DO VERTEBRATES GRAZE MOSS AFTER FIRE IN BUTTONGRASS MOORLAND?

Mikayla Jones & Emma J. Pharo

School of Geography and Environmental Studies, University of Tasmania , Private Bag 50, Hobart, Tasmania 7001; email: mikaylaj@utas.edu.au

INTRODUCTION

The consumption of bryophytes (mosses, liverworts and hornworts) by vertebrate herbivores is widely documented for the Northern Hemisphere, mainly in boreal and arctic environments where nutrient sources are limited for at least part of the year (Prins 1981; Staaland & White 1991; Virtanen *et al*. 1997; van der Wal *et al*. 2001). Prins (1982) suggested that mosses provide little energy for herbivores but supply polyunsaturated fatty acids such as arachidonic acid that most likely increase the cold resistance of these herbivores and their young. Generally, moss-eating animals live permanently in cold environments, or migrate to these environments annually (Prins 1982). In Australia, the degree to which bryophytes are eaten by vertebrate herbivores is virtually undocumented.

Research into the effects of grazing on bryophytes in Australia has been carried out on the effects of trampling (Eldridge *et al.* 2000) and the nitrogen content of moss beds after the exclusion of grazing (Carr *et al*. 1980), rather than vertebrate consumption of moss. Given that bryophytes are mainly used as a food source by vertebrate herbivores when other nutrient sources are limited, such as in extreme cold conditions, we wondered whether bryophytes may be utilised by vertebrates as a food source in challenging habitats in Australia, such as in the buttongrass moorlands of Tasmania.

The buttongrass moorlands of Tasmania are burned often and are an extremely low nutrient environment. The foliage of the dominant plant (*Gymnoschoenus sphaerocephalus*) has high silica levels and the lowest recorded phosphorus levels in its foliage of any plant species (Bowman *et al.* 1986). The buttongrass moorlands are periodically inundated with water, yet the soil surface may be dry, cracked and hard in summer (Driessen 2007). Possibly due to the harsh and changeable conditions, only a few mammals are known to spend their entire lifecycle in the buttongrass moorlands: Swamp Antechinus (*Antechinus minimus*), Broad-toothed Mouse (*Mastacomys fuscus*) and the Swamp Rat (*Rattus lutreolus*) (Driessen 2007). Several other mammals use buttongrass moorland for feeding but usually shelter in other habitats: Common Wombat (*Vombatus ursinus*), Bennetts Wallaby (*Macropus rufogriseus*), Eastern Quoll (*Dasyurus viverrinus*) and the Short-beaked Echidna (*Tachyglossus aculeatus*) (Driessen 2007).

The lack of mammals that spend their entire lifecycles living in the buttongrass moorlands could also be a response to the regularity of fire. Buttongrass moorlands are frequently burned by naturally occurring and human induced fires. Following fire, patches of moss are often visible between the remaining short charred buttongrass tussocks. Given the loss of vegetation and potential food sources for the vertebrate herbivores that feed in the buttongrass moorlands, we decided to investigate whether vertebrate herbivores were grazing moss in recently burnt buttongrass moorland.

METHODS

A buttongrass moorland plain near Lake St. Clair burnt in spring 2005 was selected as the study site (Figure 1).

