Long Database Report

The Dutch National Vegetation Database

Joop H.J. Schaminée, Stephan M. Hennekens & Wim A. Ozinga

Abstract: The Dutch National Vegetation Database (GIVD ID EU-NL-001) is currently the largest database of its kind in the world, comprising more than 600,000 computerized vegetation-plot descriptions, covering the whole variety of vegetation types in the country. It was started in 1987, when the government – in close collaboration with a number of nature conservation agencies – commissioned a new national vegetation classification, based on field data and documented with vegetation tables. Within the framework of this initiative, it was decided to develop adequate software for handling the large amount of data that would be brought together. This has resulted in the computer package TURBOVEG. After the publication of the new vegetation classification between 1995 and 1999 (*De Vegetatie van Nederland*), the focus was shifted towards the development of so-called information systems, for which the vegetation databases form the basis. Within the Netherlands, the information system *SynBioSys Netherlands* has been developed, which proved to be a model for similar initiatives elsewhere in the world. The databases and allied information systems offer great opportunities for fundamental and applied research in the field of community ecology, nature conservation and landscape planning.

Keywords: functional trait; information systems; national vegetation classification; nature conservation; *SynBioSys Netherlands*; TURBOVEG.

Nomenclature: van der Meijden et al. (1996).

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A short sketch of the history of vegetation research in the Netherlands

Vegetation research has a long tradition in the Netherlands, dating back to the second half of the nineteenth century. Already in 1870, Franciscus Holkema got his doctoral degree (posthumous, as he died – only thirty years old – just before the defence of his PhD thesis) for his study on the vegetation of the Dutch Wadden islands (Holkema 1870). Holkema used a quantitative method to study the vegetation, long before the 'classic' French-Swiss school came into existence. He estimated the presence and abundance of all species in his vegetation plots, thus making 'relevés' which formed the basis for further analysis. A set of 17 relevés, recorded in 1868, on the isles of Texel, Vlieland and Terschelling (covering different types of vegetation, including small sedge communities, higher salt marshes, grasslands and shrubs), are the oldest vegetation records in the Netherlands, and probably the oldest in the world.

The first relevés in the Netherlands according to the Braun-Blanquet approach (e.g. Braun-Blanquet 1928; Westhoff & van der Maarel 1978) were made in 1927, by W.C. de Leeuw, a lifelong friend of Braun-Blanquet. De Leeuw was a chemist and botanist, who founded and administered the famous institute of Braun-Blanquet in Montpellier (Station Internationale Géobotanique Méditerranéenne et Alpine, SIGMA). He encouraged Dutch students to be trained at this institute, including Jan Barkman and Victor Westhoff, who became famous vegetation researchers in later time.

Phytosociology was booming in the Netherlands in the first half of the 20th century, and already in 1937 Jan Vlieger published a small booklet *Aperçu sur les unités phytosociologiques supérieurs des Pays-Bas*. This study, however, offers more than the title promises: apart from an overview of alliances, also a large number of associations is mentioned. In the period 1942–1946, different versions of a second synopsis of plant communities in the Netherlands were published (Westhoff et al. 1942, 1946), but it took another twenty-five years before a comprehensive classification was accomplished, by Westhoff & Den Held (1969). Still, this overview did not include any vegetation tables. At the end of the 1980s, the time was ripe to fill this gap. The numerical processing of digitized field data became possible by the use of computers and the development of specialized software. In the meantime, it was demonstrated that convincing syntaxonomical results could be obtained with numerical methods (Goodall 1978, van der Maarel 1979, Jongman et al. 1987). An ambitious research program was started to revise and document the national vegetation classification. From that time on, thousands of relevés could be digitized, which resulted not only in the above-mentioned series of books, but also in a huge national vegetation database.

TURBOVEG and the input and management of vegetation plot data

The computer package TURBOVEG was designed, as mentioned, within the context of the national vegetation classification of the Netherlands, first as a DOS-version, some years later followed by TURBOVEG for Windows. The software comprises a comprehensive database management system for the input, proc-

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essing and presentation of vegetation data (Hennekens & Schaminée 2001). Currently, this software package has been installed in more than 30 countries throughout Europe and abroad, resulting in a series of national databases, incorporating hundred thousands of individual vegetation descriptions. TURBOVEG also includes the possibility to identify relevés relative to a reclassified set of reference relevés (e.g. from national vegetation classifications) with the identification program ASSOCIA (van Tongeren et al. 2008). For each individual relevé, ASSOCIA calculates the probability (likelihood) of its belonging to each of the vegetation types of the national vegetation classification, which enables to assign the relevé to a certain plant community.

