The Biological Valuation Map (BVM): a field-driven survey of land cover and vegetation in the Flemish Region of Belgium

De Saeger Steven*
Oosterlynck Patrik
Paelinckx Desiré

steven.desaeger@inbo.be
Research Institute for Nature and Forest (INBO)
Kliniekstraat 25
1070 Brussels
Belgium

Abstract

The Biological Valuation Map (BVM) is a major database for land and vegetation cover of the Flemish Region in Belgium. In this contribution we will discuss methodological issues encountered over 35 years of mapping. The application of the BVM in Flemish environmental policy is illustrated by a number of examples. Following an evaluation of strengths and weaknesses, some improvements for future mapping initiatives are proposed. To allow the BVM to evolve towards an instrument for habitat monitoring, a stricter and updated methodology will be needed. Our extensive experience reflected in these guidelines can serve to facilitate the development and use of similar mapping projects throughout Europe and the world.

Keywords : Vegetation mapping; Natura 2000 habitats; Habitat monitoring; Biodiversity policy

Résumé

La Carte d'Évaluation Biologique (CEB): une cartographie établie à partie de la couverture du sol et de la qualité de la végétation en Flandre (Belgique).

En 1978, un projet de cartographie, appelé la carte d'évaluation biologique (CEB), a été lancé par le gouvernement Belge. A cette époque, le but était d'aboutir à une carte couvrant le territoire entier, compréhensible et facilement interprétable illustrant avant tout les paysages naturels ou semi-naturels. En même temps la politique exigeait un inventaire détaillé de la qualité biologique de l'environnement sur la base de critères scientifiques. Depuis lors la CEB est devenue l'outil principal pour toute une série d'applications concernant la conservation de la nature, l'aménagement du territoire et l'évaluation des impacts sur l'environnement (DE BLUST *et al.* 1985). Actuellement la CEB est employée couramment dans les actions provenant de la Directive Natura 2000 comme par exemple le rapportage sur l'état de conservation des habitats (Fig. 3).

Mises à part des catégories générales pour désigner l'occupation du sol (champ, habitation, …) la typologie utilisée pour la cartographie des végétations est établie sur une base phytosociologique (Fig. 1). La végétation est cartographiée à l'aide

d’une liste référentielle d’unités cartographiques. Le niveau typologique syntaxonomiques utilisé se situe souvent au niveau des alliances, mais également au niveau des associations. Pour une interprétation facile et rapide, les unités de cartographie sont traduites en une évaluation biologique et représentées par un code couleur sur la carte (Fig. 2). Le travail de terrain est mené par une équipe permanente de scientifiques et de techniciens afin de réduire les sources de variations dues aux observateurs et d'assurer un niveau acceptable de cohérence. Régulièrement des ateliers de cartographie sont organisés pour avoir une concertation et un échange maximal.

Aujourd’hui, deux inventaires complets de l'environnement biologique et de la couverture du sol en Flandre ont été effectués. La première version a été accomplie entre 1978 en 1996, et la deuxième entre 1998 et 2010. Entre ces deux périodes, la méthode de travail (par exemple l’échelle de cartographie) a tellement évolué qu’une comparaison diachronique robuste n’est pas possible. Pour rendre la CEB opérationnelle comme un outil de surveillance, il faut établir des règles plus strictes concernant la délimitation des polygones et l’identification univoque de la typologie. Autrement dit, on doit rigoureusement améliorer la possibilité de reproduire la cartographie dans le temps. Pour s'aligner avec la directive INSPIRE, il est nécessaire d'avoir une meilleure intégration des typologies européennes existantes dans le référentiel utilisé (tout d’abord EUNIS et les habitats Natura 2000). Pour adapter les règles de cartographie dans une approche européenne, la méthodologie de BIOHAB / EBONE constituera notre base. Pour que cette méthode puisse être un instrument de surveillance, en utilisant les règles de base et une sélection d'éléments utiles, nous avons l’ambition de produire une répétabilité satisfaisante.

Pour des raisons budgétaires, la troisième période de cartographie (2013-2025) sera largement orientée vers les zones du réseau Natura 2000 et les habitats Natura 2000 en dehors du réseau Natura 2000.

Mots-clés : Cartographie de la végétation; Habitats Natura 2000; Surveillance des habitats; Politiques de biodiversité

Introduction

Belgium has a long tradition of mapping biotopes and habitats. A mapping project called the Biological Valuation Map (BVM) was launched in 1978 at the request of the national government. At that time policy makers demanded a map covering the entire territory which would be straightforward in its interpretation by indicating the biologically valuable elements on the scale of the landscape. At the same time, a more detailed and scientifically solid inventory of the biological environment was expected.

