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WHY ARE SUB-TROPICAL GRASSLANDS SO SPECIES RICH?

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ABSTRACT

A survey of grassy eucalypt woodlands in sub-tropical Queensland recorded herbaceous species richness at 30m^2 scale. At this scale, the native grassland occurring in pastures, roadsides and stockroutes appears to be very species-rich by global standards. Results were compared with a published survey of temperate grasslands. When habitats with similar management histories and disturbance regimes were compared, we found native species richness in the sub-tropics to be approximately 50% higher than the temperate survey results. Possible explanations for this result include differences in fertiliser use, exotic legume populations, livestock types and fire regimes.

INTRODUCTION

Species richness is a widely reported measure of plant diversity, presumably due to its ease of measurement. Richness is a measure of the density of species and like all diversity measures, has limitations. It is highly scale dependent and provides information on local heterogeneity, rather than spatial heterogeneity (Chaneton and Facelli 1991). In this study, richness is used to indicate the level of coexistence of grassland species at the patch scale. It can be a useful indicator of conservation status at this scale, as the richness of native species is correlated with that of regionally rare species (McIntyre and Lavorel 1994). This paper reports the patterns of species richness in the herbaceous layer of eucalypt grassy woodlands in sub-tropical Queensland, and data comparisons with a similar study in grassy woodlands on the temperate New England Tablelands.

METHODS

The survey was conducted in the Southeast Queensland Bioregion (Sattler and Williams 1999) in grassy woodlands. The sample area was bounded by 27 - 28°S and 151 - 153°E and samples covered an elevation range of 400-500m. Sampling was focussed on three properties with a total area of 2,756 ha. A range of habitats typical of cattle grazing enterprises and their environs was sampled and site variables included lithology, slope position, tree density, soil disturbance, soil enrichment and grazing. Results were compared with a previously published survey of a similar range of habitats and environments in temperate grasslands which recorded richness at the same spatial scale, described in McIntyre *et al.* (1993) and McIntyre and Lavorel (1994).

Sampling took place in the summers of 1997/8 and 1998/9, with most data being collected between December-March 1998/9. Rainfall around the time of sampling was optimal for full expression of growth by the warm-season species, but would have resulted in an under-representation of the obligate winter-growing species (mainly exotic annuals) and spring-growing forbs. A total sample of 212 quadrats (one quadrat, 5 x 6 m, per site) was collected. Data comparing richness on the same location between seasons were recorded for 120 fixed quadrats (0.5 x 0.5 m) located at sites at two of the properties (60 quadrats per site).

RESULTS AND DISCUSSION

Lunt (1990) recorded total richness of grassland species in three temperate woodland plots in Victoria, and totals ranged from 62-85 species per 32m^2. These species totals were the accumulation of records taken repeatedly over an 8-month period and the vegetation was claimed to be the richest in the world at small (1 m^2) scales. In this sub-tropical survey the highest density in the 30m^2 plots was 83 (total species) and 17 sites (8%) had >60 species. Considering that the species counts were made at a single visit in the summer, and that winter and spring growing species were missed, the actual totals are therefore potentially higher. This puts the sub-tropical grasslands as being extremely rich, even by global standards (Lunt 1990).

Although temperate grasslands can be very species rich, samples from New England grasslands had a much lower species density than the sub-tropical grasslands. The average richness for total species was 41 species per 30m^2 (n = 212) compared with the New England average of 28 species per 30m^2 (n = 120). Table 1 compares average richness of native and exotic species. Habitats have been grouped broadly into disturbed, grazed and low disturbance categories (the most comparable habitat pairs are S3-T1 and S4-T4, Table 1). It can be seen that within the broad categories, exotic species richness is very similar in sub-tropical and temperate environments. However, sub-tropical habitats appear to be richer in native species by about 50% across comparable habitats. Temperate 'natural' pastures (T2) are generally fertilised and aerially sown to legumes and had a similar species richness to the sub-tropical crop and sown pasture habitats. The latter two habitats had recent cultivation histories, while the New England 'natural' pastures, if cultivated at all, were not recently disturbed in this way.

Table 1. Comparison of species richness for native and exotic plants in sub-tropical Queensland (S) and temperate grasslands (T) on the New England Tablelands (McIntyre and Lavorel 1994). Averages (± standard error) are number of species per 30m^2 quadrat (= site) across habitat types.

		Habitat	No. sites	Native	Exotic
	S1	Sown pasture (tillage, fertiliser)	16	14 ± 1.3	12 ± 1.2
DISTURBED	S2	Crop (tillage, fertiliser, irrigation)	14	15 ± 3.7	11 ± 1.2
SITES	S3	Roadside (soil disturbed and/or enriched sites)	18	20 ± 2.8	12 ± 1.2
	T1	**Roadside** (disturbed and/or enriched sites)	20	12 ± 2.1	10 ± 1.0
	S4	Native pasture (no inputs)	109	36 ± 1.0	9 ± 0.3
GRAZED	T2	'Natural' pasture (fertiliser)	19	12 ± 1.3	9 ± 0.8
SITES	T3	Stock route (no inputs)	39	22 ± 1.2	7 ± 0.8
	T4	Grazed reserve (**no inputs**)	21	23 ± 1.8	8 ± 1.1
LOW GRAZING LOW DIST.	S5	Roadsides (includes stockroutes, reserves; neither soil disturbed or enriched)	35	37 ± 2.0	7 ± 0.7
SITES	T5	**Reserve** (no domestic livestock, low levels of disturbance)	21	24 ± 2.0	6 ± 1.0

