Suo 35 (3): 57—61, 1984

MICHAEL R. STARR

NON-METRIC MULTIDIMENSIONAL SCALING OF A PEATLAND VEGETATION DATA SET

ERÄÄN MONIMUUTTUJAMENETELMÄN KÄYTTÄMISESTÄ SUOTYYPPIEN VÄLISTEN SUHTEIDEN TUTKIMISESSA

Starr, M. R. 1984: Non-metric multidimensional scaling of a peatland vegetation data set. (Erään monimuuttujamenetelmän käyttämisestä suotyyppien välisten suhteiden tutkimisessa.) — Suo 35: 57—61, Helsinki.

Non-metric multidimensional scaling (MDS) is used to produce a two-dimensional sample ordination of a set of peatland site type community data. The MDS ordination is assessed by comparing it to Heikurainen's and Pakarinen's informal two-dimensional ordination of peatland site types.

The MDS ordination produces clusters of quadrats which correspond to the five site types sampled. The result with species presence-absence data is similar to that with species percentage cover data although the clusters are more distinctive with presence-absence data.

The relationship of the five sampled site types to trophy and wetness gradients as indicated by Heikurainen and Pakarinen could only be approached by fitting curved, overlapping gradients in the MDS ordination. The reason for the curvature of the environmental gratients is considered to be largely the result of the bias towards nutrient poor and dry conditions represented by the site types sampled.

The effect of drainage upon ecological conditions in two of the site types sample is briefly discussed.

M. R. Starr, The Finnish Forest Research Institute, Soil Science Dept., P.O. Box 18, SF-01301 Vantaa 30, Finland.

INTRODUCTION

Numerical ordination techniques are used in plant ecology to objectively extract the latent structure in plant community data in terms of a limited number of dimensions which account for most of the variation. Sample units (species or quadrats) placed near each other should have similar habitats than those further away. Thus, the relationship of the sample units to each other can give useful information concerning the identity of important environmental (or successional) gradients operating within the community.

A range of ordination techniques have been developed with varying degrees of sophistication and success (Orlóci 1978, Gauch 1982). The success of a particular technique is assessed by the degree of recovery of the known structure in either a simulated data set or that in a real data set in which only a few, well understood environmental gradients operate.

Peatland plant communities are suitable cases for this latter approach since the peatland ecosystem is relatively well understood and can be effectively described by two environmental gradients: one expressing nutrient status (trophy) and the other expressing wetness (Moore & Bellamy 1974). In a description of the Finnish peatland site type classification widely used in forestry, Heikurainen & Pakarinen (1982, see also Heikurainen 1972) use these two gradients explicity to define a two-dimensional ecological space in which the site types are subjectively placed.

In this paper a peatland vegetation data set representing five site types is ordinated in two dimensions using non-metric multidimensional scaling. This technique is lesser used than other, metric techniques, but is considered to have several advantages (Austin 1976, Fasham 1977, Prentice 1977, Mathews 1978, Clymo 1980). The MDS ordination is compared to Heikurainen and Pakarinen's informal ordination of site types and the same trophy and wetness gradients sought for. The ecological effects of forest drainage on two of the site types sampled in relation to these two gradients is also briefly discussed.

MATERIAL AND METHODS

The study material was collected from Lakkasuo, a raised bog complex, situated near Hyytiälä Forestry Station in Central Finland (61°40'N24°19'E, 120 m a.s.l.). The peatland has been described by Mannerkoski (1979).

Throughout the peatland 25×25 m permanent plots have been established by the Peatland Forestry Dept., University of Helsinki on representative communities of different site types in order to demonstrate the site type classification. Five of these plots and a further plot for two of the site types on an adjacent drained area were selected for the purposes of this study (Table 1). The five site types are among the most common types found in southern Finland.

During July 1978 a vegetation survey was made of each of the seven selected plots. Ten 1×0,5 m quadrats were located randomly in each of the plots and the percentage cover of the species present estimated. Quadrats falling on or near to tree trunks were rejected in favour of those falling on the level surface between trees.

The complete species percentage cover data matrix is presented elsewhere (Starr 1982). A total of 26 species was recorded and the number of species in a quadrat ranged from 4 to 13. The species composition of the quadrats belonging to the same site type were relatively homogeneous, but heterogeneous between site types.