GIVD Database ID: EU-NL-001		**Last update:** 2012-05-10
Dutch National Vegetation Database		
Scope: The database covers all existing plant communities in the Netherlands from 1868 (!) up to now.		
Status: completed and continuing	**Period:** 1864-2010	
Database manager(s): Stephan Hennekens (stephan.hennekens@wur.nl)		
Owner: A third part is property of by Alterra, the other part is owned by many different parties		
Web address: http://www.synbiosys.alterra.nl/lvd		
Availability: according to a specific agreement	**Online upload:** no	**Online search:** yes
Database format(s): TURBOVEG, PostgreSQL	**Export format(s):** TURBOVEG, MS Access, SQL, Excel	
Publication: [NA]		
Plot type(s): normal plots; time series	**Plot-size range:** 0.1-1000 m²	
Non-overlapping plots: 600,000	**Estimate of existing plots:** 750,000	**Completeness:** 80%
Total plot observations: 650,933	**Number of sources:** 80	**Valid taxa:** 922
Countries: NL: 100.0%		
Forest: 14% — **Non-forest:** aquatic: 14%; semi-aquatic: 20%; arctic-alpine: 0%; natural: 7%; semi-natural: 30%; anthropogenic: 16%		
Guilds: all vascular plants: 100%		
Environmental data: [NA]		
Performance measure(s): presence/absence only: 1%; cover: 99%		
Geographic localisation: GPS coordinates (precision 25 m or less): 50%; small grid (not coarser than 10 km): 40%; political units or only on a coarser scale (>10 km): 10%		
Sampling periods: < 1919: 0.0%; 1930-1939: 1.0%; 1940-1949: 1.0%; 1950-1959: 1.0%; 1960-1969: 2.0%; 1970-1979: 15.0%; 1980-1989: 21.0%; 1990-1999: 35.0%; 2000-2009: 19.0%; unknown: 0.1%		
Information as of 2012-07-19; further details and future updates available from http://www.givd.info/ID/EU-NL-001		

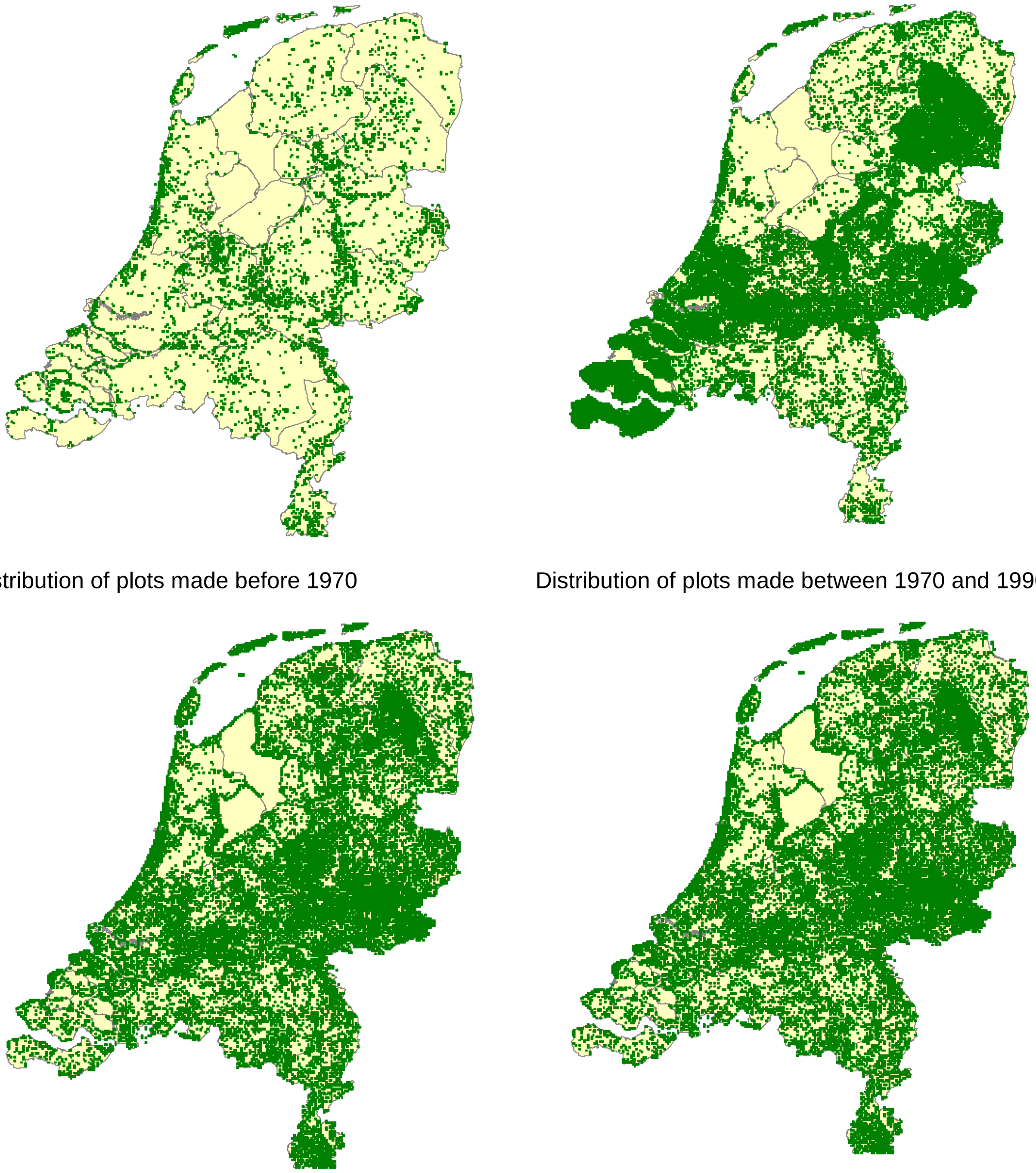
The Dutch National Vegetation Database: some figures