The BVM was conceived as a uniform, field-driven survey of land cover and vegetation. Since then it quickly became a primary tool for a wide variety of applications concerning nature conservation and environmental planning (DE BLUST *et al*. 1985, DE BLUST *et al.* 1994). Recently a second version of the BVM has been completed in the Flemish region of Belgium. The first version, which ran from 1978 to 1996, turned out to be a global overview of the biologically valuable landscapes and the remaining nature values. In the second version (1998-2010), the list of mapping codes was extended, and overall detail and accuracy were drastically improved as a response to increasing user requirements. More intensive fieldwork and closer

cooperation between the field workers were necessary to achieve these goals (DE SAEGER *et al.* 2010, VRIENS *et al.* 2011). A third mapping period started in 2013 with a methodology which in turn will be fine-tuned to the present-day requirements (e.g. monitoring the Natura 2000 network).

The Biological Valuation Map (BVM)

The BVM is a full inventory of the biological environment and land cover. Land cover classes and vegetation types are defined by an extensive list of legend units. For fast and easy interpretation the survey is also translated into a biological valuation and depicted by a colour code on the map (Fig. 2).

The legend units

The field survey is carried out using a fixed list of legend (mapping) units. Some of the units reflect information about the land use (e.g. arable land, urban area). Most of them however describe vegetation types (e.g. dry heath, mesotrophic swamp alder wood, wet oligotrophic grassland). Their phytosociological relation is often at the level of alliances (e.g. *Filipendulion*, *Nympheion*, *Ericion tetralicis*), but also at the level of vegetation associations (e.g. *Cladietum marisci*, *Fago-Quercetum*). If we consider all units, except 'urban' and 'intensively cultivated', about two-third of the number of legend units match a phytosociological alliance or association (Fig. 1). The choice of developing a relatively easy and pragmatic mapping system is the main reason for the difference in the syntaxonomic levels of the units. This choice was made to obtain a relatively fast mapping procedure with sufficient (degree of) standardisation. Not all vegetations are easily recognisable at the association level. Therefore the mapping of communities with similar species composition and appearance produces a high degree of confusion between surveyors and could lead to typological uncertainties in the map (HEARN *et al*. 2011). Making vegetation recordings or other methods for *a posteriori* standardisation, could provide an improvement regarding this surveyor bias but would triple (or more) the survey time.

Linear and point elements in the landscape are also mapped (e.g. lines of trees, hedgerows, ponds, sunken roads). Extra codes are added to indicate the dominant tree or scrub species; (e.g. a thorny hedge dominated by *Crataegus sp.* or by *Prunus spinosa* have a different notation).

It is not uncommon in our landscape that (semi-)natural vegetations are forced back to small relicts due to habitat fragmentation and habitat loss. A specific set of codes describes these small landscape elements. More specifically a prefix is added to an existing legend unit in order to indicate that the actual vegetation type is restricted to a parcel border or a ditch.

Figure 1

The biological valuation

In order to meet the original demand for straightforward interpretation of the maps, the BVM also contains a biological valuation. This biological valuation is classified as low, moderate or high. For the purpose of standardisation the biological value of each

legend unit is fixed a priori. It is determined by expert judgement, based on a number of ecological criteria: rarity of the biotope, biodiversity of the biotope (flora & fauna), vulnerability (e.g. to eutrophication, acidification, disturbance ...) and replaceability of the vegetation type. Generally well developed (semi-)natural vegetations are rated with a high value, basal and degraded communities of the latter with a moderate value. Pioneer vegetations and tall herb communities on anthropogenic soils (e.g. artificially raised terrains, abandoned quarries) also have a moderate biological value. Intensively used agricultural grasslands, arable lands, and urban areas are of low biological value, unless they contain valuable small landscape elements.

Frequently, parcels containing vegetations and landscape elements with different values are encountered (e.g. species-poor grassland with species-rich hedgerows). In Fig. 2 this is indicated by a shading of different valuation classes. For example '*cm*+*ce*', a mosaic of *Molinia caerulea*-dominated heathland (*cm*) with well-developed areas of wet heath (*ce*) is valuated as a "complex of biologically valuable and very valuable elements".

Because valuation is mainly based on plant species and vegetation, additional red shading has been added for areas of faunistic importance (Fig. 2). This is determined by the occurrence of important populations of one or several species, mentioned in the Flemish red lists or the annexes of the Birds Directive (EUROPEAN COMMISSION 1979) or Habitats Directive (EUROPEAN COMMISSION 1992). Also nationally and internationally important numbers of migrating and wintering water birds or geese are taken into account. The data used for the fauna criterion comes from other inventories and databases (DE KNIJF *et al.* 2010).

