BIODIVERSITY, STABILITY AND PASTURE MANAGEMENT - THE ROLE OF FUNCTIONAL GROUPS

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Abstract

Data collected in 1968/69 and 1996/97 from a North Island, New Zealand hill research farm have been used to identify relationships between biodiversity, stability and production. These data sets have been collected at sites that have been subjected to different management regimes for approximately 20 years. It is proposed that the use of functional groups simplifies interpretation of changes in pasture composition and hence production, in the differently managed systems. Both the historical and new data are used to identify functional groups in the species present using a number of techniques. The effectiveness of these techniques is discussed as is the contribution of functional groups to the study of biodiversity, production and stability of production in North Island, New Zealand hill pastures.

Key words: Hill land pastures, management, biodiversity, production, functional groups

Functional groups are collections of species that have been grouped or clustered together based on sets of traits common to these species (*eg.* morphological, physiological, environmental responses). Functional groups are used to simplify ecological systems and are most commonly used to make predictions about the effects of environmental changes on vegetation (1,? 3).

There are two ways of defining functional groups, objectively and subjectively. The objective definition of functional groups involves submitting a range of data, collected from a population of plants, into a statistical package that is able to analyse the data and group similar species together. Two problems exist with this method:

• the resulting clusters are specific to the environ-ment from which the data were collected; and,

• the resulting functional groups can be biased by the data chosen to be used (1).

The second method of grouping species into funct-ional types is to do so subjectively. Subjective grouping is based on knowledge about species in terms of their physiology, morphology, and how they respond to environmental influences. No specific data sets are required. Again, resulting clusters can be biased due to the factors chosen to be used for the clustering.

Specifically for North Island hill pasture in New Zealand hill, a method needs to be developed to best define functional groups. The use of these functional groups is in identifying the role of functional group biodiversity in hill pastures and how this responds to farm management

Methods

In October 1968 and January 1969, a survey was carried out on two low fertility North Island hill pasture sites, 20 km NE of Palmerston North, New Zealand.? These sites are described fully in Nicholas *et al.* (7), but had average Olsen P values of 3.4 (Site 1) and 1.9 (Site 2) mg P/g of soil, respectively. The survey involved measuring botanical composition, species yield, species growth rate, Olsen P and hill slope on 200 microsites at each of the sites.

The survey was carried out again on the same farm (now Ballantrae Hill Research Station) in October 1996 and January 1997. Spring and summer surveys were carried out to identify the effects of seasonality on species abundance. The farm had been broken up into farmlets that have had differing management histories imposed on them for the last 20 years (5). The resulting average Olsen P values of the sites were 50 (Site 3), 19 (Site 4) and 21 (Site 5) mg P/g soil. Site 1 in the 1968 survey and Site 4 in the 1996 survey were positioned at the same location.

Three methods were used to cluster the species present in this hill farm pasture (7) into functional groups. The first used groupings devised by Lambert *et al.* (6), developed particularly for North Island hill pasture species. The second method was the use of literature (2, 4) to fill in a matrix of factors for each species, which was then put into a cluster analysis in SAS to identify clusters of species. The variables used included: ability to respond with increased growth to increased P levels; nitrogen fixing ability; ability to grow well on slopes; low growth habit; and tolerance to above average treading, grazing and drought levels. The third method used the Ballantrae data collected in 1968/69 and 1996/97 surveys, which were averaged for each species over all 8 data sets. The data were standardised (using ranking and assigning standard numbers to identify relationships) and again put into a cluster analysis in SAS to identify clusters of species.

Results and discussion

The example of objective grouping of species into functional groups was carried out using a cluster analysis on standardised Ballantrae data. The inputs for each species were: yield (kg DM/ha), % cover, growth rate (kg DM/ha/day) and the regression slope of the relationship between growth rate and Olsen P, growth rate and hill slope and yield and Olsen P. The first three factors were standardised by ranking (3) and the last three were standardised by allocating a 3 to those species with a positive regression and 1 to those with a negative regression. The following 7 groups were identified from the analysis:

• *Trifolium dubium, Lotus pedunculatus,* and *Centella uniflora;*

• *Trifolium subterraneum and Poa pratensis;*

• *Anthoxanthum oderatum*, *T. repens*, *Cynosurus cristatus* and *Muscii* spp.;

• *Holcus lanatus*, *Poa annua*, *Rytidosperma* spp.

