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SHORT COMMUNICATION

PHORMIUM TENAX, AN UNUSUAL NURSE PLANT

Summary: In this paper we document the role of *Phormium tenax* as a nurse plant in unimproved pasture. We show that for our study area the regeneration of woody species was limited solely to *P. tenax* clumps with 22 native and one introduced regenerating woody species present. The number of woody species and of individual woody plants regenerating within *P. tenax* is not correlated with distance from the edge of the remnant forest but is significantly correlated with *P. tenax* clump area. *P. tenax* is acting as a nurse plant facilitating the succession from pasture to forest and we suggest that this species has considerable potential for use in restoration plantings.

Keywords: *Phormium tenax*; restoration; secondary succession; dispersal.

Introduction

A number of pathways for secondary succession to native forest have been described in New Zealand (Wardle, 1991; Allen, Partridge and Lee, 1992; Wilson, 1994). Historically, *Kunzea ericoides*[1] and *Melicytus ramiflorus* were dominant species in successions to tall forest, especially in drier areas of New Zealand, but with European settlement, several introduced species, especially *Ulex europaeus*, *Cytisus scoparius* and *Sambucus nigra*, have become locally important in the early stages of succession (Williams, 1983). While *K. ericoides* can invade bare ground and lightly grazed, short-stature pasture (Allen *et al*., 1992; Wilson, 1994), this and other native woody species are less able to establish into ungrazed pasture and grassland dominated by tall introduced grass species such as *Dactylis glomerata* L. (Esler, 1967; Allen *et al*.,1992; Wilson, 1994). In these situations, *Pteridium esculentum* is often the only native species that can establish and secondary successions to forest may be delayed for a considerable period of time.

The absence or poor establishment of woody plants in ungrazed and lightly grazed pasture or grassland can be attributed to the high competitive ability of ungrazed grasses, especially through the presence of a deep litter layer and a dense shallow fibrous root system (Grime, 1979). The rank growth of ungrazed introduced grasses also reduces light intensities at ground level, further limiting seedling establishment and growth, and can physically smoother woody seedlings (Rogers, 1996; Widyatmoko and Norton, 1997). Thus the absence or very slow establishment of woody species in these situations is a result of their poor competitive ability against the dominant grass sward.

In some areas of the Port Hills, Canterbury, *Phormium tenax* appears to be invading lightly grazed and ungrazed grasslands and providing opportunities for native woody species to establish that are not otherwise present because of competition. In this paper we (1) document the role of *P. tenax* as a nurse plant, (2) assess any patterns associated with woody species regeneration into *P. tenax*, and (3) discuss the consequences of this mode of forest succession for native forest conservation.

Methods

This study was undertaken in Sugarloaf Scenic Reserve, Port Hills, Canterbury (Port Hills Ecological District, Banks Ecological Region, 43° 36' S, 172° 39' E). Kelly (1972) and Wilson (1992) describe the reserve in detail. The vegetation comprises *Melicytus ramiflorus* mixed broadleaf forest centered on the main gully, and extensive areas of unimproved pasture dominated by *Dactylis glomerata*, with *Poa cita* Edgar, *Discaria toumatou* and *Phormium tenax* also present, on the surrounding slopes. It is in these areas of unimproved pasture with *P. tenax* that this study was undertaken. The study site is at *c*. 400 m a.s.l. and has a southerly aspect.

