SEED BANKS IN A NATURAL PASTURE IN TASMANIA, AUSTRALIA: IMPLICATIONS FOR SPECIES COMPOSITION CHANGE

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ABSTRACT
Seed banks in a natural pasture in Tasmania were examined as part of a study of the effects of grazing on changes in species composition. The dominant native perennial grasses had relatively low seed banks, whereas annual grasses, sedges, rushes and a number of forbs had relatively high seed banks. The results confirm the vulnerability of the native grasses to local extinction in the event of loss of the established plants, *e.g.* through overgrazing.

KEYWORDS
Seed bank, natural pasture, *Themeda*, *Danthonia*, *Microlaena*, overgrazing

INTRODUCTION
Seed banks (Roberts, 1981) are an important aspect of the dynamics of grasslands. Seeds provide for replacement of plants in the present population and enable the plant population to increase, given favourable conditions for germination and establishment (Harper, 1977; Van der Valk and Davis, 1978; Thompson and Grime, 1979). A low seed bank makes a species vulnerable to extinction in the event of widespread plant loss (Chancellor, 1979; Oesterheld and Sala, 1990; O'Connor and Pickett, 1992; McIvor and Gardener, 1994).
This paper reports preliminary results from a study of seed banks in a natural pasture, consisting of native and naturalised species, in the temperate grassland zone of Tasmania, Australia (Moore, 1970). The study forms part of a grazing trial looking at the effects of different grazing management strategies on botanical composition of the pasture. This work is part of a national study, the Temperate Pasture Sustainability Key Program, other results of which are reported in separate papers at this Congress.

METHODS
The pasture is at Nile in the northern Midlands of Tasmania ($41^0$44'S, $147^0$27'E). The area has been grazed by sheep since settlement around 170 years ago. It has never been fertilised or sown to introduced species. The pasture is dominated by native grasses, but also contains naturalised grasses and native and naturalised forbs (Table 1). The principal native grasses are *Themeda triandra*, *Danthonia* spp. and *Microlaena stipoides*. These species together make up about 80% of the total herbage mass. The only other species to contribute significantly to herbage mass is *Anthoxanthum odoratum* (*c.* 10% HM).
The climate of the site is characterised by warm summers (mean max./min. temperatures for January 23.1^0/10.0^0C) and cold winters (mean max./min. temperatures for July 10.8^0/2.3^0C). Mean annual rainfall is 530 mm, with a slightly higher winter rainfall than summer rainfall.
Soil cores were taken in the autumn about the time of the beginning of seedling emergence, following the period of summer soil moisture deficit. The cores were 50 mm in diameter, and 75 mm deep. Twenty cores were taken from each plot of selected treatments (set stocking, seasonal spelling and year-long spelling).
Estimates of the soil seed bank are based on the emergence of seedlings from the cores. These were kept intact initially. The vegetation trimmed to about 0.5 cm above the soil surface, and and they were placed in an unheated glasshouse. The cores were watered regularly to keep them moist. Counts of seedlings were made 10 - 12 weeks after collection, when seedlings of the principal species that had emerged were sufficiently developed to be identified, and seedling emergence appeared to be completed. The number of shoots arising from established plants of each species, or species group, in the cores were also counted. These provided a measure of the abundance of the species in the vegetation cover. The cores were then broken up, the plant material removed, and the soil spread out in shallow earthenware saucers, which were kept moist by placing them in trays of water. Records of emergence of seedlings from the saucers were continued until the autumn of the following year.

RESULTS
There were no significant treatment effects on the seed banks of the grasses, and only minor treatment effects on the seed banks of other species, so the only data presented are the grand means over all treatments for each species (Table 1). The seed bank estimates equate to the "readily germinable" seed banks described by Thompson and Grime (1979).
Most native grass seedlings recorded in the total count came from the intact cores (Table 2). This was true also for the annual grasses, whereas for other species (except *Solenogyne*), relatively high numbers of seedlings were recorded after breaking up the cores.
The seed bank in both years was dominated by annual grasses, sedges and rushes (Table 1). The introduced forb species also had relatively high seed banks.
Seed banks of *Themeda*, *Danthonia* and *Microlaena* were low compared with their shoot populations. By contrast, seed banks of *Anthoxanthum* were similar to the shoot populations. Most forbs, sedges, rushes and other monocotyledons had similar or higher seed banks to their shoot populations.
The fall in the seed banks of most perennial grasses between the two years (Table 1) contrasts with the increase in most forbs, sedges and rushes (notwithstanding the high variability in the estimates). The seed bank of the annual grasses was maintained between the two years.