Figure 2

A field driven survey

The field work for the second version was done by scientists and technicians from the Research Institute for Nature and Forest (INBO). Most of the territory (81%, excluding the urbanised areas) was visited during an intensive field survey. To fill in the expectations of the stakeholders the mapping scale is at the level of parcels and habitat patches (approximately 1/5.000). Extra attention went to areas wherever (semi-)natural vegetations occur. Urban areas and intensively cultivated agricultural areas were mapped in lesser detail. To complete the mapping of such a vast surface within a reasonable time span, areas were visited only once. Nevertheless, an accurate result could optimally be reached by mapping an area in the most appropriate time of year to recognise the vegetation types. The exact date (year, month) of the field visit (or of other used data) is always included in the database for each individual map unit. This provides the user with an indication of the reliability of the map in terms of origin of the information (e.g. field work, interpretation of aerial photographs) and the date or season of the field visit. Aerial photographs and other existing GIS layers (e.g. forest inventory maps, soil maps, historical maps) were used to speed up the field work and to collect additional information.

Availability

All the maps are freely available through the internet (more information on www.inbo.be/bvm). Until 1998 the Biological Valuation Map was also published as paper maps at a scale of 1:10 000.

Applications of the Biological Valuation Map

The BVM offers a unique window on the biological environment of Flanders. Therefore it has become the baseline instrument for nature conservation, environmental impact assessment, environmental management and spatial planning. The use of colour shading, indicating the biological value, makes the BVM also accessible for a wide group of users other than ecologists. There are numerous applications that build on the BVM database (e.g. connectivity studies, ecosystem vulnerability maps). Some of these applications were intended from the start of the BVM-project (DE BLUST *et al*. 1985), others (e.g. Natura 2000) came along the way.

Nowadays the BVM is intertwined into the Flemish legislation concerning nature conservation and environmental protection. The map itself has no statutory base, but several legislative texts mention protected vegetations in terms of BVM legend units.

The BVM and Natura 2000

The Biological Valuation Map (BVM) proved to be an important instrument in locating and quantifying the amount of Natura 2000 habitats in Flanders. In some instances, a BVM-unit can be directly interpreted in terms of a Natura 2000 habitat (e.g. wet heath, white dunes). Unfortunately, there is not always a one-to-one relationship (e.g. the freshwater habitats). In such cases, there is an uncertainty about the presence/absence of the habitat type (e.g. *ao* on Fig. 2 indicates oligotrophic lakes, but only a small amount of these can be identified as habitat 3160, natural dystrophic lakes) The overall result of this translation is an indicative habitat map for Flanders (Fig. 3). Since 2003 the Natura 2000 habitat types are mapped directly during the field surveys, so in time there will be no uncertainties left due to translation (orange areas on Fig. 3).

In the framework of the European Natura 2000 network, the habitat map has proven to be very useful in obtaining reliable data on the location, range and surface area of most habitat types (LOUETTE 2011). This provided a strong backbone in the process of delineation of the Special Areas of Conservation and the Art. 17 reporting required under the Habitats Directive (EUROPEAN COMMISSION 1992).

Figure 3

The manure action plan

Within spatial planning zones with a nature destination there can be a restriction on the amount of manure used for fertilising agricultural land. This amount is among other things dependent on the actual vegetation. The latter is described by the legend units of the BVM. The amount of manure spread on semi-natural and species rich grasslands, for example, is restricted to the equivalent of 2 animal units (cows)/ha/year. On the other hand, species poor agricultural grasslands and arable land are exempted from restrictions in the use of fertilisers (Fig. 4).

Figure 4

Lessons learnt, an evaluation of the BVM and its methodology

Are stakeholder needs filled in?

All stakeholders in the field of nature conservation are confronted to some extent with the BVM. In most cases consultation, evaluation or updating of the BVM are mandatory steps in any type of conservation project. The concept of the BVM is therefore widely recognised throughout government agencies, non-governmental organisations and the scientific community. Generally stakeholders with opposing interests accept the scientific evidence of the BVM, although sometimes long discussions are needed to convince them that the BVM offers an objective basis for decision making.

The use in legislation causes problems. Lawyers do not question the intrinsic value of the BVM, but state that land owners are not supposed to know the biological characteristics of their properties, neither their representation on the BVM. Environmental lawyers insist on an official recognition of (derived maps of) the BVM and announcement of these in the Belgian Legal Publication ("Belgisch Staatsblad") (DE SMEDT 2011).