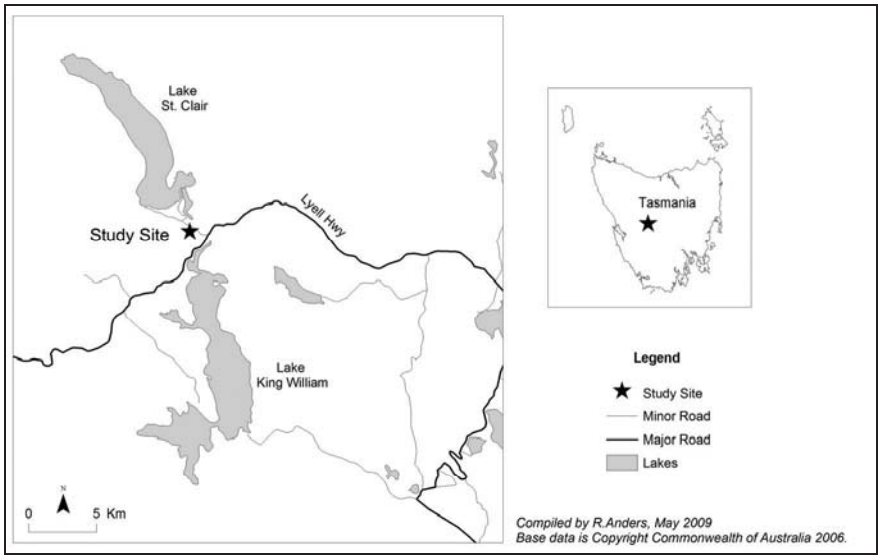

Figure 1. The study area.

Twenty wire cages (30 cm x 30 cm x 20 cm) were used as grazing exclosures, with a wire mesh of 1 cm that allowed invertebrate access but not vertebrate (Plate 1). In spring 2005, twenty patches of moss (either *Campylopus* spp. or *Dicranaloma* spp.) with a minimum diameter of ten centimetres were selected in the recently burnt buttongrass moorland. One cage was placed over half of each moss patch, so that one side of the moss patch was exposed to possible grazers, and one half was protected beneath the cage. Cages were dug down 3 cm below the ground surface and secured with four pegs. The height (taken as base of moss shoot at ground

level to tip of shoot) of the moss patches was recorded as a baseline in 2005. The height of the moss patches was recorded yearly, concluding in spring 2008, with measurements being taken for each patch both inside and outside of the cage. Data was analysed using two-way ANOVA (Minitab 2000) to determine if grazers were significantly impacting on the growth of moss patches.

Plate 1. Grazing exclosures in the buttongrass moorland.

RESULTS

There was no significant difference in moss growth beneath the grazing exclosures compared to the moss exposed to grazers across the three years (Year: $P = 0.345$; $r^2 = 2.15\%$; $df = 2$; Grazing: $P = 0.986$; $r^2 = 2.15\%$; $df = 1$). After years one and two, no differences were recorded in moss growth on either side of the grazing barriers at any of the twenty grazing exclosures. During the third and final survey of the grazing exclosures, three of the twenty cages had disappeared entirely. However, no difference was recorded in bryophyte height between the enclosed and exposed bryophyte patches of the seventeen remaining grazing trials (Table 1). The potential moss grazer, the wombat, was sited at dusk, and wombat scats were found throughout the study site (Plate 2).

Plate 2. Wombat scats provide evidence of the presence of this mammal in the study area.

Table 1. Change in height of moss from 2005–2008.

Cage number	Base height 2005 (cm)		Height 2006 (cm)		Height 2007 (cm)		Height 2008 (cm)	
	inside cage	outside cage	inside cage	outside cage	inside cage	outside cage	inside cage	outside cage
1	18	18	18	18	19	19	19	19
2	15	15	15	15	17	17	17	16
3	12	12	14	14	14	14	14.5	14.5
4	21	21	21.5	21.5	21	20	0	0
5	25	25	25	25	25	25	27	27
6	13	13	13	14	14	14	14	14
7	17	17	15	14	15	15	17	17
8	24	24	24	25	28	28	28	28
9	16.5	16.5	17	17	19	19	19	19
10	11	11	11	11	14	14	15	15
11	19	19	21	21	21	21	21	21
12	25	25	24	24	24	24	0	0
13	20	20	22	22	22	22	23	23
14	15.5	15.5	16.5	16.5	17	17	17.5	17.5
15	18	18	17	17	18	18	18	18
16	14	14	13	13	15	15	0	0
17	26	26	25	25	26.5	26.5	27	27
18	22	22	22	22	22	22	23	23
19	24	24	26	26	26	26	28	28
20	17	17	19	19	20	20	22	22

It is possible that herbivores may only consume the fruiting capsules of moss. In another buttongrass moorland plain we observed capsules of the moss *Tayloria tasmanica* that appeared to have been grazed (Plate 3). The patches of moss used in this study were never observed to fruit, and any herbivory of sporophytes went unrecorded. The moss *Pleurophascum grandiglobum*, endemic to the Tasmanian buttongrass moorlands, is known for its pale green ball-like capsules. Whilst not seen in the study site, in other buttongrass moorlands the capsules of this moss sometimes appeared ragged, as if they had been grazed. However, it is possible that this is due to the manner in which the capsule releases its spores – it simply breaks open at the side.

