PROBLEMS IN VEGETATION MONITORING IN NATURE MANAGEMENT PRACTICE: TWO CASE STUDIES

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Abstract - One of the major requirements of the monitoring of vegetation is the comparability of data between years. Therefore, a proper sampling scheme is essential. However, through the years, in nature management practice lots of data collected without a primary monitoring goal. Afterwards, it often seems very valuable to include these older data in the analysis for several reasons. In two examples from military ranges in the Netherlands, two of the problems which can be met with in comparing unequivalent or biased data in monitoring are shown. In the first example, the frequency of grassland species in two sets of relevés is examined. A solution is presented for the overrepresentation of relevés from one or more vegetation types from the first year, based on the area of the vegetation types on the vegetation map of this same year. In the second example, two sequential vegetation maps are compared. A major problem is often the thematic incongruence of sequential vegetation maps. Afterwards, this can only be resolved by upscaling one or both maps. It is concluded that the use of old data for monitoring purposes can be very valuable, but that this often calls for creative data handling, in which GIS and modern computer programmes are very helpful.
Key words - monitoring, GIS, random sampling, sampling scheme, vegetation mapping

Introduction

In phytosociology, from the beginning much attention is paid to vegetation dynamics. Braun-Blanquet in the first edition of his "*Pflanzensoziologie*" (1928) dedicated a whole section to this topic, but it was Clements (1916) who firstly reviewed vegetation dynamics, already more then a decade before. Since these early years, a vast amount of literature has been published on the nature and causes of vegetation dynamics and methods of studying vegetation dynamics (e.g. the contributions in Knapp, 1974 and Van der Maarel, 1980 and the overview given by Dierschke, 1994; more recent contributions are given by e.g. Bakker *et al.* ,1996; Wildi, 2001 and Grime, 2001).

In his *magnus opus*, Dierschke (1994) summarized the methods of studying vegetation dynamics in two categories, *viz.* indirect and direct methods. The indirect methods comprise the chronosequence approach (time for place substitution), the use of indicator species, the age structure of populations, seed bank studies, the study of datable remains of plants (e.g. pollen, turf layers etc.), soil profiles, historical documents and the comparison of sets of vegetation relevés. The latter forms a bridge to the direct methods, comprising the study of the vegetation in permanent plots, sequential vegetation mapping and the comparison of vegetation complexes in time. As was stressed by the author, the most exact method to studying vegetation dynamics is the monitoring of vegetation in permanent plots, and this might be the reason that this method is the most widely used method in scientific and probably also in applied studies of vegetation dynamics.

The applied study of vegetation dynamics has its own methodical problems. Although widely used in applied vegetation monitoring, permanent plots have one big disadvantage, especially when the focus of the study in concern is on a larger area instead of on one particular vegetation type, as is often the case in vegetation monitoring for nature management practice or other cases of applied vegetation monitoring. This disadvantage is the questionable possibility of extrapolation of the results from the permanent plot to a larger area. The other side of the same coin is that not all changes in a larger area are recorded in a permanent plot with a very limited area. A second, probably even more serious problem in monitoring practice is the design of the monitoring baseline. Often this baseline is not collected for monitoring purposes, challenging the creativity of the monitoring practitioner who has to combine two incompatible datasets or otherwise has to adapt to the baseline design. This last option causes less problems in the interpretation of the results, but the answers collected might possibly not be correspondent to the specific questions asked.

In this paper, we will give some examples of the problems which can be met in the monitoring practice of nature management due to the latter problem. This will be done on the basis of two case studies from military areas in the Netherlands. Since 1994 on, at all military ranges in the Netherlands an inventory of vegetation, breeding birds and butterflies was carried out. A serious problem of this inventory was the lack of a proper sampling design, as is often the case with similar inventories. From 2000, a monitoring project started, in which the areas were revisited on a regular basis. Although monitoring schemes are developed for the future monitoring of each individual training area, a comparison of the data from the first monitoring round with the data collected in the inventory was urgently needed by the local managers, which lead to many interpretation problems.

Biased sampling: case study Naval Flight Camp "De Kooy"

In 1999 a vegetation survey was carried out at Naval Flight Camp "*De Kooy*", near Den Helder in the province of Noord-Holland (Hornman and Van der Berg, 1999). For the inventory of the 90 hectares of grasslands at this airport, 55 relevés were made (Figure 1). These relevés were not evenly distributed in the grasslands: approachability and species density clearly played a roll in the decision where to sample, resulting in many relevés in species rich vegetation types and no relevés at an adjacent golf course. In 2005 the first round of a monitoring cycle started (De Ronde and Horman, 2007), and to overcome these problems methods were