• Flatweeds; *Festuca rubra* and *Nertera setulosa;*

• *Lolium perenne*; and*,*

• *Agrostis capillaris*.

These groupings do not appear to have been made based on function. *T. repens* for example, a productive, grazing tolerant legume has been grouped with *A. oderatum* and *C. cristatus* (both grazing intolerant grasses that are usually associated with low fertility sites) and *Muscii* spp. which are a non-significant species in agricultural production, with little or no grazing tolerance. A similar pattern arises in the grouping of *H. lanatus*, *P. annua, Rytidosperma spp.* and flatweeds. *H. lanatus* and *P.annua* are similar in that they are associated with high fertility sites and both are intolerant of drought. *Rytidosperma* spp. are associated with low fertility sites and are drought tolerant, the opposite to *H. lanatus* and *P. annua*. Flatweeds are morphologically different from grasses, hence the grouping of these four species does not seem to be based on function.

It appears that these groupings have been biased by the inputs used in the clustering analysis. The variables used in the analysis are variables that would commonly be measured in a biodiversity study (yield, growth rate and % cover of each species). However, these are all? measures of abundance. One of the factors in each of the regressions used to define the relationships with Olsen P and hill slope was either growth rate or yield, hence abundance factors have been incorporated into these relationships. It appears the cluster analysis has grouped according to species abundance.

This is demonstrated by the yields of the species that were grouped together in the cluster analysis.

• *T. dubium, L. pendunculatus*, and *C. uniflora*, 15, 16 and 14 kg DM/ha, respectively.

• *T.subterraneum* and *P.pratensis* both 3 kg DM/ha.

• *A. odoratum, T. repens, C. cristatus* and *Muscii spp*. 152, 151, 148 and 196 kg DM/ha, respectively;

• *H. lanatus, P. annua, Rytidosperma spp*. and Flatweeds? 95, 100, 88 and 115 kg DM/ha, respectively;

• *F. rubra* and *N. setulosa* had 45 and 32 kg DM/ha, respectively;

• *L. perenne* 340 kg DM/ha; and,

• *A. capillaris* 680 kg DM/ha.

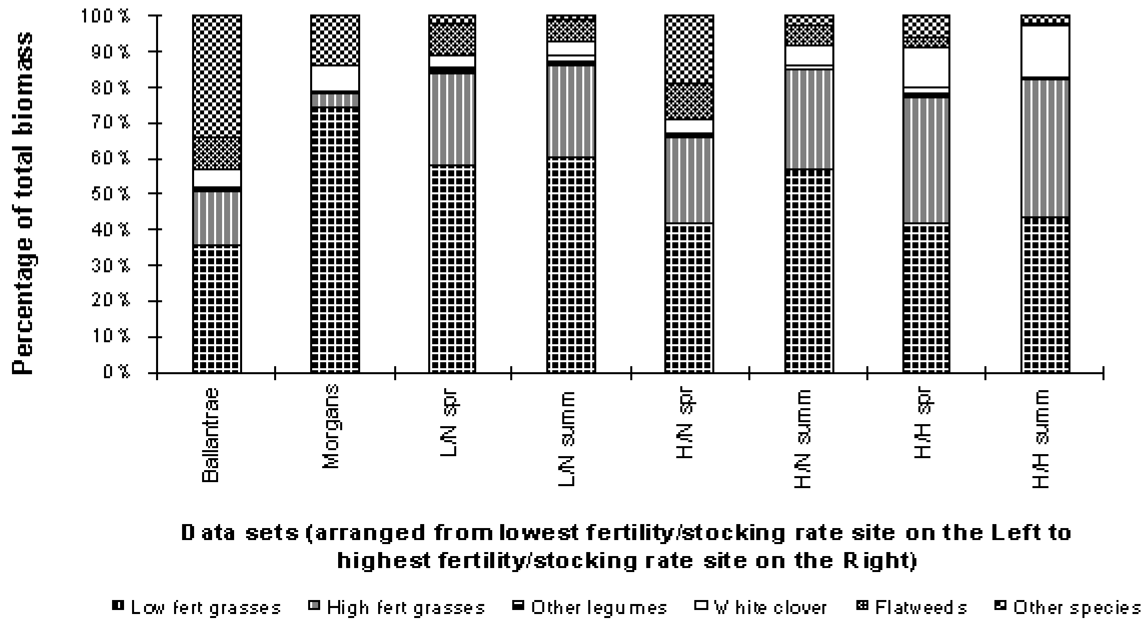
These results indicate that the cluster analysis has been based on the yield factor. If objective definition of functional groups is desired then the data describing the species need to be based on the function of the species, not on common agronomic measures of abundance.

