RESEARCH REPORT

Establishment of native grassland vegetation at Organ Pipes National Park near Melbourne, Victoria: Vegetation changes from 1989 to 2003

By Keith L. McDougall and John W. Morgan

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John Morgan *is a lecturer and plant ecologist at the Department of Botany, La Trobe University (Bundoora, VIC 3086, Australia. Email: J.Morgan@latrobe.edu.au).* *This work commenced in the mid 1980s and, with the toil of many volunteers, has greatly changed the appearance of former agricultural land at Organ Pipes National Park on the outskirts of Melbourne.*

Summary Native grassland establishment works undertaken on former agricultural land at Organ Pipes National Park, Victoria, during the 1980s were monitored from 1989 to 2003 to assess whether re-introduced native plant populations had established and persisted at the site. Trends in vegetation were determined by examining the composition and cover of native and weed species in permanent transects at 2-year intervals. The average number of native and weed species in plots changed little over 15 years, although weed species richness exhibited great variability. Of the 85 native species introduced to the grassland by seed, sods and tube-stock, 33 were still present in 2003. The dominant native species, Kangaroo Grass (*Themeda triandra*), the native intertussock spear grasses (*Austrostipa* spp.), and the nationally endangered Large-headed Groundsel (*Senecio macrocarpus*), have become common elements of the grassland but most other native species remain minor components. The cover of native and weed species has fluctuated dramatically over the study period in response to fire and drought. While the site remains largely weedy, the project has served to introduce native species into a secure reserve. It is clear that on-going management (weed control, fire) and supplemental plantings will be necessary to maintain and expand the native species populations in the re-established grassland.

Key words *Kangaroo Grass, monitoring, restoration, seed sowing, transplants.*

Introduction

The native grasslands of western Victoria have been severely depleted due to more than 100 years of agricultural use. Less than 5% remains and the community is now recognized as being amongst the most threatened in Australia (McDougall & Kirkpatrick 1993). Around Melbourne, grasslands have been further threatened by urban expansion during the last 20 years (McDougall & Kirkpatrick 1993; Williams *et al*. 2005). Protection of a small number of urban grassland remnants in the 1980s was achieved by reservation and planning controls, but many other remnants were lost to housing and infrastructure development. As such, the community remains threatened with extinction and dependent on the reservation, sympathetic management and restoration of the remaining small patches.

In the mid 1980s, the National Parks Service of Victoria conducted trials into the establishment of Kangaroo Grass (*Themeda triandra*) at Organ Pipes National Park near Melbourne (McDougall 1989). The trials were expanded in the late 1980s to include other native grassland plant species. The aim of the work was not to construct a replacement for the natural grassland remnants lost in nearby areas (i.e. to replicate the original community as has been the aim of many North American prairie restorations (e.g. Sluis 2002)) but rather to: (i) provide a refuge for displaced grassland species (many of which are now very rare in the region); (ii) improve knowledge about the ecology of grassland species and their establishment requirements; and (iii) better understand the patterns and processes underlying grassland communities (McDougall & Morgan 1990).

Between 1988 and 1993 grassland species were established at Organ Pipes National Park using seed and vegetative material collected from grasslands on nearby development sites. Since 1993 there has been little further species augmentation. The focus for the site has now shifted to the recovery of threatened grassland fauna.

To assess the establishment and spread of the reintroduced grassland species at Organ Pipes National Park, permanent plots were set up early in the program. Species composition and cover were monitored on the site biennially between 1989 and 2003. This paper reports on changes that occurred in that time. The value of the project and the future of grassland re-vegetation are discussed.

Methods

The establishment site

Organ Pipes National Park (OPNP) is situated 20 km north-west of Melbourne (Fig. 1). The Park straddles Jacksons Creek, a stream that has cut into the flat basalt plain exposing the sedimentary material below. Historically, the land around Jacksons Creek was used for farming. The OPNP was proclaimed in 1972, primarily for the geological features exposed in Jacksons Creek. At that time, the park was largely dominated by weeds such as Boxthorn (**Lycium ferocissimum*) and Artichoke Thistle (**Cynara cardunculus*) and severely

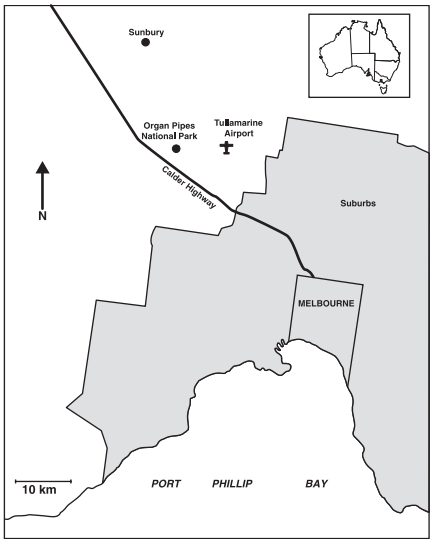

Figure 1. Location of grassland re-establishment trial at Organ Pipes National Park near Melbourne.