Non-metric multidimensional scaling (MDS), unlike metric ordination techiniques (e.g. PCA and RA), uses only the rank order of the sample dissimilarity measures and ordination interpoint distances to arrive at the final ordination configuration. A full technical account of MDS is given by Kruskal (1964a, b) and a comparison of several available MDS algorithms using real and simulated data sets given by Gauch et al. (1981). MDS has been used in a Finnish study by Oksanen (1983).

The MDS algorithm used in this study was the 5M version of MDSCAL (Green & Carmone 1972). The initial configuration of points is randomly generated and the final solutuion arrived through an iterative procedure. The inter-point distances are Euclidean The inter-quadrat resemblance measures used were the Coefficient of Community with the species presence-absence matrix, and the Percentage Dissimilarity index with the species percentage cover matrix. The programme is limited to a maximum of 64 samples (quadrats) and therefore one quadrat from each of the seven plots was randomly excluded from the ordination.

There was no manipulation of the field recorded data before ordination.

Table 1. Sample plot site types and their abbreviations.

Taulukko 1. Näytealat, suotyypit sekä niistä käytetyt lyhennykset.

Site type *Suotyyppi*	Abbreviation *Lyhennykset*
Undrained plots — *Ojittamattomat ruudut*	
Sphagnum fuscum pine bog *Rahkaräme*	RaR
Ombrotrophic small-sedge bog *Lyhytkorsineva*	LkN
Low-shrub pine bog *Isovarpuräme*	IR
Tall-sedge pine swamp *Varsinainen nevaräme (sararäme)*	VNR
Vaccinium myrtillus spruce swamp *Mustikkakorpi*	MK
Drained plots[a] — *Ojitetut ruudut[a]*	
Tall-sedge pine swamp (1955) *Varsinainen nevaräme (sararäme(1955)*	VNR
Vaccinium myrtillus spruce swamp (1965) *Mustikkakorpi (1965)*	MK

a) Year of drainage given in brackets

a) Ojitusvuosi annettu suluissa

RESULTS

The two-dimensional MDS ordination of the 63 sample quadrats using species presence-absence data and species percentage cover data are given in Figure 1.

Discrete groups of quadrats corresponding to site type are observed. The ordinations using presence-absence data and percentage cover data are similar although the site type clusters are more distinctive with presence-abcence data.

If the site type structure in the MDS ordinations is compared to that in the informal two-dimensional ecological space presented by Heikurainen & Pakarinen (Fig. 2), it is seen that the MDS ordination has made a limited recovery.

The trophic gradient appears to loosely correspond to Axis 1 and the wetness gradient to loosely correspond to Axis 2. Interestingly, the subgroup of three Ombrotrophic small-sedge bog quadrats in the lower left-hand corner of the MDS ordinations, indicating wet conditions, were located in the wetter hollows of the peatland surface. *Sphagnum fuscum* pine bog, Low shrub pine bog and *Vaccinium myrtillus* spruce swamp site types in Haikurainen & Pakarinen's ordination differ in trophy but have a similar degree of wetness. In the MDS ordination this can only be achieved by fitting curved, overlapping gradients.

DISCUSSION AND CONCLUSIONS

The formation of distinct clusters of quadrats corresponding to the site types was to be expected because of the sampling design and discontinuities in the species compostion between the site types studied. The similarity of the species presence-absence and species cover based ordinations may have significant implications as fas as vegetation survey work is concerned since presence-absence data can be recorded much faster than quantitative data and is also less susceptible to error.

The recovery of the site type structure as described in the ecological space of Heikurainen & Pakarinen (Fig. 2), however, could only be approached by fitting non-orthogonal, curved trophic and wetness gradients. This distortion is probably related to the following two factors. Firstly, ordination techniques can only describe the structure in the data given. The site types studied (Table 1) do not span the full combination of environmental conditions described in Heikurainen & Pakarinen's ecological space, i.e. there is an absence of wet, mesotrophic site types — fens. Secondly, the MDS ordinations were based on the data from a single peatland. Heikurainen & Pakarinen's space is that for the theoretical, generalised site types. In practice there is variation in the species compostion and abundance of each site type. There is