Two books have been published on the search for vegetation relevés in the Netherlands, archiving them, the content of the databases, and the use of the data for nature study and nature conservation (Schaminée & van't Veer 2000, Schaminée et al. 2006).

Within the context of this article, only a few aspects can be addressed. The Figures 1–4 give an up-to-date overview on the spatial and temporal distribution of the plots, the most active researchers, and the applied cover-abundance scales, respectively. Until 1935, the number of relevés was rather low, but the figures increased rapidly with the upturn of phytosociology in that period. Generally, some 5,000–10,000 relevés were made per decade until the 1970s. In that period, the interest in vegetation research and sampling obtained a new impetus, both from science and from nature conservation and planning. At the universities, phytosociology became a popular field of study and nature conservation agencies strongly supported vegetation research in their reserves. Governmental bodies, especially at the level of the provinces, set up special divisions for monitoring their natural heritage. As an example, only in the period 1990–1995 more than 100,000 relevés were made. In more recent times, the overall input of data is relative stable. On the one hand, universities are showing less interest in descriptive vegetation science, but on the other hand new and ambitious monitoring schemes have been set up by the national government and there is an extra demand for data as a consequence of the implementation of Natura 2000. In 1989, the Dutch Phytosociological Circle (*Plantensociologische Kring Nederland*) was founded, which also – together with the large number of books on plant communities that came on the market – had a clear effect on the recording of vegetation and its diversity.

The vegetation data that have been brought together in the national database derive from different sources, varying from articles, books and all kinds of reports, to personal field notebooks and institutional archives. In the late 1990s, a specific project was commissioned by the national authorities to collect and computerize the legacy data, from the period before 1975. Much more data than could be expected were revealed, with the result that we are now able to analyse long-term time series. These data from the past have proven to be of great value, for example in nature restoration projects.

A special set of data concerns the permanent-plot data. The oldest permanent plots were established from 1904 onwards by A. Rauwerda, a teacher at an agricultural school, who was interested in the effects of different types of fertilizer (artificial and farmyard manure) on grassland ecosystems (Schaminée et al. 2006).



Distribution of plots made before 1970

Distribution of plots made between 1970 and 1990

Distribution of plots made after 1990

Distribution of plots made during the whole period

Fig. 1: Distribution of vegetation relevés in the Netherlands, plotted on a 5 km × 5 km grid, for three periods (for 1990, between 1970 and 1990, after 1990) and for the whole period. As can be seen, only very few grid cells have no recorded vegetation data.

The oldest permanent plots according to the French-Swiss school were made in the 1930s by Jan Vlieger, Gideon Kruseman and Eduard van Zinderen Bakker. They studied the effects of the damming of the Zuiderzee. In the same period, van Zinderen Bakker established a series of permanent plots in the Naardermeer (the oldest nature reserve in the Netherlands) to study the vegetation development along the borders of this lake. At present, about 6,000 series of permanent plots are registered, of which more than 2,500 have been recorded at least five times and some 1,500 at least ten times. Some series have a time span of more than 50 years (Smits et al. 2002).

The relevé data cover, as has been indicated already, the whole variety of vegetation types in the Netherlands, ranging from open water, wetlands, salt marshes, ombrotrophic and minerotrophic peatlands, and all kind of pioneer and ruderal communities to arable fields, grasslands, heathlands, fringe communities, scrub and forests. Figure 5 shows the 30 most fre-