Plate 3. *Tayloria tasmanica* with grazed capsules.

DISCUSSION

Patches of moss persisting from pre-burn vegetation are often one of the only remaining groundcovers besides charred and much-reduced buttongrass tussocks in burnt buttongrass moorlands. However, native grazers were not eating the moss patches we monitored. It is possible that the cages were somehow deterring the grazers from approaching the moss patches, but we did not observe any other evidence of moss being grazed at the site despite the presence of wombat scats and extensive moss cover.

The presence of a potential grazer, the wombat, was confirmed at the study site. The main food source of wombats are native grasses, with shrubs, roots, sedges, bark and herbs also eaten, with moss supposedly being a particular delicacy (Parks & Wildlife Service 2008). It has been observed that some moss species are favoured by wombats when they are green and moist, but usually ignored when dry (Triggs 1996). Triggs (1996) suggested that mosses are primarily eaten for their water content because mosses have little nutritional value. Wombats and other vertebrates found in buttongrass moorland may access adequate food by roaming into neighbouring scrub and forests to feed, where food sources can be found that have a greater nutrient content than moss. Wombats are known to roam many kilometres at night and would have no difficulty moving into adjacent habitats (Parks & Wildlife Service 2008). If snow lie and the cold-adapted vegetation are important limiting factors for grazers in Northern Hemisphere winters, vertebrate herbivores would be not be able to roam into more favourable feeding environments. It may be the difference between the scale of the buttongrass plains and the scale of the arctic tundra or boreal forests that has necessitated the

Northern Hemisphere vertebrate herbivores to adapt to consuming any available food source, such as mosses and lichens.

Mosses are difficult to digest, although their caloric value is in the same range as that of higher plants (Hegneuer 1962 in Prins 1982). Due to a high concentration of a polyphenolic lignin-like compound, the cellular contents of mosses are less accessible to the digestive enzymes of herbivores (Prins 1982). Polyphenols in some mosses can also have an antibiotic action which is likely to impede the digestion of ruminants or hindgut fermenters (Prins 1982). Given that wombats are hindgut fermenters (Hume 1999) it is possible that this is why wombats avoid consuming the mosses in buttongrass moorland.

Little is known about the consumption of bryophytes by vertebrates in Australia. No quantitative studies investigating the direct consumption of bryophytes by vertebrate herbivores have been performed that we are aware of, and any references to mammals grazing on bryophytes are purely observational. The dispersal of bryophytes by the spectacled flying fox (*Pteropus conspicillatus*) in the wet tropics of Queensland was established by Parsons *et al*. (2007), although they suggested that bryophytes were consumed indirectly with grooming, rather than directly grazed as a food source.

While our study did not include any trials to determine which, if any, invertebrates consumed bryophytes in buttongrass moorlands, overseas few invertebrate species have been found to eat moss plants readily (Davidson *et al.* 1990), although many invertebrates use bryophytes for shelter (Gerson 1982). Insects are the most commonly found arthropod sheltering in bryophyte communities, with some insects feeding on bryophytes by sucking the juices from leaf cells (Schofield 2001).

It appears that bryophytes are probably not eaten by many vertebrate animals in Australia. Studies are needed to confirm whether wombats do eat moss and under what conditions, and whether there are other animals, vertebrate or invertebrate, that also consume moss on occasion. In terms of buttongrass moorland, the close proximity of more benign feeding environments may mean that animals have not needed to use the unpalatable food source moss presents. More comprehensive studies are needed that look at landscape scale grazing dynamics and the possibility of moss being consumed in other environments, if only to establish that bryophytes are a last resort for hungry vertebrates in Australia.

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