Applied Vegetation Science 1: 161-266, 1998
© IAVS; Opulus Press Uppsala. Printed in Sweden

SPECIAL FEATURE

Vegetation mapping: Theory, methods and case studies

Editors

George Bredenkamp, Milan Chytr❑, Hagen S. Fischer,
Zdenka Neuhäuslová & Eddy van der Maarel

Based on contributions presented at the 40th Symposium of the International Association for Vegetation Science in České Budějovice, 18 - 22 August 1997

Contents

Vegetation mapping:
Theory, methods and case studies: Introduction

Bredenkamp, George[1], Chytrý, Milan[2], Fischer, Hagen S.[3], Neuhäuslová, Zdenka[4] & van der Maarel, Eddy[5]

[1]*Department of Botany, University of Pretoria, Pretoria 0002, South Africa; Fax +2712432184; E-mail gbredenk@scientia.up.ac.za;*
[2]*Department of Systematic Botany & Geobotany, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic; Fax +420541211214; E-mail chytry@sci.muni.cz;*
[3]*IFANOS, Hessestr. 4, D-90443 Nürnberg, Germany; Fax +49911284958; E-mail michler.fischer@t-online.de;*
[4]*Institute of Botany, Academy of Sciences of the Czech Republic, Zamek, CZ-252 43 Průhonice, Czech Republic; Fax +420267750031; E-mail neuhauslova@ibot.cas.cz;*
[5]*Department of Ecological Botany, Uppsala University, Villavägen 14, SE-752 36 Uppsala, Sweden; Fax +4618553419; E-mail eddy.van_der_maarel@vaxtbio.uu.se*

Background

This Special Feature on Vegetation mapping results from a session on 'Vegetation mapping: scales in space and time and hierarchical vegetation classification' during the 40th Symposium of the International Association for Vegetation Science in České Budějovice, Czech Republic. Sub-sessions were devoted to Theoretical approaches, Remote sensing, Predictive mapping of vegetation, and Applications. In total 22 lectures were presented and some scores of posters demonstrated. We received 18 manuscripts based on these presentations, of which 12 were accepted for this Special Feature. Three papers deal with Potential Natural Vegetation and related concepts; they represent the sub-session on Theory. Six papers describe various methodological aspects of vegetation mapping; they are concerned with remote sensing and hierarchical vegetation classification, keywords referring to the title of the symposium session; in a way they are also case studies. The final three papers are case studies in a stricter sense, but also contain methodological aspects.

Potential natural vegetation and related concepts

Vegetation mapping of larger areas in the cultural landscape of densely populated parts of the world suffers from the absence of more-or-less natural vegetation. It is not satisfactory to leave most of the mapped area blank on the map. This is a problem especially when the map is meant to serve landscape-ecological and/or physical planning purposes. In this connection the concept of 'potential natural vegetation' (PNV), introduced by Tüxen (1956), provided an excellent tool. According to the English description in the 'Handbook of Vegetation Science' by Westhoff & van der Maarel (1973) the PNV is the vegetation that would finally develop in a given habitat if all human influences on the site and its immediate surroundings would stop at once and if the terminal stage would be reached at once. This concept refers also to community complexes and indeed several complexes of semi-natural and cultural landscape elements may belong to one PNV-type.

Zerbe, in the first paper, makes clear that it was Tüxen's intention that PNV-maps serve different purposes in land use, landscape planning and nature conservation, in particular with regard to forestry, agriculture and landscape management. Indeed, many PNV-maps with different scales have been made. *Zerbe* discusses the validity and applicability of PNV-maps in landscape planning and nature conservation. PNV-maps are useful for the differentiation of natural and landscape units on a small scale but they are less useful for detailed planning on larger scales (> 1 : 100 000). Problems arise, for example, from the often highly hypothetical character of the construction and the practice of taking remnants of 'natural' vegetation as a reference object for PNV. With regard to the goals of modern landscape planning and nature conservation purposes the exact documentation of the actual real vegetation (ARV) on intermediate and large scales gives much more detailed information than a hypothetical PNV.

Various related concepts have been considered to overcome some of the difficulties in the application of the PNV-concept. Two of them are discussed here.