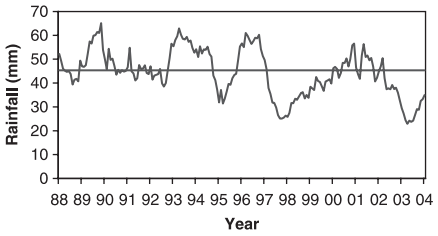

Figure 2. Rainfall (12 month running average) for Melbourne Airport (the nearest Meteorological Station to Organ Pipes National Park) between 1988 and early 2004. The horizontal line at 45.4 mm represents the mean monthly rainfall for the Station (n = 33 years). The grid ticks on the x-axis represent January in the year indicated.

degraded by rabbit grazing (Kemp & Irvine 1993). [Nomenclature follows Ross (2003). Weed species names are preceded with an asterisk.] Although it contained some remnants of the native vegetation in the valley, there was almost no native vegetation on the better volcanic soils of the plain above, which had been used for cropping.

Based on nineteenth century survey maps of the area, these plains were largely treeless (McDougall 1987) and would have supported predominantly grassland dominated by Kangaroo Grass with an array of intertussock species (Groves 1965), of which many small remnants survive in the vicinity along railway and roadside verges. A revegetation plan was devised to restore native plant communities to the park based on soils, topography and aspect (Kemp & Irvine 1993).

A section of basalt plain (approximately 3 ha) was chosen as the site for the establishment of native grassland. This area is almost flat, with a minor northerly aspect. Soils are heavy red–brown clays that crack in prolonged dry weather. Oats (**Avena* spp.) were grown on the site prior to its incorporation into OPNP.

The annual rainfall at Melbourne Airport near OPNP is 546 mm, evenly spread through the year. During the period of the trial, annual rainfall was at or above average for most of the time until 1997 (Fig. 2). Since 1997, the annual rainfall has generally been below average. The annual rainfall in 1997 was only 57% of the long-term mean.

The area is grazed by rabbits and macropods at low densities.

Plant establishment

Kangaroo Grass was introduced to the site in three ways: (i) in the experimental trials described by McDougall (1989); (ii) as sod transplants from imminent housing developments in the surrounding area; and (iii) as seed-bearing hay from imminent housing developments. The last of these methods accounted for most of the Kangaroo Grass established at the site.

For the hay establishment method, Kangaroo Grass hay was harvested in December/January using a range of mowers (such as the sickle bar mower) that cut near plant bases and leave the hay on the ground. The hay was immediately raked into piles, put into old wool bales, and taken to OPNP for spreading. The hay was spread on the day of cutting at the rate of about 500 g/m^2 (i.e. just enough to cover the ground so that no spaces were visible beneath). This rate was up to 10 times the density of culms harvested. The hay was then trampled to limit displacement by wind, and then left. No weed control took place prior to sowing. Utilizing the hygroscopic awn, seeds then make their way into the ground and usually germinate during the following spring. Although emergence success was not quantified for most of the sowings, it appeared to vary from year to year, probably due to differences in seed viability and establishment conditions.

Other grassland species, many of them regionally rare or uncommon, were introduced to the site as seed, as transplants in sods, and as tubestock grown in a shadehouse at the Park's nursery. The method of introduction, where known, is shown for each species in Table 1. In all cases, except Kangaroo Grass, the total amount of seed and plants introduced was small (generally less than 10 g and 200 plants). All of the seeds (used both for direct seeding and propagation of tubestock) and transplants were obtained from grassland remnants of similar topography and soils within 10 km of OPNP. Most of the seed collection, propagation, sod transplanting and tubestock planting was undertaken by a volunteer group (the Friends of Organ Pipes) and staff at OPNP using the methods outlined by Kemp and Irvine (1993).