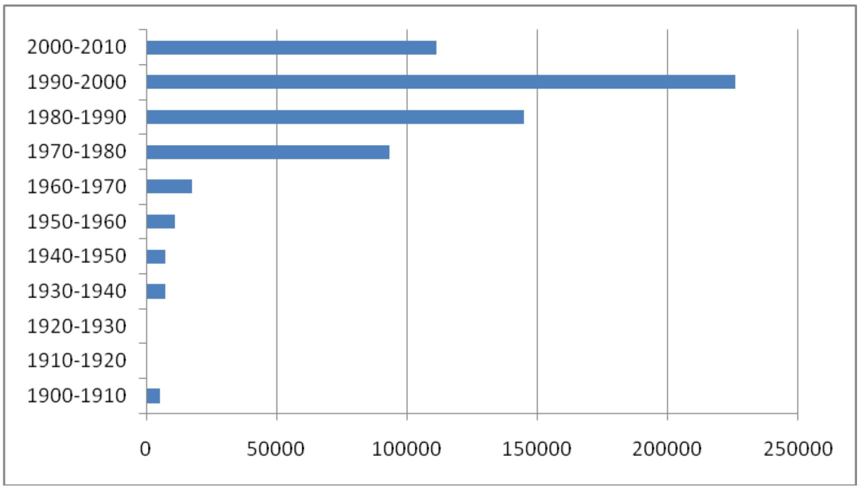


Fig. 2: Number of vegetation plots per decade (situation 2010). The largest number were made between 1990 and 2000 (in that period many provincial monitoring programmes were carried out, for which thousands of relevés were made), but also during the last decade, more than 100,000 relevés have been made.

quent species in the database. With regard to the individual vegetation classes (according to the Dutch national vegetation classification; see Fig. 6), grasslands have been documented by most relevés (particularly *Molinio-Arrhenatheretea*, *Koelerio-Corynephoretea* and *Plantaginetea majoris*), followed by communities of open water (*Potametea*) and forests (*Quercetea robori-petraeae* and *Querco-Fagetea*). Well represented are also reed communities of *Phragmitetea*, salt-marshes of *Asteretea tripolii*, and to a bit lower extent ruderal communities of *Artemisietea vulgaris*, tall forb communities of *Convolvulo-Filipenduletea* and weed communities of arable fields (*Stellarietea mediae*).

Information systems: the example of *SynBioSys*

The availability of large datasets in combination with syntaxonomic overviews, maps on water regime, aerial photographs distribution data of species and plant communities, and a whole variety of thematic maps (including topographic maps, geological and soil maps, and remote sensing images) offers the possibility to integrate different sets and layers of information in computer models or so-called information systems (Schaminée et al. 2007). An example is *SynBioSys*, which has been developed in the Netherlands. This computer program on the national level (*SynBioSys Netherlands*; Fig. 7) is serving as an example for the development of a similar expert system on the European level, called *SynBioSys Europe* (Ozinga & Schaminée 2004; Schaminée & Hennekens 2001, 2005), as well as for similar systems outside Europe. In South Africa, *SynBioSys Kruger* and *SynBioSys Fynbos* are under development, whereas the options for a *SynBioSys Quinling* for the biotope of the Giant panda in China and a *SynBioSys BES* for the Caribbean islands Bonaire, Saint Eustachio and Saba are under consideration.

The *SynBioSys* systems are integrating various levels of information: plant species, plant communities and landscapes. The systems are driven by local and remote web data sources, functioning as a network of distributed databases. They incorporate a GIS platform for the visualisation of spatial information. The information systems will offer the possibility to identify plant communities and to analyse relationships between plant species, plant communities and landscape types. By including photographs and text parts from books, they also serve as an electronic encyclopaedia of plant communities.

In course of time, various examples have been presented of how *SynBioSys* and its underlying maps and databases can be used for different types of analysis (e.g. Schaminée et al. 2007). Here, we will summarize just one of these. As plot data are spatially and temporally explicit, they allow spatiotemporal analyses. In the Netherlands, the distribution patterns of all plant communities are published in a series of four volumes by Weeda et al. (2000–2005). On the basis of these data, the temporal changes in the distribution of – for instance – species-rich grassland communities from dry, low-productive river dunes over the 20th century (*Sedo-Cerastion*) was analysed. This community type has become highly fragmented in the present-day landscape due to overgrazing, fertilizer application and excavation of the levees where these communties could be found, as well as to the heightening and widening of river dikes. At present, these ecosystems are among the most threatened in the Netherlands. In the past, it was found along all major and some minor river systems in the Netherlands, whereas nowadays it is restricted to a small number of sites along the major river systems only. This example, unfortunately, is illustrative for many plant communities within and outside the Netherlands.

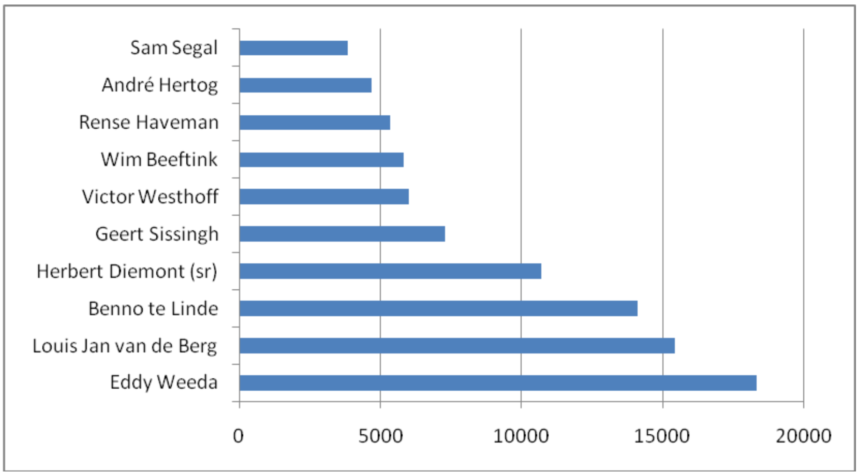


Fig. 3: Top 10 of the most productive vegetation researchers (situation 2010). Eddy Weeda, the first author of the distribution atlases of Dutch plant communities) is having the lead with more than 18,000 relevés made.