The cluster analysis based on the literature derived variables resulted in similar groups to those defined by Lambert *et al.* (6), but with some slight differences. The low fertility grasses defined by Lambert *et al.* (6) were the same as those that formed the first group: *C. cristatus, Rytidosperma spp., F. rubra, A. capillaris* and *A. odoratum*. The high fertility responsive grasses (6) were the same as the second group of *L. perenne, H. lanatus* and *P. annua.* Lambert *et al.* (6) had *L. perenne* as a functional group on its own as it is more responsive to high fertility than either *H. lanatus* or *P. annua*. The two remaining functional groups defined by Lambert *et al.* (6) were legumes and other species. In the literature based analysis, all the legumes (*T. subterraneum*, *T. dubium* and *L. pedunculatus*) grouped together except for *T.repens* which was in its own functional group. Flat-weeds also formed a functional group, but this was because they were the only weed species present. There were other species present in the pasture such as *C. uniflora, N. setulosa* and *Muscii* spp., but they were removed from the cluster analysis due to missing values.? More would need to be known about the grazing toler-ance of these species to group them correctly. That these species are indigenous suggests they are intolerant of sheep grazing and would therefore form their own functional group separate to flatweeds.

The key functional differences between groups in this analysis appear to be grazing tolerance and response to fertility. This would be expected as three of the input variables were fertility related and three to grazing avoidance/tolerance. These are important variables from a pastoral perspective.

The cluster analysis resulted in 6 functional groups: low fertility responsive grasses, high fertility responsive grasses, other legumes, white clover, flatweeds and other species (in this pasture including *C.uniflora, N. setulosa* and *Muscii spp*.)

The relative contribution to biomass production of the 6 functional groups in response to soil fertility and grazing management history is shown in Fig. 1. The trend, with the exception of the Ballantrae site, is that low fertility responsive grasses decrease as fertility increases. Similarly, high fertility responsive grasses increase with increasing fertility. This suggests a funct-ional response of these two groups to a fertility/grazing management gradient. The Ballantrae site has a low occurrence of all grasses and the highest occurrence of other species. Perhaps at this low fertility level, the function of the other species is more suited to the environment than that of low fertility responsive grasses. There does not appear to be any noticeable pattern over the fertility range with the functional group of other legumes, though the occurrence of these legumes in spring is greater due to annual species dying out in summer. The occurrence of white clover increases with increasing fertility, with the exception of the Ballantrae and Morgans sites. It appears to be equally abundant on the two sites with the lowest fertility. Flatweeds appear to occur more frequently on the lower fertility sites, with the exception of the Morgans site.



Conclusion

Functional groups can be formed from a group of species either objectively or subjectively. In either case, the inputs used to group species together must be chosen carefully and be relevant to the environment that is being studied. Functional groups can usually be broken down into sub groups based on lower levels of function, however, in ecological studies the purpose of using functional groups is to simplify the system and a level of function must be chosen, below which the function is not of major importance to the system being studied. The functional groups chosen were shown to respond to fertility and management histories in a predictable manner and provide a basis for investigations into how management factors affect biodiversity, production and stability of North Island, New Zealand hill pastures.

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