Site management

Apart from spot spraying of aggressive perennial weed species such as Chilean Needlegrass (**Nassella neesiana*) and Serrated Tussock (**N. trichotoma*), herbicides were not used on the site. The site was burnt in March 1993, 1995 and 1997 with the aim of favouring native species. Basalt rocks were imported from local development areas and partially buried in soil at the eastern end of the site in the late 1980s to recreate the typical soil surface of local grasslands and potentially to act as habitat for grassland fauna either (i) rescued from neighbouring residential development, or (ii) deliberately introduced as part of species recovery programs.

Monitoring

Six parallel transects, 40 m apart and 120–140 m long, were established across the site in 1989 to sample changes in vegetation with time. Hardwood pegs were placed at the ends of the transects to assist relocation. Quadrats were sampled using a 1 m^2 frame, at 10 m intervals. A total of 76 quadrats were sampled every 2 years in November between 1989 and 2003. All species rooted within each quadrat were recorded with an estimate of cover using the Braun–Blanquet cover abundance scale.

No sampling was done prior to the commencement of establishment trials

Table 1. Native species introduced to the Organ Pipes National Park grassland restoration trial, their method of introduction and persistence (shown by asterisk)

Species	Years of introduction[1]	Method[2]	1991	1993	1999	2003
Acaena echinata	89, 90, 92	a, d	*	*	*	*
Acaena novae-zelandiae	88	d				
Agrostis avenacea		f	*			
Alternanthera denticulata	90	d				
Arthropodium strictum	88	d	*	*	*	*
Asperula scoparia	90	a, c	*	*	*	
Atriplex semibaccata	89	d	*		*	*
Austrodanthonia duttoniana	90	a	*	*	*	*
Austrodanthonia pilosa		e	*	*	*	*
Austrodanthonia racemosa		e	*	*	*	*
Austrostipa aristiglumis		b	*	*	*	*
Austrostipa gibbosa		b, c	*	*		
Austrostipa nodosa		b	*	*	*	
Bothriochloa macra	90	a	*		*	*
Brachyscome basaltica	88, 89	a, c, d	*	*	*	
Brachyscome dentata	89	a, d		*		*
Brunonia australis	89	a, d				
Bulbine bulbosa	92	a	–	*	*	*
Burchardia umbellata		a				
Caesia calliantha		a				
Calocephalus citreus	89, 90, 90	a, c, d	*	*	*	*
Calotis anthemoides		f			*	
Calotis scabiosifolia		f			*	
Calotis scapigera	88–90	d	*			
Carex inversa		c	*	*	*	
Cassinia arcuata	90	a				
Centipeda cunninghamii	89	a				
Chloris truncata	89	a		*	*	*
Chrysocephalum apiculatum	90, 92	a, d		*	*	*
Chysocephalum semipapposum	88, 89	d	*	*	*	*
Comesperma polygaloides		c		*		
Convolvulus erubescens	89	a, d	*	*	*	*
Crassula peduncularis		e	*	*	*	*
Craspedia chrysantha	88–90	d		*		
Cullen tenax	92	a	–	*	*	
Dianella longifolia		c, d	*		*	
Dianella revoluta	89	d			*	*
Dichanthium sericeum		a	*		*	
Dichondra repens		e	*			
Elymus scaber		f			*	*
Enchylaena tomentosa	89, 90	a				
Eryngium ovinum	88, 89, 90, 92	a, d	*	*	*	
Eutaxia microphylla	88, 89	d	*			
Geranium retrorsum	88	d	*	*	*	
Goodenia pinnatifida		c	*			
Haloragis heterophylla	88	d	*	*	*	
Helichrysum rutidolepis	88, 89	a, d	*	*	*	*
Homopholis proluta	89, 90	a, c	*	*	*	*
Hypericum gramineum	88–90	a, d				
Isolepis cernua	90	d				
Juncus subsecundus	90	d, e	*		*	*
Leiocarpa panaetioides	93	d	–	*	*	*
Leptorhynchos squamatus	89, 90	d	*	*		
Linum marginale		a	*			
Lobelia pratioides	90	a				
Lomandra filiformis		d	*		*	*
Lythrum hyssopifolia	89	a	*	*		
Mentha diemenica	91	d	*			
Microlaena stipoides		f			*	
Microseris lanceolata	93	d		*		