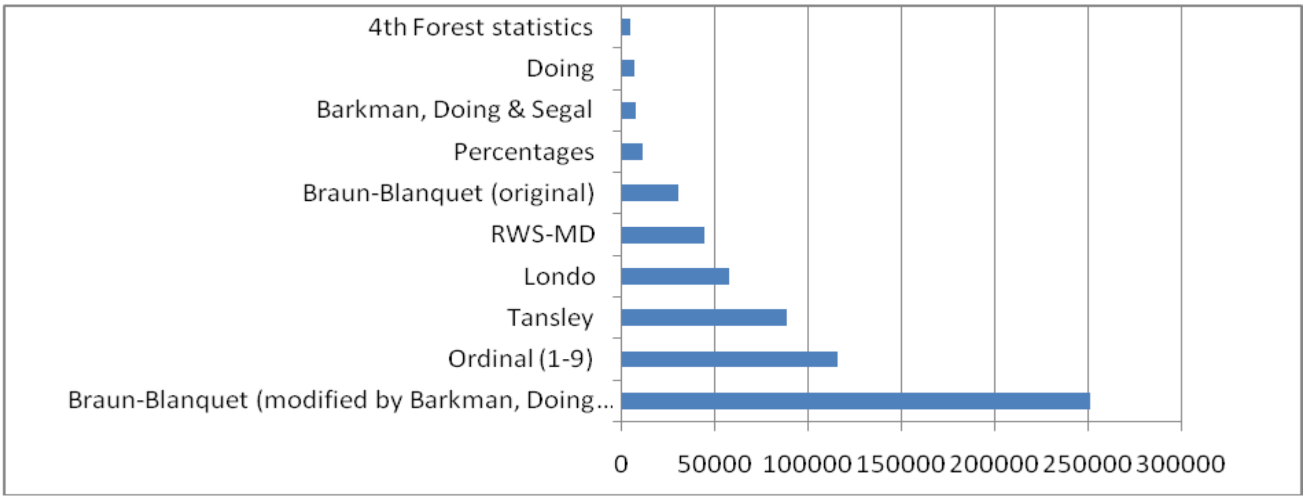


Fig. 4: In the Netherlands, a whole range of cover-abundance scales is in use for describing vegetation plots (situation 2010). However, the modified Braun-Blanquet scale is by far the most popular.