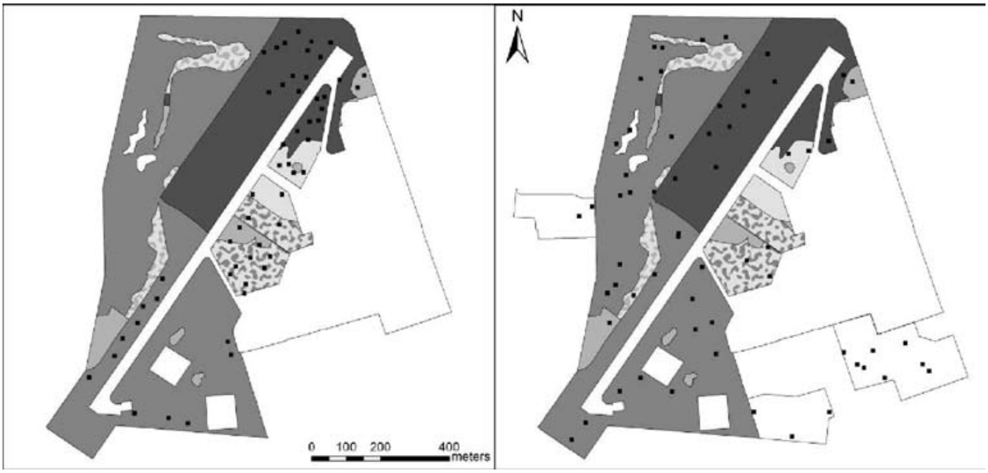

FIGURE 1 - Distribution of relevés at Naval Flight Camp "De Kooy" in 1999, placed subjectively (left) and 2005, placed randomly (right). Light colours indicate species rich vegetation types, darker colours indicate species poor vegetation types, as mapped in 1999.

changed. Instead of a field-based decision where to place the relevés, in a GIS, 61 relevés were placed randomly in the area to be sampled; this included also some new parcels (Figure 1). Despite the described differences in methods in 1999 and 2005, a comparison of the data was necessary to evaluate the management. Therefore, we compared the species composition of the sets of relevés from 1999 and 2005. Besides, we estimated the area of the vegetation types in 2005 on the basis of the relevés according to the vegetation typology of 1999 to compare the areas of the vegetation types in both years (not shown).

Comparison of species composition 1999-2005

To test whether the species composition differed between both years, the synoptic tables of all grassland relevés of both years were compared. In the computer program JUICE (Tichý, 2002) the difference in frequency between both research years was tested, using Chi-square statistics with a 95% significance level (Table 1, columns 2-3, 'INI'). From the field experience it was clear that the results were heavily biased. For example *Poa annua* shows a significant increase in frequency during the years, but this increase is only due to the fact that this species grows on the golf course, which was not sampled in 1999.

To get a better result, from the initial dataset of 2005, the relevés which were made on the golf course and the three other extra parcels (Figure 1) were removed, and the species frequencies were tested again (Table 1, columns 4-5, 'Subset 1'). To overcome the problem of overrepresentation of relevés from species-rich vegetation types in 1999, a resampling strategy was developed, according to Haveman and Janssen (2008). This resampling strategy consists of the random selection of a maximum number of relevés from the initial dataset of 1999 according to the ratio of areas of each vegetation type in the vegetation map of 1999 in the GIS (Table 2), after which the species frequencies were tested again. This procedure was carried out 10 times and only species showing significant changes in more than 5 out of 10 runs were considered to have changed significantly. The results are shown in Table 1, columns 6-7 ('Subset 2').

Discussion

From the results in 'Subset 2' it was concluded that the grasslands at "*The Kooy*" have been changed slightly in the period 1999-2005. *Agrostis capillaris*, a species of rather infertile, dry grasslands has increased at the expense of species from more mesophytic, nutrient richer environments (*Poa trivialis* and *Phleum pratense*). In

Table 1 – Changes in frequency of species in grasslands of the naval flight camp "De Kooy" between 1999 and 2005. Only species with a significant difference between the two years are shown. INI = comparison between both total sets of relevés; Subset 1 = comparison of total set of relevés of 1999 and a subset of relevés of 2005 from which the relevés of extra parcels are removed; subset 2 = comparison of a weighted subset of relevés from 1999 and a subset of relevés of 2005 from which the relevés of extra parcels are removed.

	INI		Subset 1		Subset 2	
	1999	2005	1999	2005	1999	2005
	n=55	n=61	n=55	n=21	n=27	n=21
Poa trivialis	76%	18%	76%	19%	85%	19%
Rumex crispus	56%	13%	-	-	-	-
Athoxanthum odoratum	62%	21%	-	-	-	-
Agrostis stolonifera	35%	3%	-	-	-	-
Phleum pratense	58%	23%	-	-	65%	10%
Poa annua	0%	38%	-	-	-	-
Agrostis capillaris	29%	74%	29%	86%	21%	86%

Table 2 – Calculation of the number of random samples from the initial set of relevés of 1999, based on the area of each grassland type on the vegetation map of 1999 (Horman and Van der Berg, 1999). Also the initial number of relevés is given.