Table 1. Continued

Species	Years of introduction[1]	Method[2]	1991	1993	1999	2003
Minuria leptophylla	89	d				
Oxalis perennans		e	*	*	*	*
Panicum decompositum		a	*			
Pimelea humilis		c		*		*
Plantago gaudichaudii		d	*		*	
Poa labillardierei		d	*	*	*	*
Poa sieberiana		d	*	*		
Podolepis jaceoides	88, 89	a, d	*	*	*	*
Pratia concolor	90	d				
Ptilotus macrocephalus		a				
Ptilotus spathulatus	89	d	*			
Rumex dumosus	90	d	*		*	*
Rutidosis leptorrhynchoides	88, 89	d		*	*	*
Schoenus apogon		f	*	*		
Sclerolaena muricata		d	*		*	
Senecio macrocarpus	90	a, d	*	*	*	*
Senecio quadridentatus	88, 89	a, d	*	*	*	*
Solenogyne gunnii	89	a				
Stylidium graminifolium sl	93	d	–	*		
Themeda triandra	86–93	a, c	*	*	*	*
Tricoryne elatior	90	a				
Velleia paradoxa	89	a, d	*	*		
Veronica gracilis	90	d	*	*	*	
Vittadinia muelleri	89	a, d		*		
Wahlenbergia stricta	88, 92	a, d	*	*	*	*
Taxa Recorded			51	46	47	33

[1]Where no date is given, the introduction occurred between 1988 and 1993 but the date was not recorded.
[2]Method of introduction: a, seed, deliberately introduced; b, seed, accidentally introduced in *Themeda* hay; c, transplanted as sods from remnant grassland; d, planted as tubestock grown in glasshouse; e, present at commencement of trial; f, unknown.

(in 1986). At that time, the site was dominated by broad-leaved weeds (mainly Catsear (**Hypochaeris radicata*)). Wallaby grasses (*Austrodanthonia* spp.) were an occasional component of the vegetation, which was frequently slashed for fire protection (McDougall 1989). Due to difficulties with the identification of infertile material, some species were identified to genus only (e.g. wallaby grasses, spear grasses, Oats, quaking grasses (**Briza* spp.), Clovers (**Trifolium* spp.)).

A census of all the native species occurring on the site was made at the time of monitoring in 1991, 1993, 1999 and 2003. The species list made in 2003 is probably incomplete because small forbs were difficult to locate among the tall flowering stems of Oats that dominated the site at that time.

Data presentation and analysis

Mean species richness for natives and weeds was calculated for each survey. Total percent cover was calculated by summing the midpoints of the range for the Braun–Blanquet cover values for all species recorded in each quadrat. Mean percent cover was calculated using the midpoints of the range for Braun–Blanquet cover values.

Results

Of the 85 native species introduced to the site, more than half were found between 1991 and 1999 (Table 1). A total of 33 native species were located in 2003 despite the difficulty in locating individuals at that time. Although counts of the numbers of individuals of each species were not made for all but a few plantings (see Morgan (1999) for details), it is clear that most species have persisted in low numbers. Further, many species seem not to have expanded their range beyond where they were originally planted. Exceptions were spear grasses, Rigid Panic (*Homopholis proluta*), Showy Podolepis (*Podolepis jaceoides*), and Large-headed Groundsel (*Senecio macrocarpus*). Showy Podolepis initially expanded greatly until 1997 but is now difficult to locate. Large-headed Groundsel, an endangered grassland species, spread from a localized planting of less than 50 plants to be scattered and abundant throughout the site.

Observations suggest that there was no clear best method for introducing native grassland species (Table 2). A total of 47 species survived through to 1999 when sown by seed, transplanted from grassland sods, and planted as tubestock. The sod transplants, however, were inadvertently responsible for the introduction of the weed Onion Grass (**Romulea rosea*), a species which has since persisted and spread.

The rarity of most native species across the site is reflected in the low diversity observed in quadrats. On average, there were about two native species recorded in each quadrat on each sampling date (Fig. 3). Most frequently these were Kangaroo Grass and wallaby grasses. The mean

Table 2. The mode of introduction for native species surviving in 1999. Species are included only where the method of introduction is confidently known for surviving plants

	Seed	Sod transplants	Tubestock
Number of species introduced by method	23	8	33
Number of species surviving (1999)	7	4	15

number of weed species per quadrat was more variable over the study period. Between six and eight weed species were observed in quadrats between 1989 and 1997. This declined to four in 2001 but rose again to more than six in 2003.

