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SPECIES SEGREGATION AND FUNCTIONAL GROUPS IN THE HILL COUNTRY OF NEW ZEALAND

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Abstract

In the hill country of New Zealand, the soil-sward relationship on hill microrelief was studied. Three categories of slope or microsites were distinguished: low, medium and high. The hypothesis was that soil variables of neighbouring microsites differ, and because of this, there is a segregation of species or functional groups of species between the microsites. Soil features, botanical composition and total annual yield were measured in the slope categories in two similar paddocks; one of which had received long-term phosphorus fertilisation and a non-fertilised paddock. ANOVA, cluster analysis and canonical variate analysis were performed on the data. Unsaturated hydraulic conductivity, slope, bulk density, volumetric soil moisture, soil total nitrogen content, soil phosphorus content and soil compressibility explained most of the variation between microsites. All the measured variables showed that differences amongst microsites were larger than between paddocks. The soil of the low slopes was more developed and fertile than the soil of the other microsites. From the botanical composition, seven functional groups were determined. Low slope microsites yielded significantly greater dry matter than medium and high slopes and were dominated by high fertility grasses and *Lolium perenne*. Low fertility species and Agrostis capillaris dominated the high slope category. Dicotyledons that colonised high fertility and species with low presence were indifferent to changes in the soil variables. The group of medium fertility species was intermediate between the high and low fertility groups. In conclusion, environmental variables segregated species and functional groups. Species and functional groups differed in ecological strategy. High competitors dominated in environments with high availability of resource. Environments with low resources availability were dominated by stress tolerant species.

Keywords: Microsite, functional type, hill country, field condition, ecological succession, segregation

Introduction

Climate characteristics and historical management of the land are variables that exert selection on species in a naturalised pasture. At the paddock level, soil constraints are continuously affecting the botanical composition, with plants species being permanently involved in processes of colonisation and competition for survival (Gastó et al., 1993). Changes in the botanical composition due to the colonisation-competition relationship can be represented through ecological succession of the species in the field or groups of species (Smith et al., 1997; Wilson, 1999) via functional groups (Gitay and Noble, 1997). The hill country of New Zealand presents, on the faces of the hills, a short scale microrelief where it is possible to distinguish three classes of slope: 1-12° (low slope: LS), 13-25° (medium slope: MS), >26° (high slope: HS) from the horizontal. In this short scale (1 meter) soil variables show large variation. The effects of this variation in soil variables on the botanical composition are not clear. The hypothesis of the current work was that the microrelief of the hill country generates differences in the soil features of neighbouring microsites that are sufficiently contrasting to segregate species or functional groups of species. The objectives of the present work were to determine whether functional groups had been generated in the hill country pasture and to analyse whether soil constraints have segregated species or groups of species amongst microsites.

Material and Methods

This work was carried out in AgResearch's Ballantrae Research Station, Palmerston North, New Zealand, in two paddocks that have had a differentiated management history since 1975. The Low-No paddock received a low input of phosphorus between 1975 and 1980, and after that no fertiliser was applied. The High-High paddock has received a high input of phosphorus since 1975. Both paddocks were set-stocked with Romney ewes (Lambert et al., 1996). The result of the interaction between field treatment and slope constituted the microsites. Pasture (4 cages $0.5m^2$/microsite) and soil were sampled from the LN and HH treatments and from the three categories of slope. Soil physical and fertility features, botanical composition and total dry matter production were determined. The data were analysed using ANOVA. Functional groups from pasture were obtained through Cluster Analysis (weighted pair-group average method). Canonical Variate Analysis (CVA) was used to analyse soil data and the soil-functional groups relationship.