Three transects 100 m long and 20 m wide were randomly located from the edge of the remnant forest up the slope above it. All clumps of *Phormium tenax* within each transect were sampled and all areas of grassland between clumps were searched for

[1]Plant nomenclature follows Allan (1961), Moore and Edgar (1970), Connor and Edgar (1987), and Webb, Sykes and Garnock-Jones (1988) unless otherwise stated.

woody plant species. The area of each *P. tenax* clump was calculated as the area of an ellipse based on the longest axis through the clump and the axis perpendicular to this. The percentage cover of *P. tenax* was visually estimated to the nearest 10 % for each clump as an indication of its "openness". Stem diameter at ground level and the height of all woody plant species, including seedlings, found within each *P. tenax* clump were then recorded. Spearman rank correlation coefficients were used to assess the relationship between distance from the forest margin, area and % cover of *P. tenax* clumps and the number of species and of individuals of regenerating woody plants. Multiple regression was used to assess the independence of the area and cover effects (both analyses run using SAS v 6.12; percent cover was arcsine transformed). Because the number of species present in clumps may not be independent of the number of individuals present, Simpson's index of concentration (Rosenzweig, 1995) was calculated and compared to clump area.

Results

Seventy eight *Phormium tenax* clumps were sampled, ranging in diameter from < 0.5 m to > 4 m, with a predominance of smaller clumps (Fig. 1). The total clump area, 833 m^2, is *c*. 14 % of the sampled area, with an average clump density of 130 ha^{-1}. Clump density declined with distance from the remnant edge, from 242 clumps ha^{-1} at 0-40 m to 83 clumps ha^{-1} at 41-80 m. No clumps were present 80-100 m from the forest remnant edge. However, clump size is significantly positively correlated with distance from the remnant edge, although the explained variance is low (r = 0.329, P = 0.003)

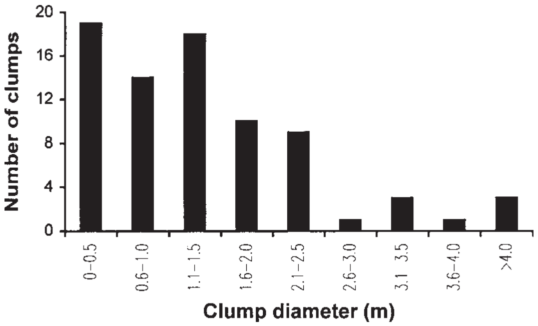

Figure 1: *Size-class distribution of* Phormium tenax *clump diameters in Sugarloaf Scenic Reserve.*

The regeneration of native woody species was limited solely to *Phormium tenax* clumps and no woody species were present in grassland within the transects. A total of 22 native and one introduced (*Ribes sanguineum*) woody species were recorded from within 52 of the 78 *P. tenax* clumps. The six most common species, *Griselinia littoralis*, *Myrsine australis*, *Coprosma lucida*, *Coprosma robusta*, *Pittosporum tenuifolium* and *Pseudopanax arboreus* account for 75 % of individuals (Table 1). For larger individuals (≥ 2 cm diameter), *G. littoralis*, *M. australis*, *C. robusta*, *P. tenuifolium*, *Coprosma linariifolia* and *Olearia avicenniifolia* are the six most common species accounting for 75 % of individuals (Table 1). Woody plants exceeded the height of *P. tenax* in 54 % of clumps with woody species, although the average height of regenerating woody plants was less than *P. tenax* clump height (Fig. 2).

The number of woody species and individual woody plants regenerating within *Phormium tenax* clumps is not significantly correlated with distance from the remnant forest edge (r = 0.214, P = 0.060

Table 1: *Proportion of individuals (total and ≥2 cm basal diameter) of woody plant species regenerating in* Phormium tenax *clumps in Sugarloaf Scenic Reserve.*

Species	% total n = 680	% ≥ 2 cm n = 218
Griselinia littoralis	25.6	24.8
Myrsine australis	17.6	24.8
Coprosma lucida	8.8	3.7
Coprosma robusta	8.5	10.1
Pittosporum tenuifolium	7.4	6.0
Pseudopanax arboreus	6.9	1.4
Olearia paniculata	5.6	1.4
Melicytus ramiflorus	3.5	2.3
Coprosma linariifolia	2.8	5.5
Pittosporum eugenioides	2.4	2.3
Olearia avicenniifolia	2.1	4.1
Pennantia corymbosa	1.8	2.3
Ribes sanguineum	1.5	2.3
Helichrysum lanceolatum	1.5	2.3
Fuchsia perscandens	1.2	0.9
Coprosma crassifolia	0.9	1.8
Pseudopanax crassifolius	0.6	1.8
Muehlenbeckia complexa	0.4	0
Coprosma rhamnoides	0.3	0.5
Cordyline australis (Forst.f.)Endl.	0.3	0.9
Carpodetus serratus	0.1	0.5
Coprosma robusta x propinqua	0.1	0.5
Pittosporum crassifolium	0.1	0

