Spatial variation in plant nutrient composition on Marion island

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Introduction

To assess nutrient budgets and nutrient cycling at Marion Island on a whole island basis we need to know how plant (and soil – see Conradie and Smith 2002) nutrient composition varies with increasing distance for sea and altitude and between sides of the island?

To reduce the complexity of whole island model it would be useful to be able to group plant species be grouped according to similarities/differences in their nutrient composition, rather than model each species individually.

Aims

To assess how plant nutrient composition of the most common vascular and bryophyte species varies spatially. To group the species into a suite of plant nutrient composition types.

Materials and methods

1. 779 plant samples representing 20 vascular and 15 bryophyte species were collected over 4 years. Samples were divided into living leaf, dead leaf, stem and root components, the subsamples dried at 100 C, ground and analysed for N, P, K, Ca, Mg, Na (BemLab, Somerset West).

2. Linear Regression was used to test effect of distance from sea and altitude. ANCOVA, ANOVA or Separate Slopes Model used to test effect of side of island. Principal Components Analysis, Clustering Analysis and Correspondence Analysis used to group species into nutrient guilds.

Effect of distance inland and altitude

1. Altitude and distance from the sea are highly correlated and thus influence nutrient concentrations very similarly.
2. N, P and Na concentrations in living leaves, dead leaves, stems and roots of vascular plants decrease significantly going inland (Fig. 1), due to a decline in the influence of animal manuring and of seaspray.
3. Ca concentration in living leaves increases significantly going inland, away from the organic peats characteristic of the lowland regions toward the mineral rawmark inland soils (Fig. 2).
4. Declining seaspray (lessening Mg input) and increasing soil minerality (increasing Mg input) going inland both affect plant Mg concentration; the net effect is a slight decrease in Mg concentration going away from the coast.
5. K concentration in living leaves and roots did not change going inland; dead leaf and stem K concentrations showed a weak decline.
6. Dead leaf, stem and root nutrient concentrations showed similar spatial patterns
7. Bryophyte shoot nutrient concentrations do not show as distinct patterns of change going inland as did the vascular plant concentrations. Considering the bryophyte species as a whole, the only significant effect is that shoot Na concentration decreases, and Ca concentration increases, going inland.

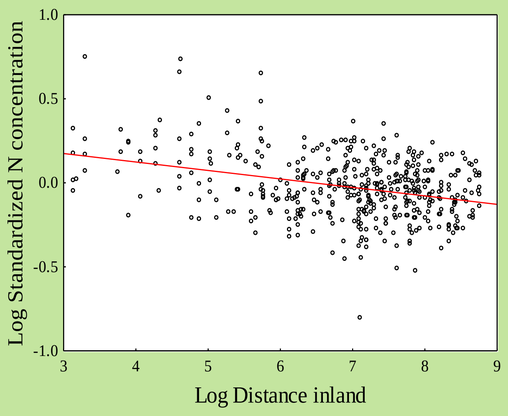

Fig. 1 The relationship of N concentrations in the live leaves of 13 vascular species to distance inland

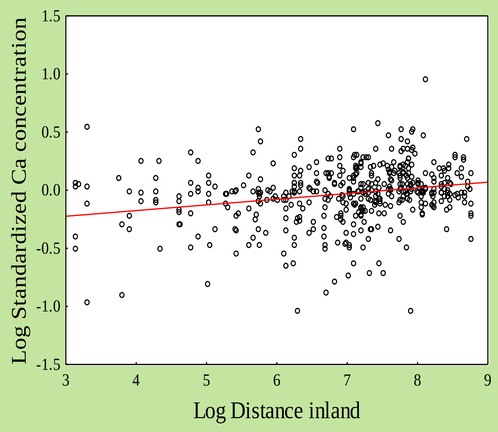

Fig 2 The relationship of Ca concentrations in the live leaves of 13 vascular species to inland

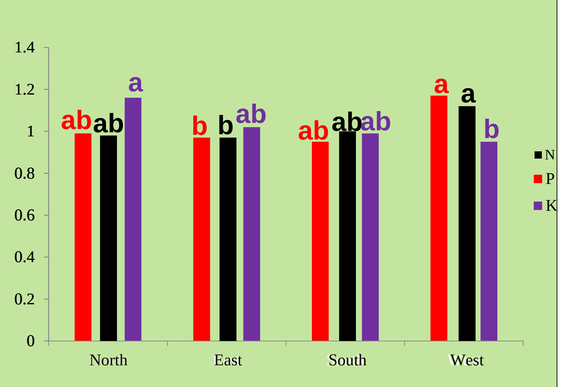

Fig. 3 The N,P and K live leaf concentrations on the four sides of Marion island. Letters indicate significant differences