Results and Discussion

Analysis of the soil showed that differences amongst microsites were larger than between field treatment. Soil CVA indicated that unsaturated hydraulic conductivity, slope, bulk density, volumetric soil moisture, soil total nitrogen content, soil phosphorus content and soil compressibility had the largest effect on differentiating microsites, explaining 96.7% of the total soil variation. LS had significantly higher water holding capacity ($P<0.001$), soil compressibility (P<0.001), soil total nitrogen content (P<0.001), soil phosphorus content (P<0.001) and significantly lower bulk density (P<0.001) and unsaturated hydraulic conductivity (P<0.001) than the HS. LS had significantly higher total dry matter production (P<0.001) than the HS. Cluster analysis separated seven botanical functional groups (Table 1). Canonical variate 1 from CVA of soil-functional groups explained 63.5% of the total variation. In one direction CAN 1 had strong positive correlation with unsaturated hydraulic conductivity, slope, bulk density and species group I. In the other direction CAN 1 had a strong positive correlation with volumetric soil moisture, soil total nitrogen content, soil phosphorus content, soil compressibility, the functional groups III and V. CAN 2 explained 28.1% of the total variation and differentiated between field treatments. In one direction CAN 2 had a positive strong correlation with soil phosphorus content and functional groups II and V. In the other direction it had a strong correlation with soil rebound and functional group I. Functional groups showed four types of behaviour in their relationship with CAN 1 related to soil attributes (Figure 1 A, Figure 1 B). Functional groups III and V dominated under high availability of soil resources. Functional groups I and IV dominated microsites with high levels of stress due to low availability of soil resources. Functional groups VI and VII were present in low amounts in the field and showed an indifferent behaviour to changes of soil variables. Functional group II was intermediate between high and low fertility groups.

Results suggest that functional groups III and V would be composed of faster growing species with a large capability to compete when there is a high availability of resources. Group III was more sensitive to increases in the environmental constraints than group V. Functional groups I and IV would be poor competitors under high availability of resources. However with low soil availability of resources, groups I and IV tended to dominate in the field, suggesting that these groups have the comparative advantage of higher tolerance to environmental constraints. Differences between groups I and IV would indicate that group IV would be more aggressive competing for resources than group I under stress conditions.

Species and functional groups were segregated by environmental variables, such that the presence of species and functional groups that dominated varied along the range of environmental variables. Species and functional groups that dominated in the different soil conditions differed in ecological strategy to succeed such that in environments with high availability of resources high competitors dominated, but when there was low availability of resources, species that are tolerant to stress dominated. The diversity of species and functional groups within a microsite would be expected to stabilise the plant community against perturbation and enhance production.

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Table 1 - Groups and sub-groups of species of the naturalised pasture of the hill country of New Zealand according to their functional type determined by cluster analysis.

Low Fertility (Group I)	Medium Fertility (Group II)	High Fertility Grasses (Group III)	Generalist Type A (Group IV)	Generalist Type B (Group V)	High Fertility dicotyledon (Group VI)
Danthonia sp.	*Anthoxanthum odoratum*	*Holcus lanatus*	*Agrostis capillaris*	*Lolium perenne*	*Cerastium glomeratum*
Festuca rubra	*Cynosorus cristatus*	*Poa annua*			*Cirsium arvense*
Hypochaeris radicata	*Trifolium repens*	*Poa trivialis*			*Plantago lanceolata*
Leontodon taraxacoides					
Muscii sp.					
Trifolium dubium					

Group: Species with low presence (Group VII)

Achillea millefolium	*Dactylis glomerata*	*Luzula sp.*	*Sagina procumbens*
Bellis perennis	*Galium arvense*	*Montia verna*	*Silene gallica*
Carex sp.	*Gaphalium sp.*	*Nertera setulosa*	*Stellaria media*
Centella uniflora	*Hydrocotile* sp.	*Poa pratensis*	*Taraxacum officinale*
Crepis capillaris	*Linum bienne*	*Polycarpon tetraphylum*	*Trifolium subterraneum*
Cymbalaria muralis	*Lotus pedunculatus*	*Rumex acetosella*	*Veronica persica*