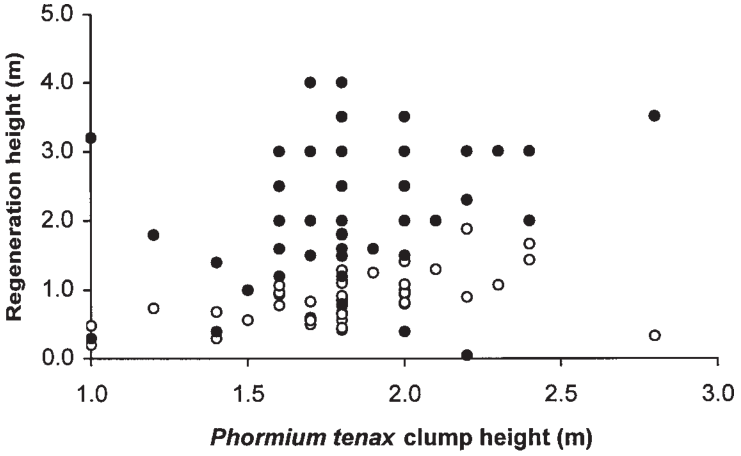

Figure 2: *Relationship between regenerating woody plant height and* Phormium tenax *clump height. Open circles show mean woody plant height; closed circles show maximum woody plant height. Only those 52 clumps with regenerating woody species are shown.*

and $r = 0.173$, $P = 0.128$, respectively). However, larger *P. tenax* clumps have more regenerating tree and shrub species and individual woody plants ($r = 0.883$ and 0.872, respectively, both $P < 0.001$) and clumps with lower *P. tenax* cover also have more woody species and individuals ($r = -0.630$ and -0.633, respectively; both $P < 0.001$). However, clump cover is also correlated with clump area ($r = -0.515$, $P < 0.001$) and a multiple regression using both area and cover shows that the main effect is that of area (Table 2). While the number of regenerating tree and shrub species is significantly correlated with clump area, species diversity (Simpson's index) is not significantly correlated with area ($r = -0.538$, $P = 0.083$) suggesting that the greater number of species in large clumps is simply a sampling artifact associated with the greater number of individuals present.

Table 2: P *values and total* r^2 *for predictors in the multiple regression models between the number of species of woody plants and the number of individual woody plants and the area and cover of* Phormium tenax *clumps (*n *= 78).*

	Number of species	Number of individuals
Area	< 0.001	< 0.001
Cover	0.091	0.503
Area x cover	< 0.001	0.003
r^2	0.740	0.823

Discussion

At Sugarloaf, *Phormium tenax* appears to be a successful nurse plant for native tree and shrub species facilitating succession to native forest. Seedlings and saplings of many woody plants were found in *P. tenax* clumps; in contrast no regeneration of woody species was observed in the grassland surrounding the clumps although occasional seedlings of woody plants were seen elsewhere in these grasslands. While the distance of individual *P. tenax* clumps from the remnant forest does not appear to influence regeneration within clumps, the size of the *P. tenax* clumps plays an important role (Table 2). As the area of each *P. tenax* clump increases so does the number of regenerating individuals present although there is no significant difference in species diversity with clump size. This relationship corresponds with a decrease in *P. tenax* cover, with the largest clumps generally being the most open. Those *P. tenax* clumps with high cover lack regeneration of woody species, while the most open clumps, which tend to be the largest, generally have an abundance of regeneration.