To explore the differences in native plant species richness between regions it is necessary to consider aspects of historical settlement and agriculture. The duration of settlement and commencement of livestock grazing is similar in both regions. There is no evidence of major differences in grazing pressure in the two regions. If anything, the sub-tropical sites may have been utilised more heavily in the years preceding sampling as south-east Queensland had recently been though the most severe drought of the century, during which time grazing pressure was extremely high in the region. The properties sampled were selected as typical commercial enterprises, and do not have histories of exceptionally low grazing pressure. However, there are some differences between the regions, and while there seems to be no convincing single explanation to account for the variation in species richness, the following factors are likely to play a role

Differences in use of improved pasture technologies

One difference between the regions is that the use of aerially broadcast fertilisers and legume seed is widespread in the 'natural' pasture habitats of New England, while native pastures in the sub-tropical study have none of these inputs. This could explain why the native species richness of S1, S2 and T2 are similar (fertiliser enrichment) and much lower than the sub-tropical pastures (S4). However, there is inconsistency between the lower diversity in unfertilised temperate habitats (T3, T4, T5) which have around two thirds the native richness of the sub-tropical native pastures (S4). Unless there are off-site effects of pasture fertilisation affecting the T3, T4 and T5 habitats, the differences between the regions cannot be accounted for fully by this explanation. The linear stock routes (T3) which run through pastures may be affected by fertilisation practices in adjoining pasture, but such off-site effects are less likely for the larger blocks of unfertilised habitat (T4, T5).

Extent of establishment of exotic legumes

Establishment of exotic legumes has been of limited success and these species were largely restricted to crops and sown pastures in the sub-tropical study. In the temperate regions, legumes are naturalised in most habitats, perhaps changing competitive interactions and soil fertility. However, this argument would rely on exotic legumes contributing more to soil nutrient status than the native legumes, which were common in the sub-tropical sites where eight native taxa had a frequency >15%. This compares with two native and six exotic legumes with >15% frequency in the temperate study (McIntyre *et al.* 1993). Suitable comparisons of native and exotic legume growth, N-fixing abilities and nutrient cycling are not available to further this argument.

Differences in livestock types and grazing impacts

Cattle are the predominant grazers in the sub-tropical study and may impact grassland diversity less than sheep, which dominated in the temperate study. Although both kinds of livestock are capable of grazing native tussock grasslands non-selectively and forming grazing lawns, they do have preferred components. As a general rule, sheep prefer forbs and cattle prefer grasses (Vallentine 1990). The fact that forbs form the major component of diversity in grasslands and that grasses are capable of suppressing forb diversity (Trémont and McIntyre 1994) makes a strong case for sheep to be having an adverse impact on species richness in grazed habitats (S4 cf. T4). However, the temperate habitats with the least livestock grazing (T5, T3) were still substantially less rich than the sub-tropical equivalents (S5).

Geographic location

Could there be an inherent feature of sub-tropical grasslands making them naturally more species rich at the scales measured? The study region, being near the boundary of tropical and temperate environments, may be inherently richer due to the overlap of distributions from parts of each flora. However, grassy woodlands form a continuous habitat over the entire latitudinal range of eastern Australia. About 80% of the species recorded in the New England (northern New South Wales) survey have a range extending into Queensland and 85% have a range extending into Victoria (McIntyre and McIvor 1998). If there is a continuum of environmental change, a continuum of floristic change over the same range seems most likely.

The prevalence of burning

While pasture burning had largely ceased in New England, winter/spring burning is still common in the sub-tropics if there is sufficient grass. Aboriginal fire management in Queensland is considered to have been predominantly in winter/autumn so current-day pastoralist management may more closely resemble endogenous disturbance than an absence of burning (Fensham 1997). Since there are so many other differences between the regions, it would be difficult to investigate this hypothesis.

Species 'apparency' during the sampling period

Amongst the grassland forbs are many species that are able to enter dormancy in unfavourable conditions, either in the from of seeds or underground organs. There are therefore times when some species will not be apparent in the above-ground sward. The two conditions that are most likely to affect the apparent species diversity are season of sampling and rainfall conditions prior to sampling. Table 2 shows quite different numbers of forbs recorded in fixed quadrats between years at two sites. The additional richness recorded in May 1998 is accounted for by winter growing annual forbs that had germinated in response to rain, but which were not recorded in the warmer March sampling periods. Grasses seem to be more consistent. There can be as much variation within a season as between seasons. Although all the data reported in Table 1 were collected in the active summer growing season and during seasons of favourable rainfall, it is difficult to prove that there are no significant differences in species richness due to 'apparency'. More favourable growing conditions during the sub-tropical survey could account for the generally higher diversity of native species (compared to the temperate data) that could not be explained by the management-related hypotheses. However, 'apparency' does not explain why richness of exotic species was so similar in habitats of similar disturbance levels.

Table 2. Species richness in native pasture habitat in sub-tropical grassy woodlands. Data are means (± standard error) of 60 fixed quadrats (0.5 x 0.5 m) measured at two locations (properties) with repeated measurements over three years.

		Grasses / sedges	Forbs	Total species
Property 1	May 1998	4.3 ± 0.3	9.2 ± 0.5	13 ± 0.7
Property 1	March 1999	4.6 ± 0.3	4.7 ± 0.3	9.3 ± 0.4
Property 1	March 2000	4.8 ± 0.3	4.3 ± 0.3	9.1 ± 0.5
Property 2	May 1998	3.4 ± 0.2	8.7 ± 0.6	12 ± 0.7
Property 2	March 1999	3.8 ± 0.3	4.7 ± 0.4	8.5 ± 0.7
Property 2	March 2000	4.2 ± 0.3	5.0 ± 0.4	9.2 ± 0.7

While no individual argument can account for all the observed differences between species richness in the temperate and sub-tropical data sets, all of them potentially play a role in accounting for the differences, and there may be interactions between them. Although our observations are at a patch scale, it is also likely that the overall human impact in the landscape context is an important influence.

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