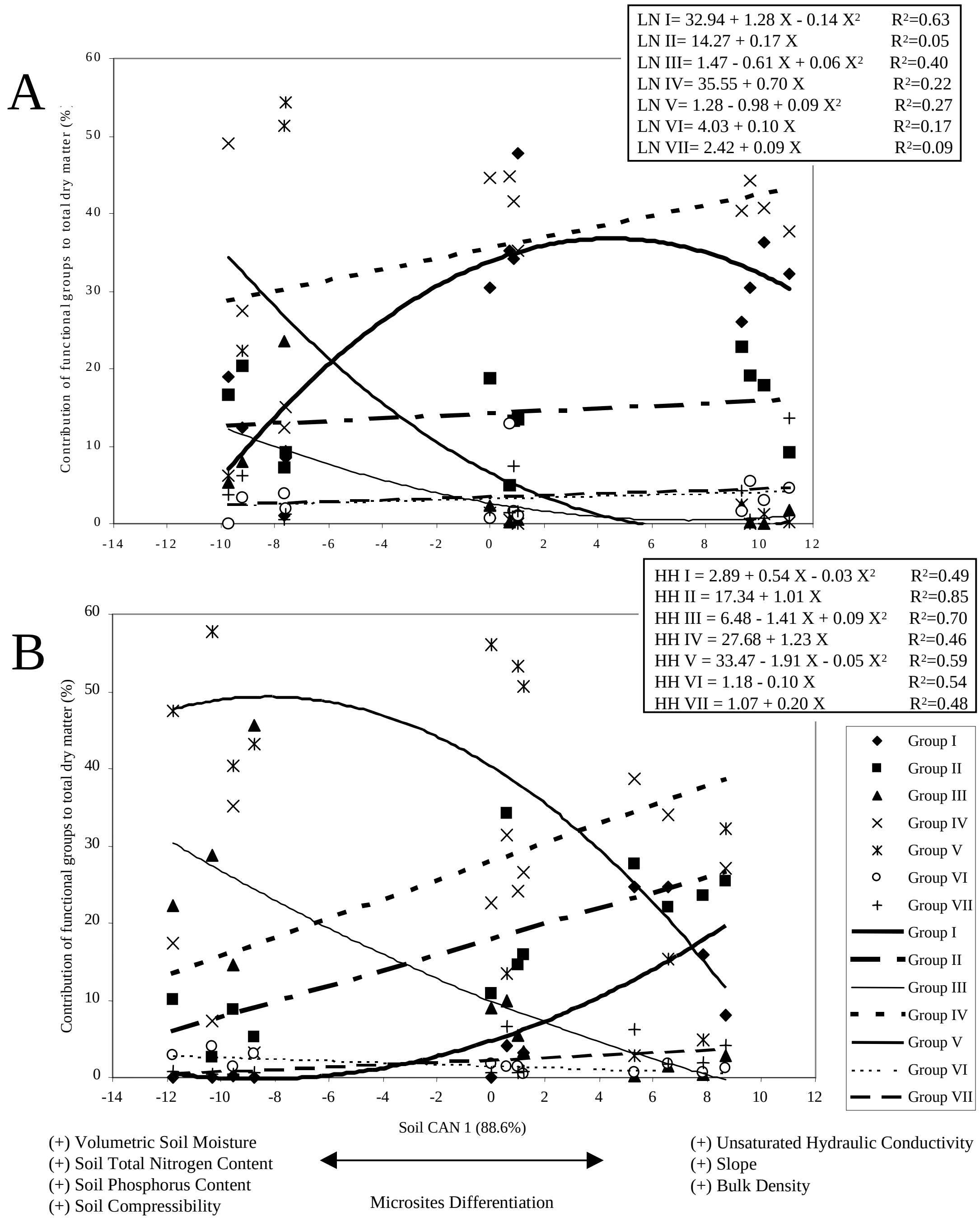

Figure 1 - Succession of functional groups according to changes in soil condition. A: Non-fertilised paddock (LN); B: Fertilised paddock (HH).