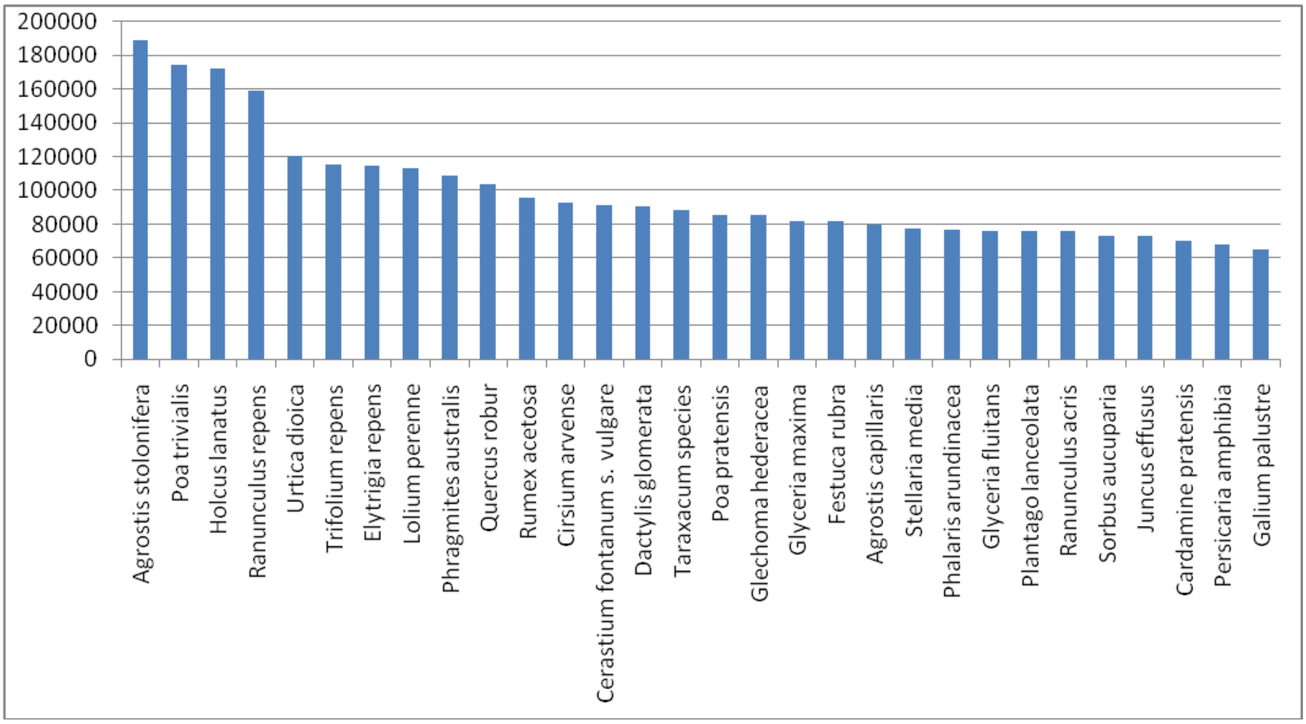


Fig. 5: *Agrostis stolonifera* is the most frequently recorded plant species in the Dutch vegetation database, occurring in more than 180,000 plots (situation 2010). The most recorded herb is *Ranunculus repens* at position 4 in the ranking.

Community types not only have become highly fragmented, they also may have changed in terms of species composition. Plant communities could be implicitly regarded to be floristically constant over time, but – to a certain extent – this idea is a misconception, as can be concluded from studies within the framework of the national vegetation classification of the Netherlands. Comparison of sets of relevés from different decades revealed that in most ecosystems the floristic composition of the plant communities involved has changed, although the appearance of the vegetation and the presence and abundance of – most of – the diagnostic species have remained the same (Schaminée et al. 2002; Haveman & Schaminée 2005). Despite the changes in floristic composition (species of nutrient-rich biotopes become more abundant, whereas less competitive species from nutrient-poor circumstances become rare are even disappear), the stands are classified within the same vegetation type. The changes may be linked to the human-driven environmental changes, but may also be related to random events, processes of succession, and other natural phenomena. In order to increase the efficiency of conservation and restoration efforts it is important to get more insight in the relative importance of these processes.

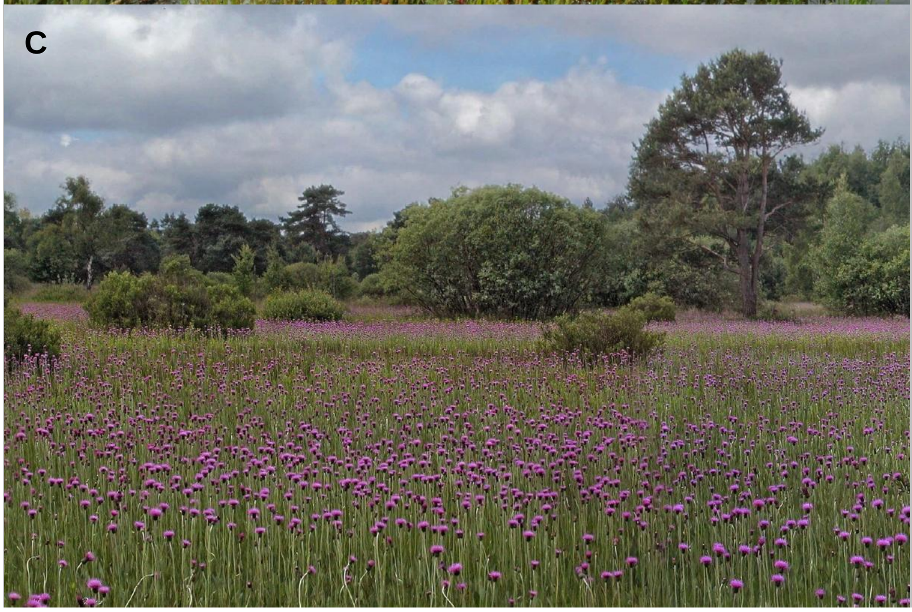


Plate: Vegetation types featured by the vegetation-plot database GIVD NA-US-001.

A: As a result of effective nature conservation strategies, wet heathlands are still well preserved in the Netherlands. *Narthecium ossifragum* indicates the areas in the landscape where lateral groundwater movement takes place. The dominant species in the Dutch wet heathlands is *Erica tetralix* (Photo: R. Knol).

B: Especially on the Wadden islands in the north of the country, ungrazed salt marshes can be found that are characterized by large stands of *Limonium vulgare* (Photo: E. Schaminée).

C: In the Netherlands, a wide range of grassland communities occur, of which several are of European interest. One of these is the *Cirsio dissecti-Molinietum*, belonging to the *Junco-Molinion*. The name-giving species *Cirsium dissectum* can colour the landscape locally purple (Photo: G. Winkel).