The total cover of native plants within quadrats was generally between 25 and 35% over the period of study (Fig. 4). The cover was greatest in 1995 (47%) following a period of above-average rainfall and lowest (16%) in 1997 during a severe drought. This is reflected in the cover of the dominant native species, Kangaroo Grass, which fell from 31% in 1995 to 10% in 1997. The study site was burnt in March 1997 at the commencement of the drought. Many individual plants of Kangaroo Grass were found to be dead in November 1997. Total weed cover within quadrats was about 60% at the commencement of monitoring but declined to only 20% in 1999. Weed cover has since increased and had reached 1989 levels again in 2003. The cover of native species exceeded the cover of weed species only in 1995 and 1999. At other sampling times, the cover of weed species was 1.3–2.3 times that of native species.

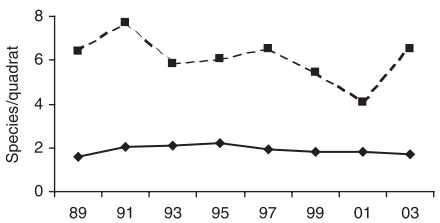

Figure 3. Mean number of species per m² for weed (–■–) and native (–◆–) species species between 1989 and 2003 at Organ Pipes National Park.

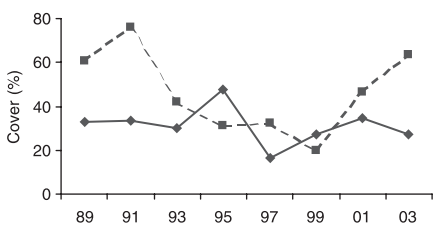

Figure 4. Mean total percent cover of weed (–■–) and native (–◆–) species between 1989 and 2003 at Organ Pipes National Park.

Changes in total native and weed cover obscure the changes that occurred in individual species. Wallaby grasses were recorded in most quadrats between 1989 and 1999 but their mean cover declined steadily during that time (Fig. 5). Spear grasses were not recorded in quadrats in 1989 and 1991 but by 1997 were present in 16% of quadrats. These species were not deliberately introduced to the site but arrived, presumably in low numbers, in Kangaroo Grass hay. Kangaroo Grass increased in frequency until 1995 largely as a result of the sowing of hay until 1993. Its cover also increased during that time but declined in 1997 because of extensive plant death.

The weed flora of quadrats changed at each sampling. At the commencement of the monitoring, Sheep Sorrel (**Acetosella vulgaris*), Cape Weed (**Arctotheca calendula*), Catsear, Perennial Rye-grass (**Lolium perenne*) and Ox-tongue (**Helminthotheca echioides*) were frequent components of quadrats (Fig. 6). However, the representation of all of these species steadily declined over the observation period to the point where they were rare or absent by 2003. Other weed species have fluctuated in cover and frequency between sampling dates. Oats were found in most quadrats throughout the period of sampling despite often having a mean cover of less than 5%. However, its cover increased dramatically between 1999 and 2001 and remained steady to 2003 at about 20%.

Fumitory (**Fumaria muralis*) and Onion Grass were both minor components of the weed flora until 1999. Fumitory was not recorded in 1997 but was found in 46% of the 1999 samples. The frequency and cover of both species declined thereafter.

The frequency and cover of Chilean Needle-grass fluctuated greatly during the trial, perhaps because of the spot spraying of herbicides. The large increase in frequency recorded between the 2001 and 2003 samples with no corresponding increase in cover perhaps suggests that this species is spreading but has not yet attained its potential cover, and urgently requires further control.

Squirrel-tail Fescue (**Vulpia bromoides*) was a frequent component of the weed flora throughout the trial but has fluctuated greatly in mean cover. Soft Brome (**Bromus hordeaceus*) and Sow Thistle (**Sonchus* spp.) were frequent in quadrats at the commencement and end of the sampling but were less common at times between 1993 and 1999. Quaking grasses and clovers have followed similar patterns. Both were uncommon at the beginning of sampling but increased in frequency and cover until the late 1990s when they declined to 1989 levels. These species were again common in 2003. Ribwort (**Plantago lanceolata*) increased in frequency over the first three samples and has been present in about two-thirds of quadrats since.

African Pepper-cress (**Lepidium africanum*) was found in < 20% of quadrats at most sample times and < 10% on four occasions. In 1997, it was found in 47% of quadrats, an increase from 9% 2 years earlier. The mean cover of this species has been consistently small. Except for the 1997 (drought year) sample, the frequency of Common Vetch (**Vicia sativa*) has tended to increase during the trial (overall, from 17% in 1989 to 57% in 2003).