DISCUSSION
The low seed banks found in the dominant native perennial grasses relative to their abundance in the vegetation cover are consistent with the results of a number of other studies (Lunt, 1990; O'Connor and Pickett, 1992; Gilfedder and Kirkpatrick, 1993; Orr and Paton, 1993; McIvor and Gardener, 1994). The low seed banks are probably a result of both a low seed production and the lack of persistence of seeds in the seed bank (Thompson and Grime, 1979).
Seed production was not measured in this study, but our observations on the phenology of the main species in the pasture (unpublished data) indicated that seed production of the dominant native grasses was relatively low. They produced few flowering culms and there were high losses due to grazing, disease and predation.
The high levels of germination recorded for *Themeda*, *Danthonia* and *Microlaena* from the intact cores compared with subsequent germination suggests that they do not have persistent seed banks. The fall in their seed banks between years also suggests a lack of persistence. Pasture growth was reduced in the second year due to low rainfall (unpublished data), and seed production was probably also lower compared with the previous year.
The high seed banks found in the annual grasses, sedges and rushes, and introduced forbs are also consistent with work on grasslands elsewhere (Roberts, 1981; Williams, 1984). Most of the forbs and sedges and rushes in this study would appear to have persistent seed banks, based on our observations of their germination pattern from the soil samples, and the maintenance of their seed banks between years. The annual grasses, however, appear to have transient seed banks (Thompson and Grime 1979), which are maintained by a high seed production each year, even in adverse conditions (personal observations).
The implications of our data on the persistence of the seed bank of *Anthoxanthum* are less certain, as there was delayed germination from the cores, but a large reduction in the seed bank between years. The results of other studies on the seed banks of *Anthoxanthum* are conflicting (Williams 1983).
Measurements on botanical composition of this pasture under a range of contrasting grazing management practices have shown that composition is relatively stable under moderate grazing pressures (2 - 2.5 DSE/ha) (see paper for this Congress by Garden *et al.*). The pasture

may be considered successionally mature vegetation, developed under the influence of periodic drought and moderate grazing pressures.

The dominant native grasses present, with transient seed banks, probably rely on vegetative persistence of the established plants, together with limited recruitment of seedlings, to maintain their population. By contrast, the persistent seed banks of most of the forbs, sedges and rushes allow these species to take advantage of disturbance when it occurs, and provide high seedling populations. The annual grasses, and perhaps also *Anthoxanthum* (Platenkamp, 1990), rely on high seed production and annual recruitment to maintain their population.

Overgrazing in natural pastures elsewhere in Tasmania has resulted in the native grasses being replaced by introduced grasses, sedges and forbs (Fensham, 1989). The low seed banks of the native grasses found in this study confirm their vulnerability to local extinction (O'Connor and Pickett, 1992; McIvor and Gardener, 1994). To maintain these native grasses, management must aim to avoid overgrazing and ensure some seed production each year, *e.g.* by spelling the pasture during the flowering and seeding period.

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Table 1

Seed banks in a natural pasture at Nile in Tasmania, compared with the shoot populations, measured in two consecutive years. (Mean no./m^2 ± standard error, based on 8 plots in 1994 and 20 plots in 1995.)

Species	Seeds		Shoots	
	1994	**1995**	**1994**	**1995**
Themeda triandra	100 ± 16	38 ± 12	1030 ± 190	250 ± 170
Danthonia spp.[1]	367 ±150	120 ± 29	3760 ± 530	4210 ± 370
Microlaena stipoides	24 ± 9	8 ± 3	812 ± 264	892 ± 206
Elymus scaber	26 ± 9	21 ± 5	53 ± 23	31 ± 10
Poa spp.[2]	6 ± 4	5 ± 3	0 ± 0	4 37 ± 419
*Anthoxanthum odoratum**	756 ± 289	356 ± 82	1440 ± 420	333 ± 89
Annual grasses*	5370 ± 1070	4350 ± 1270	0 ± 0	0 ± 0
Other grasses[#]	53 ± 7	37 ± 7	106 ± 72	175 ± 42
Gnaphalium spp.	147 ± 51	503 ± 69	26 ± 14	18 ± 9
Leptorhynchos squamatus	62 ± 46	12 ± 9	24 ± 11	112 ± 47
Solenogyne spp.	3 ± 3	30 ± 11	6 ± 4	185 ± 149
*Hypochoeris radicata** & *Leontodon taraxacoides**	1170 ± 240	774 ± 234	153 ± 36	182 ± 51
Trifolium spp.*	360 ± 390	2010 ± 420	0 ± 0	0 ± 0
Other forbs[#]	593 ± 199	1150 ± 220	133 ± 54	132 ± 51
Sedges & rushes[#]	5300 ± 1660	12800 ± 3800	5720 ± 920	3980 ± 660
Other monocotyledons[#]	24 ± 8	18 ± 12	47 ± 41	56 ± 16[1]

[1] Includes *Danthonia caespitosa, D. pilosa* and *D. carphoides* var. *angustior.*
[2] Includes *Poa labillardierei* and *P. rodwayi.** Introduced species.
[#] Includes both native and introduced species.

Table 2

Germinability of the seed bank of the main species in the pasture at Nile, as shown by the emergence of seedlings from the intact soil cores, expressed as a percentage of total seedling emergence (see text)

Species	% Germination from
Intact Soil Cores	
Themeda triandra	97
Danthonia spp.	87
Microlaena stipoides	71
Elymus scaber	88
Poa spp.	50
Anthoxanthum odoratum	52
Annual grasses	94
Other grasses	94
Gnaphalium spp.	33
Leptorhynchos squamatus	50
Solenogyne spp.	100
Hypochoeris radicata & *Leontodon taraxicoides*	50
Trifolium spp.	70
Other forbs	57
Sedges & rushes	70
Other monocotyledons	83