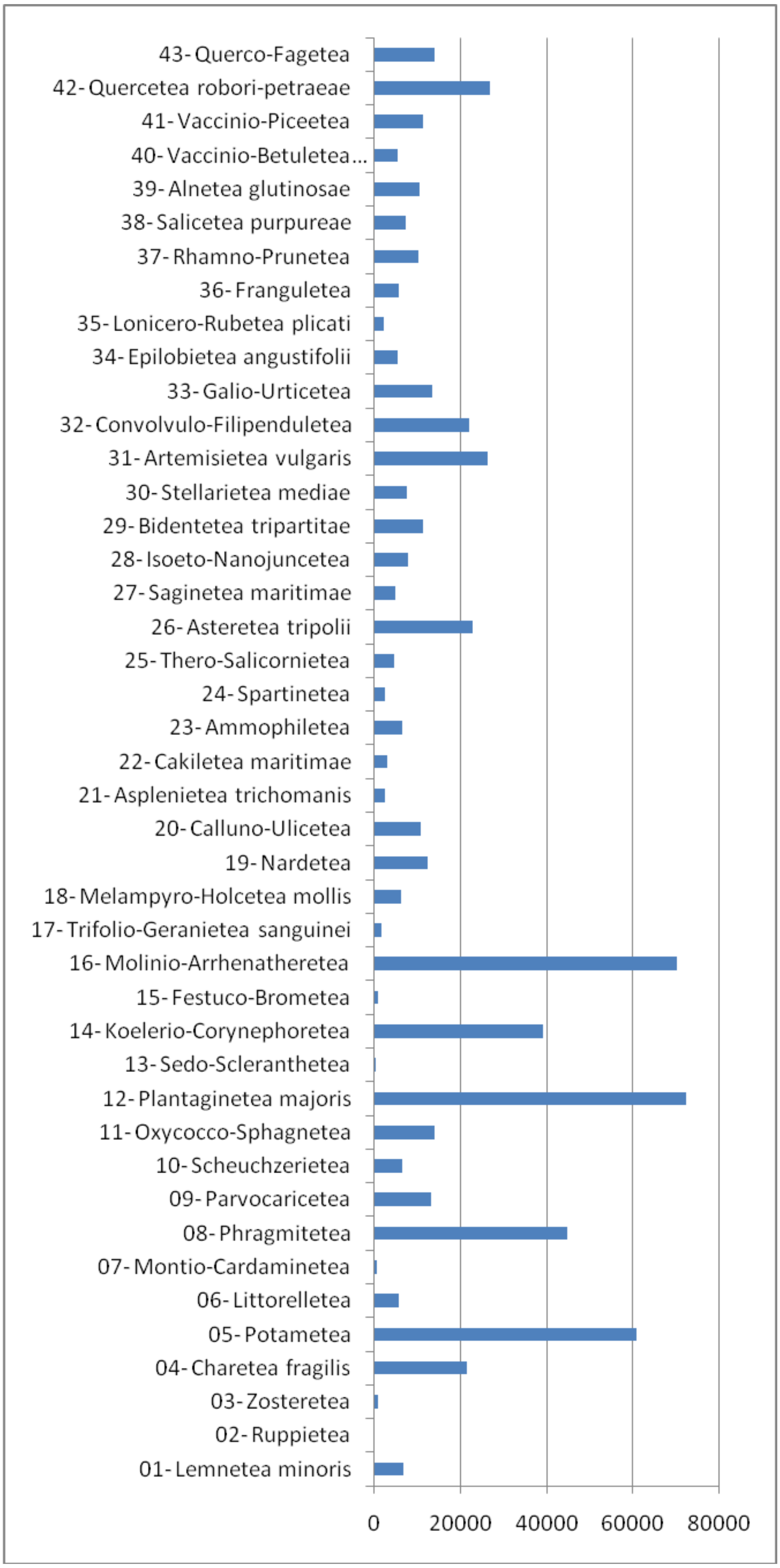


Fig. 6: The number of relevés per vegetation class in the Netherlands (situation 2010). The grasslands classes *Plantaginetea majoris* (with the order *Agrostietalia stoloniferae*, referring to intensively used grasslands) and *Molinio-Arrhenatheretea* comprise the highest numbers, followed by aquatic communities (*Potametea*), marsh communities (*Phragmitetea*) and dry grassland communities (*Koelerio-Corynephoretea*).

The use of the Dutch National Vegetation Database in fundamental and applied research

The new perspectives of the joint research on theoretical and methodological aspects by mining large data sets have been demonstrated already by some recent studies. Traditionally the analysis of plant communities focuses on the species composition within and across communities. With the increasing availability of large databases of plant traits, it becomes easier to add traits as another dimension. This opens the way for macro-ecological studies on patterns of traits across a wide range of ecosystems (Grime 2001, Díaz et al. 2004, Ozinga et al. 2004). Examples of large trait databases include Comparative Plant Ecology (Grime 2001), BiolFlor (Klotz et al. 2002) and LEDA (Kleyer et al. 2008). The LEDA Traitbase has been used in combination with the Dutch vegetation database to show that the predictability of local species composition from environmental conditions is constrained by dispersal traits (Ozinga et al. 2005). Another example is the analysis to what extent the local persistence of plant species is determined by functional traits and habitat preferences, using survival statistics (Ozinga et al. 2007). The results provided evidence for a trade-off relationship between local aboveground persistence and belowground seed persistence, while the rate of species turnover increases with productivity.