The dominant weed flora shifted markedly over the period between 1989 and 2003 (Fig. 7). In 1989, Catsear was initially the dominant weed species, but in 2003 it was only a minor component of the weed flora. Oats, Ribwort, and clovers are now the major weeds. Squirrel-tail Fescue has been both a dominant and an inconsequential weed species during the period of observation.

Despite the persistence of many weed species, the OPNP site looked like a native grassland for much of the project, until recently when Oats again became dominant.

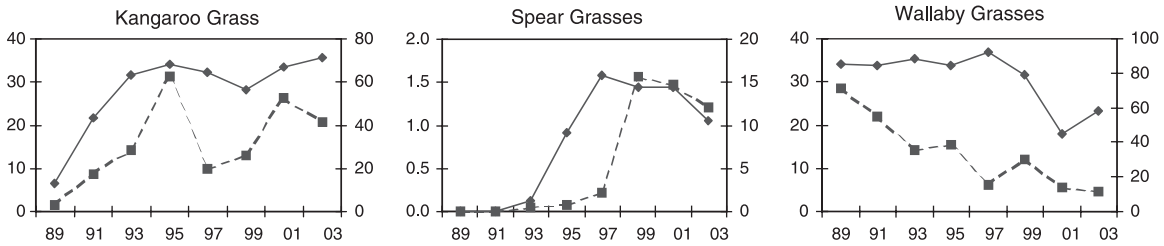

Figure 5. Mean percent cover (left hand axis, –■–) and percentage frequency (right hand axis, –◆–) of selected native species between 1989 and 2003 at Organ Pipes National Park.

Discussion

The long-term monitoring of the grassland re-establishment project at OPNP has shown that: (i) there is great instability from year to year in species composition; (ii) native species have not entirely covered the site after planting; and (iii) abiotic and biotic factors have a substantial effect on species abundance.

Native species richness in the re-established grassland did not change substantially over the 15 years of observation, suggesting that few of the native species expanded their range after initial establishment. Indeed, some of the 33 native species recorded in 2003 were clearly still present only where they had been planted. Morgan (1999) has previously highlighted the long-term failure of some grassland re-introduction plantings in western Victoria and attributed this to the failure of the initial plantings to produce seedlings. The establishment of a new cohort may fail because of poor seed production, inappropriate conditions for seed germination or the death of seedlings from competition by dominant plants or climatic stresses. None of these factors alone appear to adequately explain the lack of recruitment at OPNP – flowers and fruit were observed on most species at some time during the project, the site had similar soil and topography to sites from which the original plants were obtained, competition was often minimal and bare ground abundant (e.g. following burning), and in the early part of the project rainfall was at or above average – yet they may all have played a part. We suspect that the small number of plants of most species originally established on the site is the main reason many species failed to expand their range. That is, there was simply too little seed produced to overcome the many potential barriers to recruitment. The local composition of many plant communities, including grasslands, is often constrained by seed availability, suggesting that ongoing re-introductions may be needed to enhance local diversity in grasslands undergoing restoration (e.g. Foster & Dickson 2004). Tilman (1993; 1997) has shown that dramatic increases in diversity can be achieved in tallgrass prairie by the manual planting of seed. Supplemental plantings and ongoing management appear necessary to improve the diversity of native plants in the OPNP site.

In the present study, there were two main exceptions to this general finding: (i) the (wind-dispersed) nationally endangered daisy *Senecio macrocarpus*, originally introduced as tubestock, and its subsequent establishment across the site, indicates that a large and functional population has established; and (ii) the slow establishment and subsequent rapid spread of spear grasses, probably introduced as seed in Kangaroo Grass hay, suggests that they will become a common component of the site in future.

Identifying the plant functional traits that enable the persistence and spread of native species in re-established grasslands will be an important research question if functional and diverse native grasslands are to be 'restored' (Seabloom *et al*. 2003). Clearly, the production of viable seed and its ability to germinate readily, along with high seedling survival, are important precursors to spread. While many native grassland species can produce seed that is readily germinable under laboratory conditions (Morgan 1998), these same species generally recruit infrequently in natural stands (Morgan 2001), suggesting that recruitment 'bottlenecks' may be common in natural (and restored) grasslands. The development of management strategies that can maximize the outcomes of infrequent recruitment events (e.g. fire regimes, weed control) requires greater emphasis in restored grasslands (Morgan 1999).

