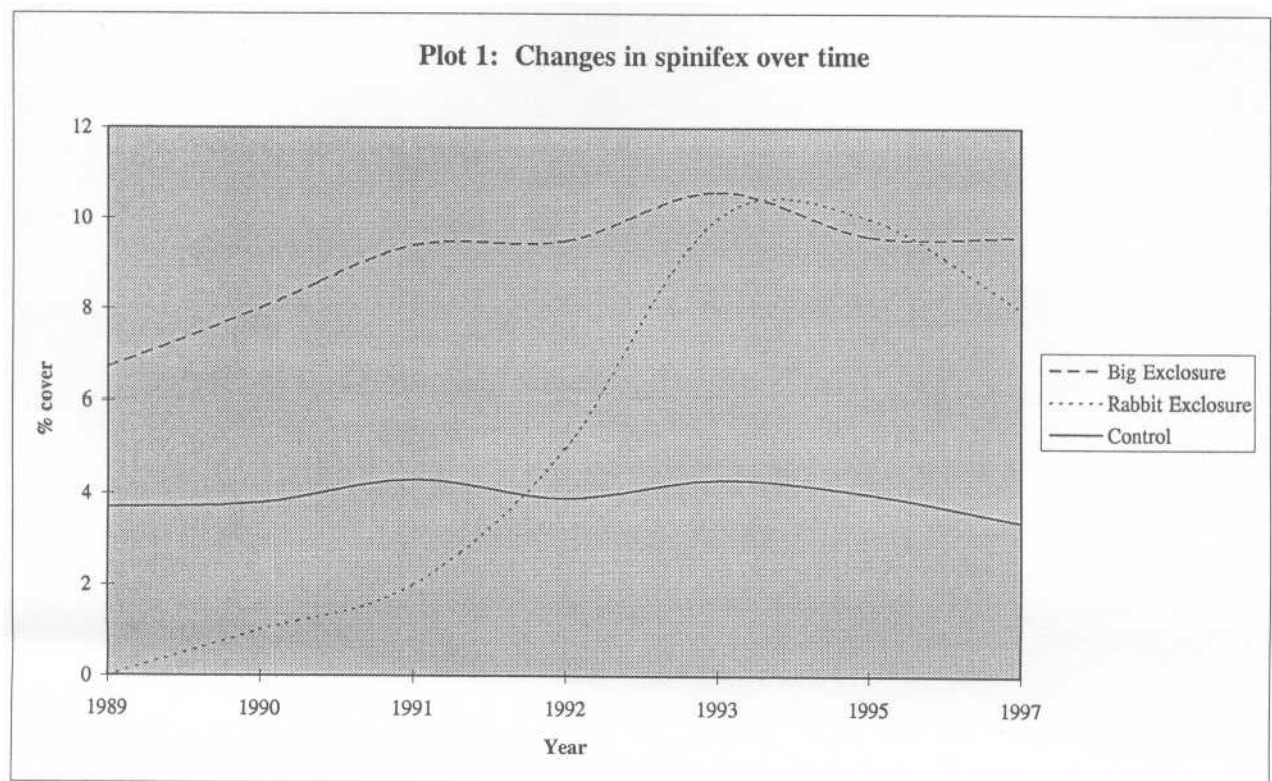


Figure 11. Changes in spinifex over time, Plot 1.

4.1.4 Marram grass

The finger has already been pointed at marram grass (Figure 32) as a serious weed of the Ocean Beach dunes. That is because this study has documented its adverse impact on the native vegetation. Figures 12 & 33 show how the percentage cover of marram increased markedly in all three situations in Plot 1. Within the rabbit enclosure there was a veritable explosion of marram, a 32-fold increase in eight years. Within the big enclosure there was an almost four-fold increase in the same time. Within the control, the increase was a mere near-doubling. It is tempting to conclude that the relative differences are due solely to browsing: that rabbits kept the marram in check to a considerable degree and that the larger browsers to a lesser degree. I believe there is truth in that conclusion, supported by observations of marram being browsed by these animals. However, there is also another factor.