Moravec reintroduces the concept of Reconstructed Natural Vegetation. Reconstruction mapping of the natural (primary) vegetation of intensively cultivated land is based on: (1) classification of actually existing remains of natural or near-natural plant communities as mapping units; (2) delimitation of their habitat types; (3) detection of correlations between vegetation units and habitat types. At sites where the natural habitat conditions have been considerably changed by man it is difficult to apply the PNV-concept. For such sites reconstruction vegetation mapping uses the extrapolation of mapping units of the primary vegetation to the original natural habitat conditions.

Chytr□ proposes the Potential Replacement Vegetation (PRV) as an alternative to PNV. PRV is a hypothetical part of the vegetation which is in balance with climatic and soil factors currently affecting a given habitat, with environmental factors influencing the habitat from outside such as air pollution, and with an abstract anthropogenic influence (management) of a given type, frequency and intensity. For every habitat, there is a series of possible PRV- types corresponding to the different anthropogenic influences, e.g. grazing, mowing, trampling or growing cereals.

The PRV-concept is especially useful in large-scale mapping (scales > 1 : 25 000) of small areas where replacement vegetation is in the focus of attention of managers and land-use planners. At smaller scales, PRV-mapping may be useful for revealing biogeographical patterns which may be different from the corresponding PNV-patterns, because replacement vegetation and natural vegetation may respond to environmental gradients at different scales. In cultural landscapes, PRV shows a direct relationship to the replacement vegetation. In habitat mapping with respect to replacement vegetation, the PRV-concept yields more valuable results since it is affected by anthropogenic influences which may be largely independent from climatic and soil factors.

Methods used in vegetation mapping

Some of the papers on mapping methodology concern the method of vegetation classification involved. Most of the papers discuss different techniques for obtaining a cartographic basis upon which vegetation or landscape units can be superimposed. Several examples are presented on the use of modern remote sensing techniques and geographical information systems. As such, they form an interesting follow-up after the publication of a Special Feature on these topics in the *Journal of Vegetation Science* (Walsh et al. 1994).

van Etten compares three vegetation classification models in a study of a remote and hardly accessible arid, mountainous region of Western Australia, with the aim to predict the distribution of floristically defined vegetation types from maps representing environmental factors. The models were: (1) decision trees; (2) statistical models; and (3) heuristic/conceptual models. Maps were produced for three different levels of a floristic classification. All models satisfactorily established relationships between the vegetation units and available environmental predictor variables, except where the number of sites of a particular unit was small. Map accuracy improved with increasing level of abstraction of the plant community types. Map inaccuracies were due to, *i.a*., poor resolution of, and errors in, available maps of predictor variables, and available predictor variables not being able to differentiate between certain vegetation units, particularly at the lower plant community level.

Lux and *Bemmerlein-Lux* also compare two different vegetation classification methods in their study of the spontaneous vegetation on parts of a Mediterranean volcanic island. The vegetation is partly (particularly post-fire) successional. Vegetation maps were based on floristic units and structural units, respectively. Both the floristic composition and the growth-form composition were analysed and subjected to multivariate analysis. Cartographic and other comparisons of the results from classification and ordination suggest that the major differences in the mapping results were associated with differences in the time scale of the underlying processes of vegetation dynamics. The distribution of the floristic vegetation units reflected longer-term processes, while the growth-form based structural vegetation units appeared to be linked to shorter-term processes.

Kamada and *Okabe* present a technique for fine-scale vegetation mapping with the aid of low-altitude aerial photography. Photographs are taken using a remote-controlled camera system lifted by a captive helium balloon. The vegetation is classified on the basis of a phytosociological survey. The shapes and locations of vegetation patches appearing in the photographs are entered into a computer, using a digitizer. Geometrical discrepancies are corrected and the map is coloured to produce the final version of the vegetation map.

Nakagoshi et al. explain how grid maps can be used for detecting vegetation changes over large areas in Japan. Such grid maps function as a basic vegetation data base established by the Japanese Environment Agency. They are simplified from vector-based vegetation maps. When reducing the resolution in order to obtain small-scale maps, errors or lack of information may appear and the study included an examination of the reliable limits of the data base. Grid maps were produced on five different scales from 50 m to 1000 m using both the whole cell of the grid and only its central circle, based on a vegetation map at scale 1: 25 000. Through similarity analysis the derived maps were compared with the original map; maps at the 50-m to the 200-m resolution reproduced the original pattern well. Because the vegetation data base of the Environment Agency used a 1000-m grid map, much information on patches less than 100 ha had disappeared, but information on dominant vegetation or large patches was reproduced quite well.