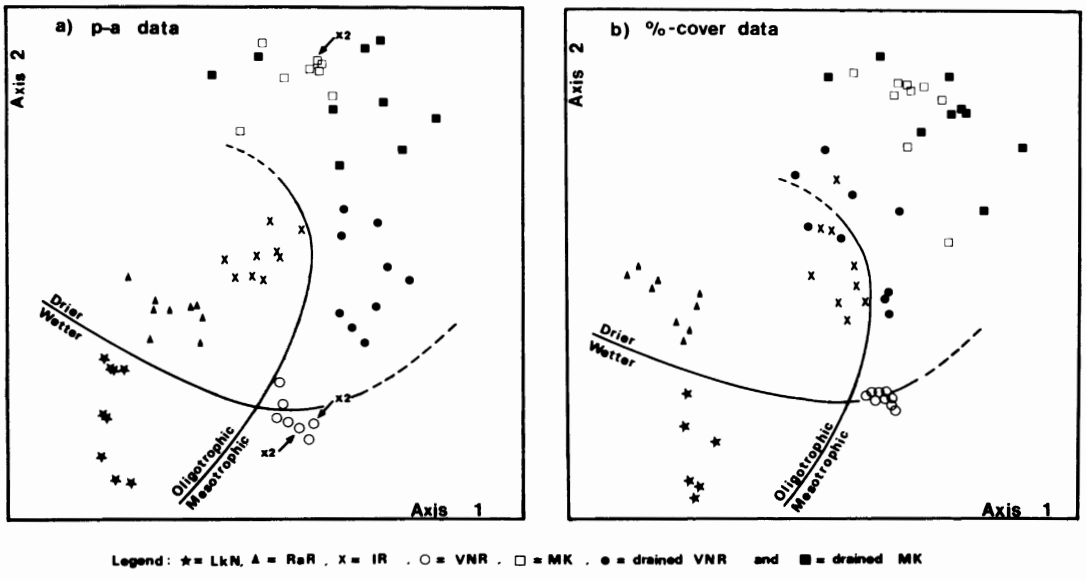

Fig. 1. Two-dimensional MDS ordination of the 63 sample quadrats according to site type. a) using species presenceabsence data and b) using species percentage cover data. For explanation of the site type abbreviations see Table 1.

Kuva 1. Näyteruutujen kaksiulotteinen ordinaatio suotyypeittäin. a) pohjautuen kasvilajien läsnä- ja poissaoloon ja b) pohjautuen kasvilajien peittävyystietoihin. Suotyyppilyhenteet ovat taulukon 1. mukaisia.

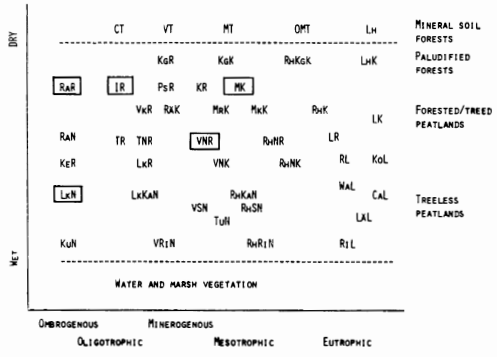

Fig. 2. Peatland site types located in two-dimensional ecological space according to Heikurainen & Pakarinen (1982.) The five site types sampled in the present study are in the boxes.

Kuva 2. Suomessa esiintyvien suotyyppien asema kahden ekologisen vaihtelusuunnan mukaan (ks. Heikurainen & Pakarinen 1982). Tässä työssä esiintyvät suotyypit on kehystetty.

also variation in the environmental conditions within site types (e.g. Starr & Westman 1978, Westman 1981).

The quadrats belonging to the two drained site type plots occupy a different space in the MDS ordinations compared to their undrained counterparts. However, because of the limited size of the data set and the uncertainly over the trends of the gradients, it is difficult to assess what specific effects drainage has had upon the ecology in the two site types concerned. Drainage would obviously reduce the wetness of a site, which is indicated in the case of the Tall-sedge pine swamp but is obscure in the case of the *Vaccinium myrtillus* spruce swamp. The principle involved, however, could be applied to a set of vegetation data collected from the same permament plots but at different times since drainage.

ACKNOWLEDGEMENTS

The author wishes to thank Jussi Kuusipalo and Jari Oksanen for helpful criticism of the manuscript.

REFERENCES

Austin, M. P. 1976: Performance of four ordination techniques assuming three different non-linear species response models. — Vegetatio 33: 43—49.

Clymo, R. S. 1980: Preliminary survey of the peat-bog Hummell Knowe Moss using various numerical methods. — Vegetatio 42: 129—148.

Fasham, M. J. R. 1977: A comparison of nonmetric multidimensional scaling, principal components and reciprocal averaging for the ordination of simulated coenoclines and coenoplanes. — Ecology 58: 551—561.