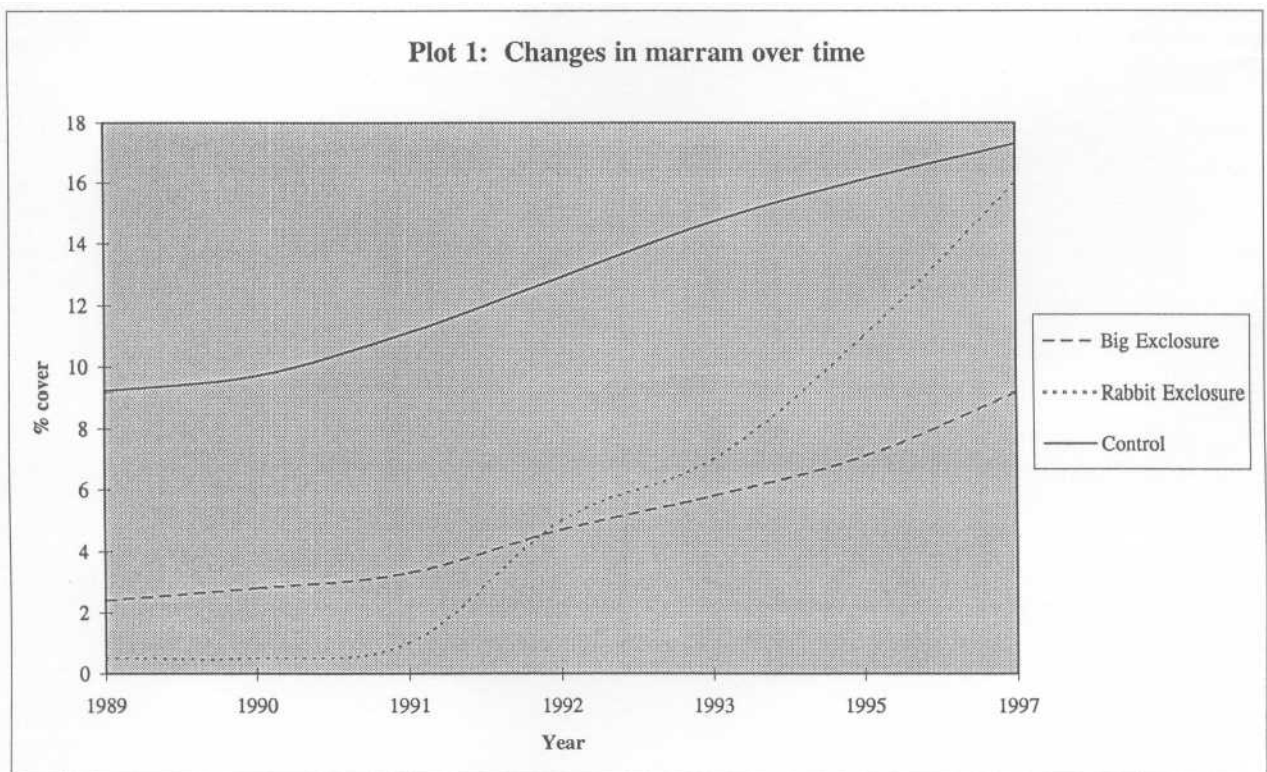


Figure 12. Changes in marram over time, Plot 1.

Marram grass is still invading the Ocean Beach system. Like the native sandbinders it thrives best in newly deposited sand. Unlike them it stabilises sand to a far greater degree and can handle a fair amount of stability, which is why it is a problem for the native plants that rely on sand flow but is beloved by those to whom sand flow is a worry. Once marram stabilises a site it does itself out of new sand to colonise, and merely sits and thickens. The inevitable medium-term result, if there is no intervention, is a sand dune system almost entirely covered in marram. In the longer term, the marram is likely to be replaced by self-sown shrubs, small trees, scramblers, grasses, rushes, sedges and other non-dune plants, ending up with a weedy vegetation that has lost its native duneland character.

In parts of Plot 1, this process is already well advanced. Marram is firmly established and changes little from year to year except to spread around its