Chytr□ and *Tich□* present a novel extension of classical phenological mapping and apply it to a topographically complex landscape. Field survey is combined with an irradiation model. Five stages of phenological development were defined based upon phenological spectra of plant communities in late April; 96 sites were assigned to one of these stages using field observations of these spectra. Potential direct solar irradiation was calculated from a digital elevation model for a 25 m × 25 m grid extending over the study area. A method was developed for interpolation of phenological observations by weighted regression of phenology on the irradiation model. The results are interpreted in terms of possible climatic processes underlying the phenological pattern, with emphasis on temperature inversions in the river valleys. The combined effects of advanced phenology and the increased risk of spring frost injury due to these inversions in the valleys is considered as an explanation for local distributional patterns of flora and vegetation.

Felinks et al. report on a vegetation survey in the former brown coal mining area of eastern Germany. The analysis of the spatial distribution of vegetation was considered as an important tool in landscape planning. A comprehensive vegetation survey by means of satellite imagery (Landsat-TM), airborne imagery (CASI), and ground-based methods, notably habitat mapping and vegetation sampling, was carried out. With respect to the scales of resolution the classification results of the four methods are comparable. Differences in the outcome can be ascribed to the fact that methods of low resolution result in a discrete array of polygons whereas methods of high resolution depict a mosaic structure with an underlying, continuously changing gradient. Neither satellite nor airborne imagery is restricted to the purpose of mapping but may also serve for vegetation classification itself.

Case studies

The case studies represent different fields of application, most of them dealing with vegetation dynamics. Most of these contributions present methodological viewpoints as well.

Cross presents a map of the potential natural vegetation of Ireland, a largely deforested country, based on several maps showing the topography, geology, soils, and various kinds of land use. The units for the potential vegetation were compiled from various published sources and field data. The map contains 20 units, including some landscape units and units of actual vegetation.

Čarni et al. compare the past and present forest vegetation in NE Slovenia using different map types, including old military and cadastral maps and modern vegetation maps. These maps show changes in land use over the past 230 yr. The vegetation map was made on the basis of satellite images. Basic classification techniques were combined with extensive field inspections and aerial photographs. The output of the procedure was verified in the field. Additionally, a comparison of statistical data about land use categories is presented.

Toyohara & *Fujihara* use vegetation maps to follow the succession of secondary forests affected by pine wilt disease in western Japan. The maps are based on a phytosociological analysis. Thanks to this approach a clear picture could be obtained of the survival of *Pinus* forests, which was restricted to the early successional stages, which were located on ridges and the upper part of slopes in the study area.

Conclusion

The picture arising from the papers included in this Special Feature is that of a threefold approach in vegetation mapping: a phytosociological basis, the use of modern remote sensing techniques, and a multi-scale approach including landscape ecology. The wealth of information contained in these maps is applied to many fields, such as landscape planning, nature conservation and forestry. The concept of Potential Natural Vegetation and its modifications is particularly important for small-scale mapping. Current vegetation mapping is increasingly influenced by remote sensing techniques. These techniques are especially powerful if combined with ground studies. GIS-technology enables a causal rather than a static-descriptive approach, with vegetation mosaics interpreted in environmental and dynamic terms.

We are grateful to our colleagues in České Budějovice and Průhonice, in particular Jan Lepš, Tomáš Herben and Petr Šmilauer, for their contributions to the organisation of the symposium.

References

Tüxen, R. 1956. Die heutige potentielle natürliche Vegetation als Gegenstand der Vegetationskartierung. *Angew. Pflanzensoziol*. (*Stolzenau*) 13: 5-42.

Walsh, S.J., Davis, F.W. & Peet, R.K. 1994. Applications of remote sensing and geographic information systems in vegetation science. *J. Veg. Sci*. 5: 609-756.

Westhoff, V. & van der Maarel, E. 1973. The Braun-Blanquet approach. In: Whittaker, R.H. (ed.) Ordination and Classification of Communities, pp. 617-726. *Handb. Veg. Sci*. 5. Junk, The Hague.