Gauch, H. G. 1982: Multivariate analysis in community ecology. Cambridge studies in ecology. — 298 pp. Cambridge University.

Gauch, H. G., Whittaker, R. H. & Singer, S. B. 1981: A comparative study of nonmetric ordinations. — J. Ecol. 69: 135—152.

Green, P. E. & Carmone, F. J. 1972: Multidimensional scaling and related techniques in marketing analysis. — Allyn & Bacon, Boston, U.S.A.

Heikurainen, L. 1972: Peatland classification for forestry in Finland. — In: Proc. 4th Intern. Peat Congr. Otaniemi, Finland, 1972. Vol. 3: 435—450.

Heikurainen, L. & Pakarinen, P. 1982: Peatland classification. — In: Laine, L. (ed.), Peatlands and their utilization in Finnish Peatland Society, Finnish National Committee of the International Peat Society. — pp. 14—23. Helsinki 1982.

Kruskal, J. B. 1964a: Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. — Psychometrica 29: 1—27.

Kruskal, J. B. 1964b: Nonmetric multidensional scaling: A numerical method. — Psychometrica 29: 115—129.

Mannerkoski, H. 1979: Peatland Path, "Cursus Paluster", Excursion route demonstrating peat site types. — Univ. of Helsinki, Peatland Forestry Dept. — 13 pp. Mimeograph.

Matthews, J. A. 1978: An application of non-metric multidimensional scaling to the construction of an improved species plexus. — J. Ecol. 66: 159—173.

Moore, P. D. & Bellamy, D. J. 1974: Peatlands. — 221 pp. Elek Science, London.

Oksanen, J. 1983: Ordination of boreal heath-like vegetation with principal component analysis, correspondence analysis and multidimensional scaling. — Vegetatio 52: 181—189.

Orlóci, L. 1978: Multivariate analysis in vegetation research. — 2nd ed. The Hague: Junk.

Prentice, I. C. 1977: Non-metric ordination methods in ecology. — J. Ecol. 65: 85—94.

Starr, M. R. 1982: The development of drained peatland forest sites in Finland. — pp. XIII+311. Unpubl. PhD. thesis, University of Sheffield, England.

Starr, M. R. & Westman, C. J. 1978: Easily extractable nutrients in the surface peat layer of virgin sedge-pine swamps. — Silva Fennica 12: 65—78.

Westman, C. J. 1981: Fertility of surface peat in relation to the site type and potential stand growth. — Acta Forestalia Fennica 172: 1—17.

SELOSTE

ERÄÄN MONIMUUTTUJAMENETELMÄN KÄYTTÄMISESTÄ SUOTYYPPIEN VÄLISTEN SUHTEIDEN TUTKIMISESSA

Tässä työssä on käytetty eräistä kasvilajien esiintymisrunsauden järjestykseen perustuvaa monimuuttujamenetelmää, non-metric multidimensional scaling (MDS). Sen avulla on analysoitu eräiden Hyytiälän Lakkasuolla esiintyvien suotyyppien välisiä suhteita ja verrattu näin saatuja tuloksia Heikuraisen ja Pakarisen (1982) esittämään kahden ekologisen vaihtelusuunnan mukaiseen ko suotyyppien väliseen suhteeseen.

MDS ordinaatio ryhmittelikin eri suotyypeiltä kuvatut kasvillisuusnäytealat niin, että ne vastaisivat viittä tutkittua suotyyppiä. Tulokset eivät ratkaisevasti eronneet käytettäessä toisaalta kasvilajien läsnäoloon, toisaalta kasvilajien peittävyystietoihin perustuvaa laskentaa. Kuitenkin eri suotyypit erosivat toisistaan selvemmin käytettäessä läsnäoloon perustuvaa laskentamenetelmää.

Viiden tutkitun suotyypin suhde Heikuraisen ja Pakarisen esittämään ravinteisuus- ja kosteusgradienttisarjaan ei kuitenkaan ollut suoraviivainen, vaan vastaavuus saatiin aikaan vasta sovittamalla kaartuva vaihettumisgradientti MDS ordinaatioon. Näin saatu ero on ilmeisesti harha, joka selittyy tämän suppean aineiston painottumisella liiaksi karuihin ja kuiviin suokasviyhdyskuntiin.

Aineistossa oli kuvauksia kahdelta ojitetulta suokuviolta ja täten artikkelissa on myös lyhyesti pohdiskeltu ojituksen vaikutusta kasvillisuuteen.