The cover of native species over the study period was mostly that of the dominant grass, Kangaroo Grass, and its contribution responded to fire and drought events. Frequent burning in the early stages of the project (1993, 1995) led to an initial increase in frequency and cover. However, fire in 1997 was followed by a drought that led to substantial tussock mortality and little vegetative growth. This highlights that fire, while necessary to prevent competitive exclusion and litter build-up (Morgan & Lunt 1999), can also be a powerful agent structuring plant communities when it coincides with abiotic stress.

Wallaby grasses also declined over the study period, although the reasons for this are unknown. Substantial increases in the frequency and cover of two weeds (Oats and Fumitory) followed the 1997 fire. These species have presumably taken advantage of the changed conditions (including the absence of fire) from 1997 onwards.

The large fluctuations in cover and frequency recorded in the dominant weed species have implications for weed control strategies both at OPNP and more generally. If weed control were attempted at the commencement of the trial, broad-leaved species such as Catsear, Cape Weed and Oxtongue might have been targeted because they were common at the time of agricultural abandonment. However, all of these species declined without specifically targeted intervention, possibly because disturbance to the soil was minimized, and all are now minor components of the site.

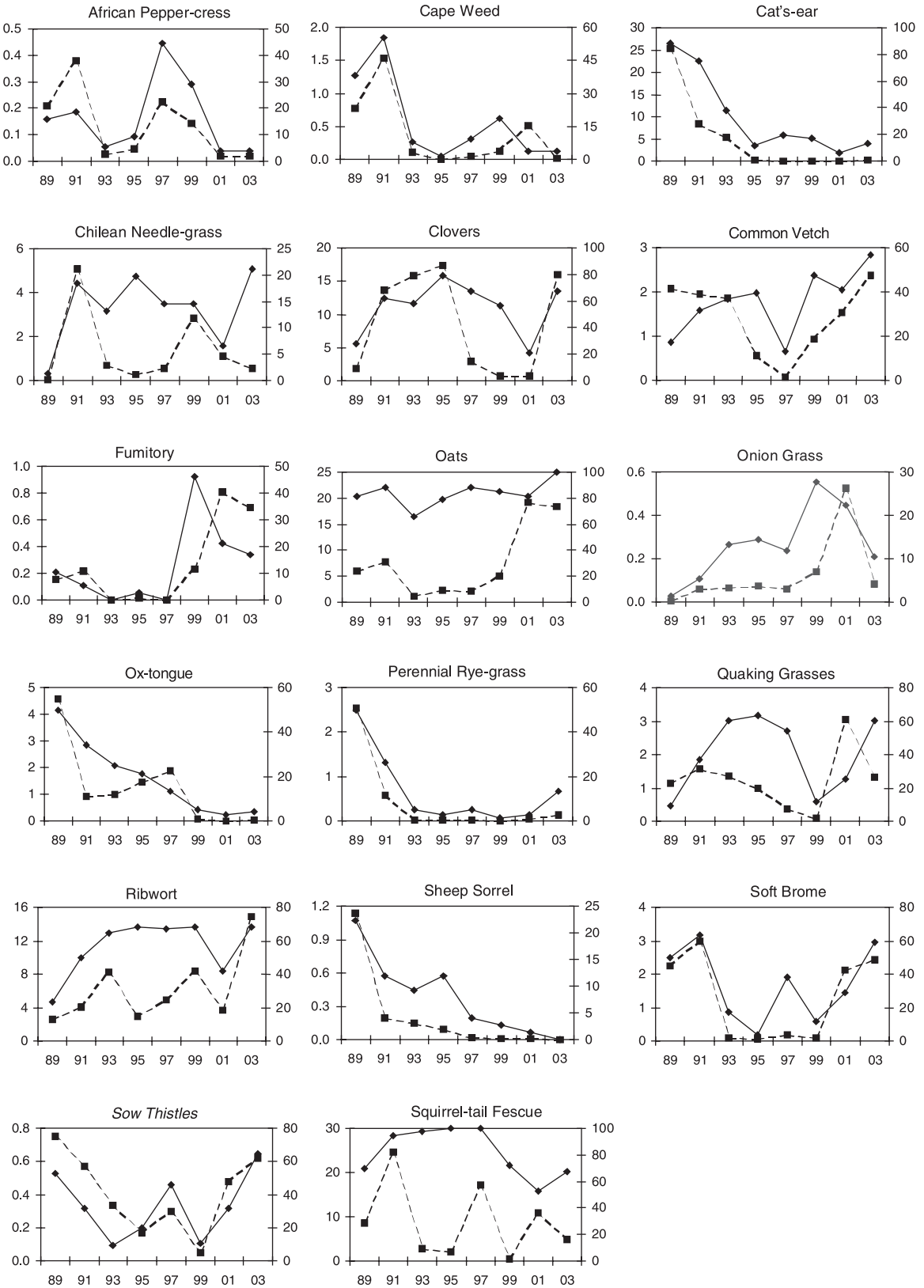

Figure 6. Mean percent cover (left hand axis, –■–) and percentage frequency (right hand axis, –◆–) of selected weed species between 1989 and 2003 at Organ Pipes National Park.