Effect of island side

1. For vascular species, the pattern of between-side differences is quite clear.
2. Living leaf N, P and Mg concentrations are higher in west side than east side plants; south and north side plants have intermediate concentrations (Fig . 3).
3. Leaf K concentrations are highest on the north and lowest on the west side, with east and south side concentrations being intermediate.
4. Leaf Ca concentrations are highest on the south side and lowest on the north side, with east and west side Ca concentrations being intermediate.
5. Leaf Na concentration declines more sharply with distance inland on the island's western and southern sides than on its eastern and northern sides, so that closer than 450 m from the shore leaf Na concentration is higher on the west and south than on the east or north sides, but further inland than that the difference lessens.
6. There was sufficient information for dead leaf, stem and root nutrient concentrations only for the west and east sides of the island. West-east differences in nutrient concentrations of dead leaves are the same as for living leaves. Stem and root west-east concentration differences are also similar to those for living leaves, except that P and Mg concentrations were similar on the two sides.
7. All organs showed the same steeper decline in Na concentration on the west than on the east side of the island.
8. Bryophytes show somewhat different between-side nutrient concentration patterns to the vascular plants. South side (not west) bryophytes have highest N and P concentrations but, like for the vascular plants, east side bryophytes have the lowest N and P concentrations.
9. Also similar to the vascular plants, bryophyte K concentration is highest on the north side and lowest on the west side, although south side concentrations are nearly as high as the north side ones.
10. Unlike the vascular plant leaves, bryophyte Mg concentration is highest on the south (not west) side and lowest on the north (not east) side, with east and west side concentrations being intermediate.
11. South side bryophytes have highest Ca and Na concentrations, similar to the vascular plant pattern.

Grouping into Plant nutrient types

1. Groupings were done using PCA, Ward Clustering and Correspondence Analysis.
2. The groups were strongly a function of broad taxonomic type (Monocot, Dicot, Pteridophyte (Fig. 4 and 5).
3. Plant guilds compiled previously for the island (to classify the island's habitats) associate poorly with the groups.
4. Nonetheless, habitat was found to a successful grouping variable (Fig. 5).

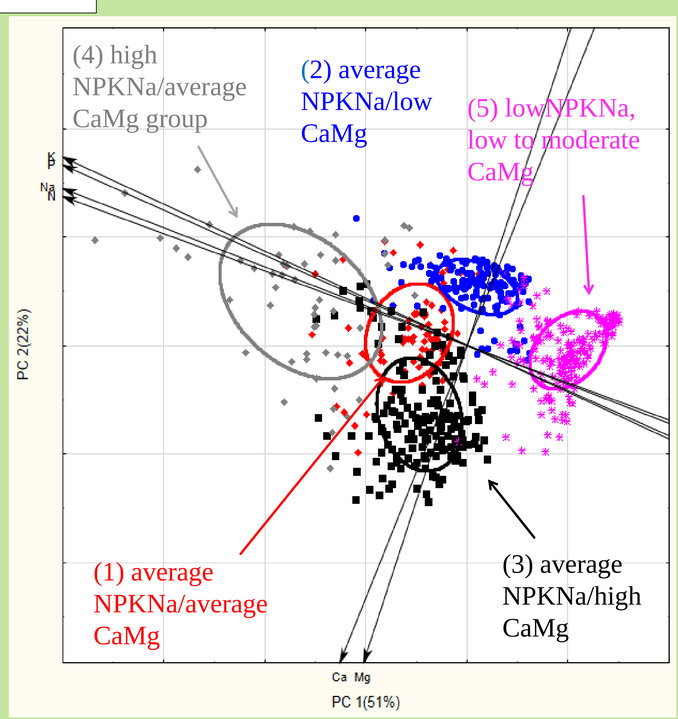

Figure 4 Biplot from PCA of leaf nutrient concentrations.. The 0.5 alpha ellipses encompassing 50% of the members of a particular cluster are shown.

