ECOLOGY OF PASTORAL COMMUNITIES IN A HETEROGENEOUS ENVIRONMENT

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ABSTRACT

A group of studies was conducted to examine environmental variables and pasture components and their relationships in heterogeneous hill country pasture. Four studies were conducted in relation to the hill country grassland ecosystem of New Zealand.

1. The effects of long-term fertiliser-stocking rate and hill country slope category (LS Low slope, 0-12°; MS Medium slope, 13-25°; HS High slope, >25°) on soil physical and fertility attributes and pasture production were examined. Field treatments, high fertility-high stocking rate (HH) and low fertility-low stocking rate (LN), have been applied to paddocks since 1975. Soil samples were taken from the slope categories of the two field treatments (microsites) and physical and fertility features were analysed. Dry matter production through the year was also measured from these units. The soil attributes that explained the largest percentage of the differences between microsites were water holding capacity (WHC), water conductivity (K_{unsat}), slope, soil compressibility (SC), bulk density (BD), Olsen-P, soil total nitrogen (Total-N) and soil rebound after compression (SR). Slope led to greater differences between soil features of microsites than fertiliser and stocking rate history. Dry matter production increased with increasing Total-N, Olsen-P, WHC and SC, and decreasing slope, K_{unsat}, BD and SR.

2. The presence of plant functional groups, species segregation and their relationship with soil features were analysed. The relationship between field condition and plant functional group was also examined. The evaluation was conducted in the same sites as the first study. The pasture botanical composition for each microsite was measured through the year and plant functional groups determined. The relationship between the presence of plant species and the soil attributes WHC, K_{unsat}, slope, SC, BD, Olsen-P, Total-N and SR (from the first study) and plant functional groups were studied, as well as the field condition-plant functional groups relationship. Seven functional groups were determined. High fertility grasses and *Lolium perenne* (Lp) were associated with LS and high availability of resources, while low fertility species were segregated to HS. Groups of species such as *Agrostis capillaris* (Ac) were indifferent to environmental changes. Functional groups proved to be good indicators of soil development. Field condition and plant functional groups were complementary concepts in grassland dynamic analyses.

3. Sheep grazing behaviour was examined in relation to slope category and plant species selection. The study was conducted in the same microsites as studies 1 and 2. Transects with marked tillers of *Anthoxanthum odoratum* (Ao), Ac and Lp were placed in the slope categories as follows: Ac and Lp in LS; Ac, Ao and Lp in MS; and Ac and Ao in HS. The evaluation was carried out during 4 weeks in each of Summer, Autumn, Winter and Spring, and records of grazed and ungrazed tillers were analysed. Pasture growth rates were calculated through the year. During Spring sheep grazed mainly the LS. With decreasing availability of pasture, sheep enlarged their grazing areas towards the HS. Species selection was only present during Winter when pasture availability was low. In Winter sheep also grazed in all slope categories and selected Lp over of Ac but showed no selection for Ao.

4. Ecotype segregation and plant phenotypic plasticity were examined. Plant material was collected from the extremes of the environmental gradient analysed in studies 1, 2 and 3 and grown in glasshouse conditions under five levels of phosphorus and three of nitrogen in the soil. The plants in each pot were cut on three occasions and total dry matter was calculated. Height, plant architecture, plant horizontal expansion and leaf growth were analysed for *Cynosorus cristatus* (Cc), *Holcus lanatus* (Hl), Ac, Ao and Lp. Morphological and physiological differences were present between genotypes of Lp whereas only physiological genotypic differences existed in Ao and Cc. Consistent differences were not found between Hl genotypes. Thus, Ao, Cc and Lp showed ecotype differentiation. Ac genotypes showed high plasticity with no ecotype differentiation.

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LIST OF ABBREVIATIONS

Ac	*Agrostis capillaris*
Al	Exchangeable aluminium
Al_{sat}	Aluminium saturation
Ao	*Anthoxanthum odoratum*
AP	Air permeability
BD	Bulk density
Ca	Exchangeable calcium
Cc	*Cynosorus cristatus*
Ctr	Control group
GDD	Growing degree days
FT	Field treatment
FVSM	Field volumetric soil moisture
HCS	*Lolium perenne* Hill Country Selection
HH	High-High
HH-HS	High high-High slope
HH-LS	High high-Low slope
HH-MS	High high-Medium slope
Hl	*Holcus lanatus*
HS	High slope
K	Exchangeable potassium
K_{unsat}	Unsaturated hydraulic conductivity
K_5	K_{unsat} at 5 mm of tension
K_{20}	K_{unsat} at 20 mm of tension
K_{40}	K_{unsat} at 40 mm of tension
K_{100}	K_{unsat} at 100 mm of tension
LL	Leaf length
LN	Low-No
LN-HS	Low no-High slope
LN-LS	Low no-Low slope
LN-MS	Low no-Medium slope

Lp	*Lolium perenne*
LS	Low slope
Mg	Exchangeable magnesium
MS	Medium slope
Na	Exchangeable sodium
NH_4-N	Ammonium-nitrogen
NO_3-N	Soil nitrate-nitrogen
P	Olsen-P
pH_{CaCl2}	pH $CaCl_2$
pH_w	pH water
SC	Soil compression
SLP	Slope
SN	*Lolium perenne* cv. Super Nui
SOM	Soil organic matter
SO_4-S	Soil sulphate
SP	Total soil porosity
SPP	Plant species
SR	Soil rebound after compression
SR:SC	Soil rebound-compression ratio
STB	Soil total bases
Total-N	Total soil nitrogen
VSM	Volumetric soil moisture
VSM_{10}	VSM at 10 cm of tension
VSM_{20}	VSM at 20 cm of tension
VSM_{50}	VSM at 50 cm of tension
VSM_{100}	VSM at 100 cm of tension
WHC	Water holding capacity