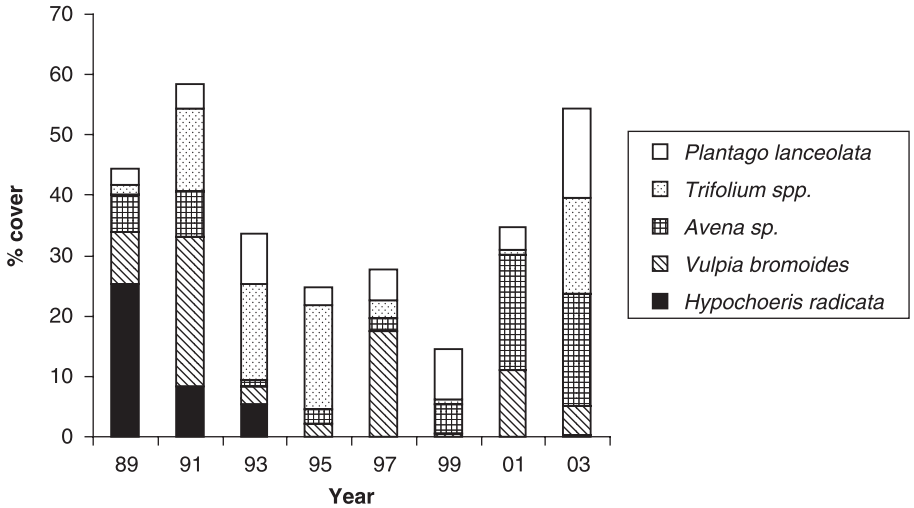

Figure 7. Mean percent cover of the dominant weeds at each sampling time between 1989 and 2003 at Organ Pipes National Park.

The grassland re-establishment trial at OPNP was characterized by large fluctuations in both native and weed species, in part due to the timing of fire and drought. A 'succession' of weed species after agricultural abandonment is common in grasslands (Huston 2004) with species responding to changes in frequency of, and time since, disturbance. It is likely that systems that are largely devoid of plants from time to time (e.g. at OPNP after the harvesting of the annual oat hay and on roadsides sprayed with broad-scale herbicides) will experience such fluctuations as primary colonists decline and seed of new species arrives. It may take years or decades at such sites for a single species to consistently attain dominance. In situations where routine weed control is performed, it may well prove more cost-effective to monitor weed populations and treat species when they are found to be truly troublesome, rather than simply spraying because there are weeds present.

The recent use of the OPNP grassland site for the establishment of an *ex situ* population of the threatened Striped Legless Lizard (*Delma impar*) could be viewed as an endorsement of this project's success. However, the presence of the reptile has created some interesting management challenges. Burning is commonly used for the maintenance of the Kangaroo Grass sward and the OPNP site appears to be long-overdue for burning (despite the decline in native cover that it seemed to cause in 1997). Burning may also affect Striped Legless Lizard populations either by burning the animals if they are unable to find protection under rocks or in cracks in the clay, or by exposing them to avian predators. A solution may be the partitioning of the site using mown fire breaks and burning in patches. Whatever approach is used, a key to understanding the interaction between the re-established floral and faunal populations, and the effects of management, will be the continuation of a long-term monitoring program.

Despite the failure of some plantings, the low native species richness across the site and the fluctuations in native plant cover, the aims of the native grassland re-establishment project at OPNP, have largely been met. When the project commenced, little was known about the methods of establishment or the potential to re-establish grassland species despite the urgency for such actions. It is now clear that it is possible to establish and maintain populations of some grassland species, including the dominant Kangaroo Grass, with little intervention by land managers. With a little more effort directed towards selective weed control and enhancement planting, it may well be possible to create something that looks and functions like a natural grassland. The long-term nature of the task faced by restorationists, however, has been well and truly identified in the present study.

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