For applied science vegetation information systems can provide a sound scientific basis for international initiatives in nature conservation. The incorporation of habitat requirements and plant traits will allow ecological information systems such as *SynBioSys Europe* to support European-scale, policy-oriented scenario studies. In European nature conservation policies, the Birds and Habitats Directive have given species policy a clear international dimension. A major instrument for preventing population decline by these directives is the establishment of a series of protected nature reserves throughout Europe for the protection of endangered species and habitats. The Dutch National Vegetation Database, in combination with the information system *SynBioSys Netherlands*, has been used intensively in the selection and demarcation of sites that have to be protected under Natura 2000 (Schaminée et al. 2006). The ecological and spatial information is used to underpin the biological values of these sites and allow a sound analysis of possible negative effects of activities in and around the protected areas.

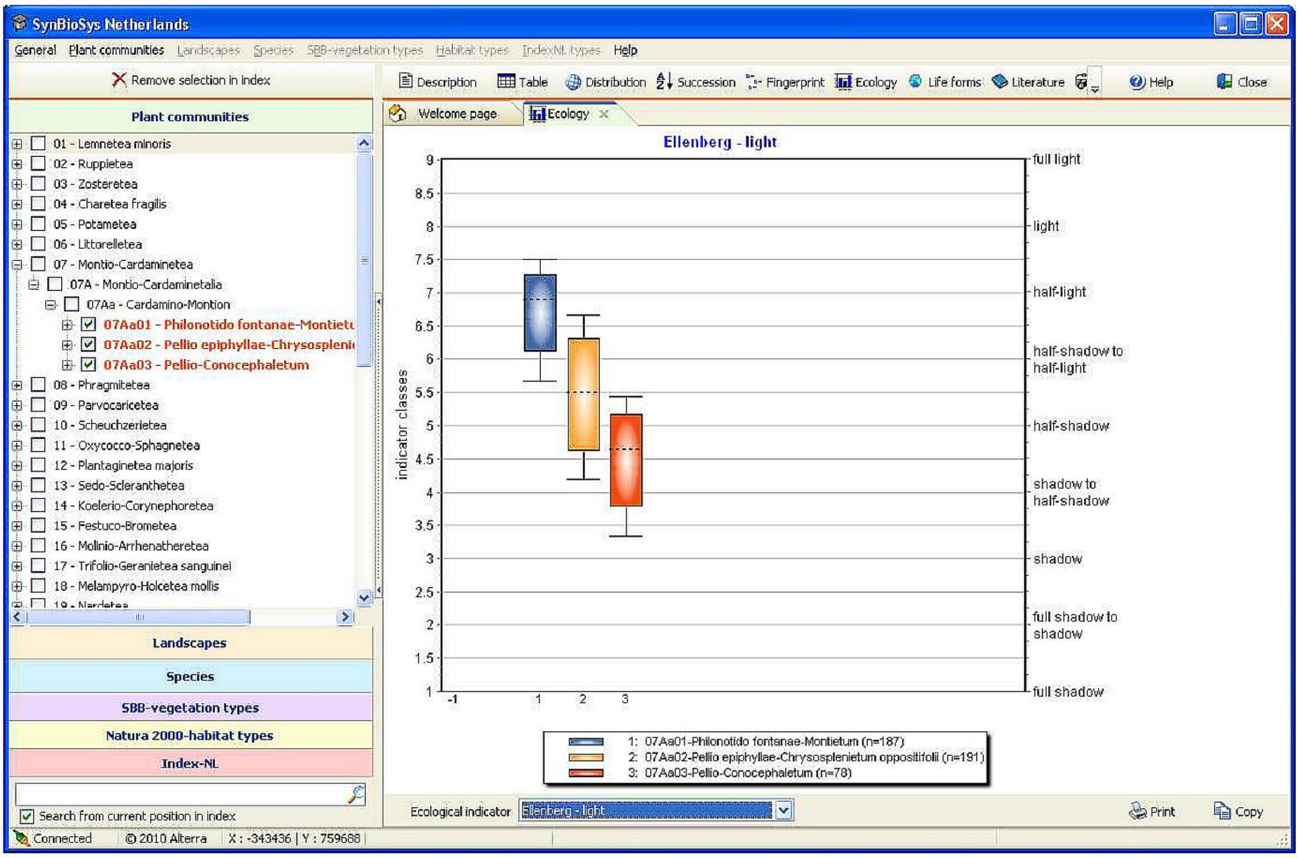


Fig. 7: By combining datasets in *SynBioSys Netherlands*, new information can be obtained. The figure shows the tolerance for shade of three spring communities in the Netherlands, derived from combining the vegetation tables of these communities with the Ellenberg indicator values for light of the species present in these communities.

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