1999				
Vegetation type	**Initial number of relevés**	**Area (ha)**	**Area (%)**	**Number of random samples**
G01	12	4,12	5,8	3
G02	16	1,53	2,2	1
G03	13	19,63	27,8	13
G04	13	14,58	20,6	10

contrary to the first analysis in which all available data was used, the analysis after correction for area gives a better estimation of the real changes. However, the method has one serious drawback, *viz.* the low number of relevés which are used in the analysis. The initial dataset consisted of 55+61 relevés, and only 21+27 were used in this example. This reduces the power of the statistical test and rather subtle changes in the vegetation can not be detected. As was shown by Haveman and Janssen (2008), random sampling from an biased set of relevés can give good estimations of real changes that have taken place.

Also for management purposes, this method can be valuable. In the example from the Naval Flight Camp "*De Kooy*", it was possible to give sound advises on the basis of the results of the analysis. The management at the Flight Camp is aiming at a reduction of the productivity of the grasslands to decrease the attractiveness of these grasslands for large birds in order to prevent plane crashes after collisions. On the basis of the results of the analysis it was concluded that the first step in such a development was set and therefore, we advised to continue the actual management to further develop dry, nutrient poor grasslands.

Thematical incongruences in sequential vegetation maps: case study "Kamp Riel"

In 1995 a vegetation survey was carried out at "*Kamp Riel*", an area of 51 ha near Tilburg in the province of Noord-Brabant. On the basis of 62 relevés a local vegetation typology was made and these local types were mapped in a map 1:2500 (Van Dijk, 1996). The area was remapped in 2004, based on a new typology consisting of 55 relevés (De Ronde and Hornman, 2005). A first comparison of the two sequential maps learned that the vegetation had changed severely during the years. However, these changes are due to a more detailed mapping procedure and a more detailed vegetation typology in 2004 in comparison to 1995. For example: in 1995 one heathland type is distinguished and in 2004 there are 4 major heathlandtypes distinguished, some of them are subdivided (Figure 2). A detail of the vegetation table (Table 3) makes clear that the only heathlandtype in 1995 can easily be subdivided in several well characterized types on the basis of dominant species (e.g. *Hypnum jutlandicum*, *Molinia caerulea* or *Deschampsia flexuosa*) or the co-occurrence of species (e.g. different *Cladonia* species). This problem of thematical differences between sequential vegetation maps was discussed in detail by Janssen (2001).

Comparison of the vegetation maps 1995-2004

In order to compare the two vegetation maps in a sound way, the comparison should be done at the same detail level. Practically, this means that the map with the least level of detail is leading and that the other map(s) have to be scaled up to the same level of detail. In practice this will lead to a comparison at, in phytosociological terms, alliance level or even at a higher level. In the given example of the heathlands of "*Kamp Riel*" the heathlands in the map of 2004 were aggregated to one 'structural type', *viz.* "heathlands", after which the maps of both years were comparable (Fig.2). This upscaling of detail in vegetation maps is common practice and often the only possible solution when comparing older vegetation maps. This is simplified by the use of Geographical Infor-

TABLE 3 - Part of the vegetation table of 'Kamp Riel' in JUICE. Shown is the part with dominance of Scottish heather (*Calluna vulgaris*). This was considered to be one vegetation type in 1995, although al least 7 distinct types can be distinguished on the basis of dominants and combination of species.

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Group number:

Releves 62
Species 106                          1112222333333344455677

Calluna vulgaris                     544555555a543443 44bm1
Hypnum cupressiforme s.l. spe        .m.mm.bmm.baam...33ama
Deschampsia flexuosa                 1m.mm.+mmm.aammm1mm4mm
Molinia caerulea                     a.1.m..mamammmab1..155
Agrostis vinealis                    .m11.mm...m.m11.m....mm
Festuca filiformis                   .m...m1...1..m..1..m..
Carex pilulifera                     m.+...r.m1.r+.1......1+1
Pinus sylvestris                     +.+r...r.+..+..r.1.+rr
Agrostis capillaris                  .....11..mm..1.....m.a
Erica tetralix                       aaa...1...............
Cladina portentosa                   .+.+.1................
Cladonia coccifera                   .1.++11........r.1....
Cladonia macilenta                   ...+.1................
Cladonia subulata                    ....+.................
Cladonia gracilis                    .....1................
Polytrichum piliferum                ..rm..m.......3ab...m.
Dicranella heteromalla               1...m...1+.m.........1+
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mation Systems, in which vegetation units can easily be aggregated at different levels.