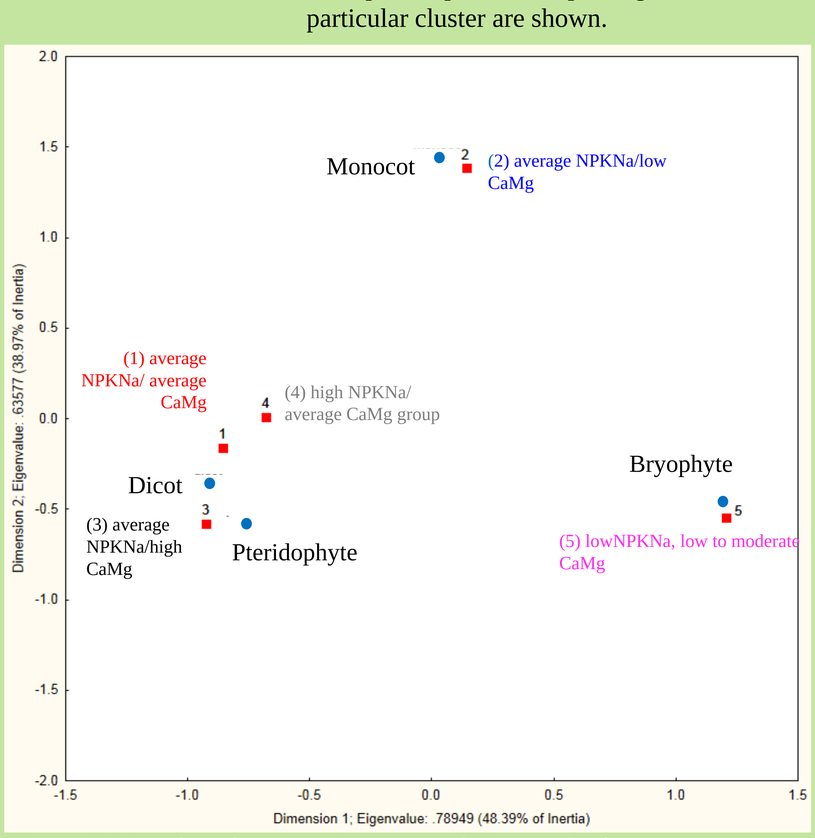

Figure 5 Joint plot of taxonomic group and K-mean leaf nutrient concentration clusters.

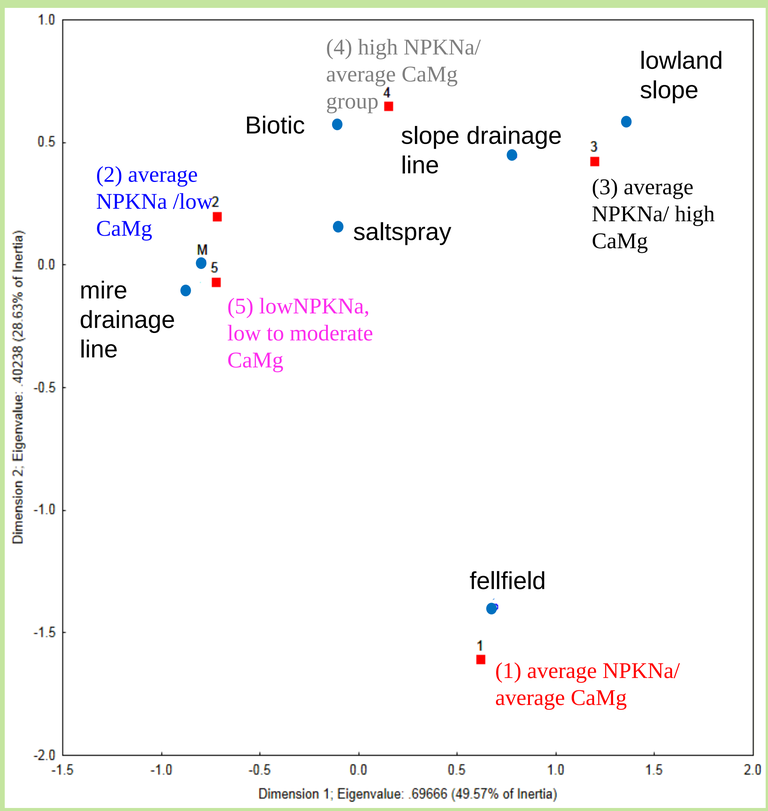

Figure 6 Joint plot of habitat complexes group and K-mean leaf nutrient concentration clusters.

Conclusions

Distance from sea, altitude and side of island influence plant nutrient concentration.

Nutrient concentration is strongly related to major taxonomic group.

Habitat also seems an important determinant of plant nutrient composition.