The likely regeneration sequence at our study site presumably started with *Phormium tenax* establishing into grassland. While some *P. tenax* clumps may have survived earlier fires, the size class distribution with an abundance of small clumps (Fig. 1) and the higher density of clumps close to the forest edge suggests that *P. tenax* invasion of grassland is an ongoing process. In his 1971 survey of this reserve Kelly (1972) commented that *P. tenax* was "very occasional" in these grasslands, while a density of 130 clumps ha^{-1} was measured here, also suggesting ongoing establishment of *P. tenax*. The study site has had a recent history of light grazing which may have been sufficient to facilitate *P. tenax* establishment, although the establishment requirements of *P. tenax* in grassland appear poorly known. Once established, *P. tenax* clumps start to expand and gaps form providing potential regeneration sites for woody plant species. As the regenerating vegetation increases in size and overtops the *P. tenax* plants (Fig. 2) it will shade out more of the *P. tenax* clump creating greater habitat for regeneration. At the same time, the *P. tenax* clump advances out into the grassland and eventually coalesces with other clumps, creating large *P. tenax* patches and greater areas for potential regeneration. Eventually the woody species will completely overtop the *P. tenax* clumps and replace them forming a low forest.

It is probable that birds are the main dispersers of woody plant seeds into *Phormium tenax* clumps as all but three of the regenerating woody species are bird dispersed (Burrows, 1994). The three that are not bird dispersed (*Helichrysum lanceolatum*, *Olearia avicenniifolia* and *Olearia paniculata*) have readily wind dispersed seed. While the absence of these three wind dispersed species from the grassland is most likely due to an inability to compete with the grass sward rather than lack of dispersal, the absence of the bird dispersed species may be due to some attraction of dispersers to the *P. tenax* clumps. None of the dominant regenerating woody species bear fruit while *P. tenax* is flowering (Burrows, 1994) suggesting that seed dispersing birds are attracted to *P. tenax* clumps for reasons other than nectar availability. Several studies have illustrated the importance of perch sites in encouraging seed dispersal into restoration areas (McClanahan and Wolfe, 1993; Robinson and Handel, 1993; Reay and Norton, *in press*) and this is also likely to be the case here. *P. tenax* clumps may also contain insects that are attractive to birds, further facilitating seed dispersal to these sites. Once the initial regeneration is established and setting fruit, it is likely to be more attractive to birds, both as potential perch sites and in food sources, thus leading to further dispersal and regeneration. Consequently larger *P. tenax* clumps contain a greater amount of regeneration.

The study area is south facing and at relatively high altitude which may favour the establishment of *Phormium tenax* over other early successional species such as *Kunzea ericoides*. *K. ericoides* is an important early successional species in the general area (Wilson, 1994) but at Sugarloaf appears to be confined to lower altitude sites. *K. ericoides* appears a poor competitor in dense ungrazed grassland (Esler, 1967) and this may have limited its establishment at the study site. *P. tenax* acts as a nurse species on south facing slopes elsewhere on the Port Hills and together with *Phormium cookianum* fills a similar role elsewhere in New Zealand especially at moister, higher altitude sites (Wardle, 1991).

This study illustrates the important role *Phormium tenax* plays in providing habitat for the regeneration of native forest species into ungrazed and lightly grazed pasture and grassland that appears otherwise generally unsuitable for regeneration of native woody species (*cf.* Wilson, 1994). Where *P. tenax* establishes into pasture it has the ability to act as a nurse species facilitating succession to native forest. Because of this facilitation role in forest succession, *P. tenax* has potential for use in restoration plantings. *P. tenax* is relatively fast growing and can successfully establish into grassland and tolerate a wide range of environmental conditions, although it probably does best in drier areas such as the Port Hills at sites with reduced soil moisture deficits (e.g., on south facing slopes). Traditionally restoration programmes have used tree species in restoration, however the results from this study suggest that *P. tenax* also has the qualities of a successful nurse species.

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