The comparison of the two vegetation maps after the upscaling of the 2004 map made clear that rather large shifts in areas of the structural types had been taken place since 1995. Species poor stands of juvenile *Pinus sylvestris* and species poor *Agrostis capillaries* grasslands belonging to the *Plantagini-Festucion* showed an increase in area at the cost of lowland heathlands of the *Calluno-Genistion pilosae* and dry pioneer grasslands of the *Corynephorion canescentis*. Although exact data on the areas of types and subtypes were not available because of the upscaling of the map op 2004, the comparison of the 'coarse' maps of "*Kamp Riel*" gave still enough detail to give proper management advises. However, this might not always be the case. When only small changes have taken place, e.g. shifts between the areas of two heathland subtypes or two subassociations, the method of upscaling will lead to the conclusion that no changes have taken place.

CONCLUSION

The monitoring of vegetation changes is a powerful instrument for nature management. However, historical vegetation descriptions (relevés, vegetation maps) were not often made for the purpose of monitoring and therefore the comparison with more recent data is bristling with pitfalls. The two case studies presented in this paper represent two common situations: 1) the ratio of relevés is biased towards more interesting vegetation types and 2) the thematical content of vegetation maps is not equivalent. We emphasize the necessity for proper sampling designs at the onset of monitoring programmes, but the comparison with older data – collected for other reasons than monitoring – is often of great value, not only in nature management and monitoring practice. This calls for creative data handling, since most of the

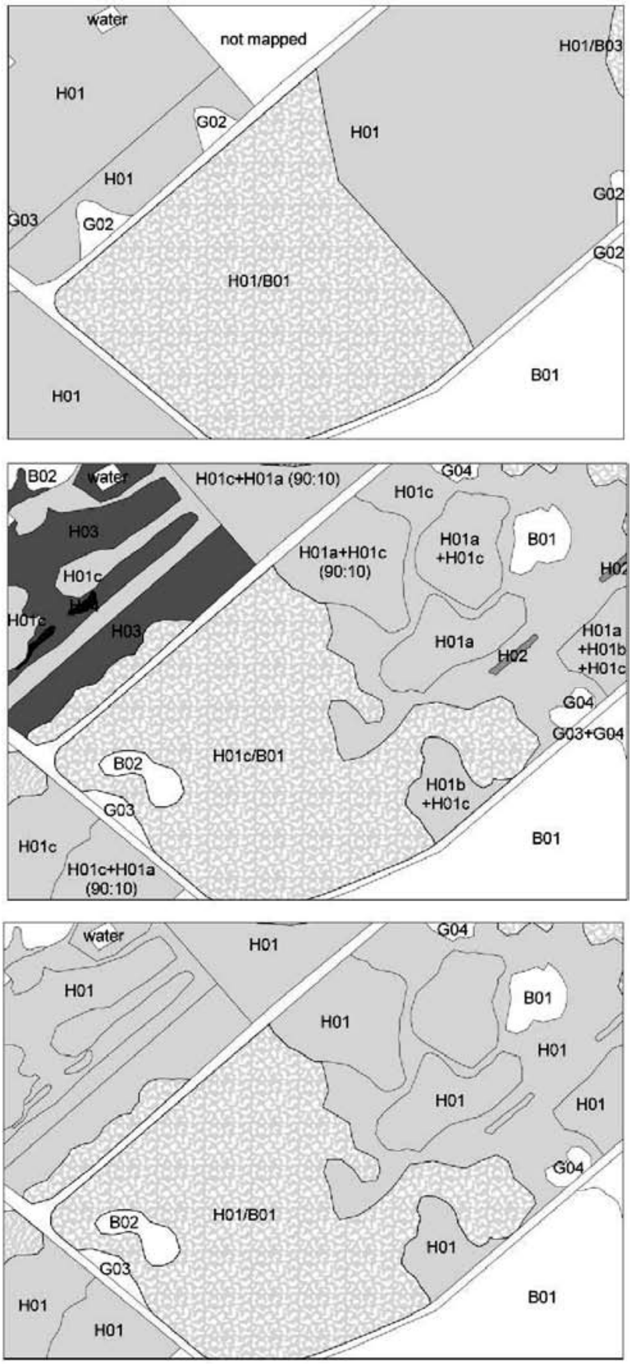

FIGURE 2 – Detail of the vegetation map of “Kamp Riel” 1995 and 2004. H = heathland; B = woodland; G = grassland. The upper map is a part of the vegetation map of 1995 (Van Dijk, 1996), the central one is the same cut from the map of 2004 (De Ronde & Hornman, 2005). The difference in detail is conspicuus. A comparison is only reliable after upscaling of the units in the 2004 map; this is done in the lower map.

historical data is biased towards ‘better’ developed vegetation and/or unequivalent to the recent data to compare with. The use of modern computer techniques and the combination of phytosociological and geographical computer programmes makes it possible to overcome some of the problems in the comparison of data, caused by unequivalent or biased data.

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