Map quality

Stakeholders demanded a high degree of standardisation, accuracy and repeatability during the second mapping period. Experience in definitions and methods can reduce observer variation and provide acceptable levels of consistency (SOUTER *et al.* 2010, KELLY *et al.* 2011, HEARN *et al.* 2011). STEVENS *et al.* (2004) found that mapping consistencies were considerably better within a carefully coordinated staff within one organisation than those reported by studies of consistency between organisations. The BVM staff is a permanent and well trained team of professional field surveyors. On a regular basis field workshops (e.g. on the use of the legend units and delineation of polygons) with all surveyors were organised to achieve further standardisation. Nevertheless surveyor bias remains an important issue (VRIENS *et al.* 2011).
Especially for monitoring purposes, further improvements are necessary. Test cases with dual mapping and cross checking can detect and quantify differences in approaches and interpretations. For example, we validated the Natura 2000 map derived from the BVM using a randomly stratified sampling survey. Map polygons served as sampling units and were remapped independently. Overall accuracy for presence/absence of Natura 2000 habitat was on average 90% with 95% confidence interval ranging from 86% to 94%. False positives were mainly due to recent natural succession (field work between 2000 and 2009; validation field work in 2010) and lack of mapping uniformity regarding the lower limits of the habitat types. For some habitat types it was apparent that lower accuracy arose from uncertainties associated with the translation of the original map legend to Natura 2000 habitat types (EEA-MNHN, *in litt*., 2013).

To streamline the mapping into a wider, European approach, updates in the mapping rules will be based on the BIOHAB / EBONE methodology (BUNCE 2011). Even

without adopting the whole methodology, using its basic rules and a selection of useful elements will lead to higher repeatability.

Legend units

DE BLUST *et al.* (1994) already pointed out problems with the legend units due to heterogeneity, the lack of hierarchy and limitations in the legend units for certain vegetation types (e.g. pioneer vegetations, fringes, tall herb communities). During the second mapping period steps have been taken to solve some of these problems, but a clear hierarchy is still missing. The detailed BVM is frequently scaled up to a broader land cover map for analysis. But due to the missing of a fixed hierarchy (and the complexity of the database), depending on the scientist, different methods are used to derive simplified maps (e.g. GODEFROID & KOEDAM 2007, STRUBBE & MATTHYSEN 2007, CHAN & PAELINCKX 2008).

To get into align with the INSPIRE directive (EUROPEAN COMMISSION 2007), further integration of the legend units with European classifications (e.g. EUNIS, Natura 2000 habitats) is needed. This will facilitate the use and exchange of the BVM in Europe.

Time base

The second survey of the Flemish region (13 521 km²) was performed over a period of approximately 12 years (1998-2010). This is a long time in a densely populated region with a fast changing landscape due to urbanisation and agricultural intensification (OLSCHOFSKY *et al.* 2006). As a result, an analysis of the dataset has to take into account this time lag.

If we want the BVM to evolve from an “inventory” to a “monitoring” tool to determine trends in area and distribution of habitats or vegetations, we have to work on the methodology. Increasing the number of field surveyors is not possible due to financial restrictions. So, we have to seek for other solutions to deal with the time lag.

OLSCHOFSKY *et al.* (2006) determined fast changes in agricultural landscapes and near built-up areas in Flanders. Landscapes dominated by high nature values like forests, dunes and heathlands changed less fast. Considering these results, the mapping intensity does not need to be the same for every landscape type. Mapping forests less intensively (e.g. every 18 years) than grasslands (every 12 years) reduces the amount of annual field work. By dividing the total area in small parts and by mapping these subsets randomly, it is possible to have a statistically solid interpretation in shorter time spans than after completing the total mapping cycle.

Much effort goes towards research on the use of innovative techniques for monitoring. Remote sensing provides an opportunity to speed up the mapping or to focus the field work on areas where changes took place. Detailed studies on site level achieved good results in following up the most important structures and functions of heathland habitats (THOONEN *et al*. 2013). Moreover, other field-based variables of interest, not directly measurable with remote sensing, were found to correlate well with these structures and functions and could be modelled with the remotely sensed input variables (SPANHOVE *et al.* 2012). In this way, at least for heathland habitats, a substantial replacement of field work by remote sensing becomes conceivable. However, the use of remote sensing is still hampered by

unpredictable image availability and high acquisition costs. A solution to these problems, together with a seamless integration into user workflows, will open the way for further implementation of remote sensing in habitat mapping (VANDEN BORRE *et al.* 2011).

Conclusions

The BVM is a detailed, uniform and freely available map of land cover and vegetation for the entire Flemish region. This gives the map its strength and power. It is broadly used, even in legal contexts and laws concerning nature conservation and environmental protection in Flanders.

At the moment two full inventories of the biological environment and land use in Flanders have been accomplished. Between those two periods the working method (e.g. mapping scale, manpower …) differed too much to make a robust statistical comparison. If we want to use the BVM as a monitoring instrument, we will have to achieve higher repeatability of the mapping procedure. Therefore we need stricter rules for polygon delineation and typological identification. Due to budget restrictions the third mapping (2013-2025) period will largely focus on the Natura 2000 network and areas with Natura 2000 habitats outside the network. The methodology is currently being updated to bring it in line with some European and international standards (e.g. BIOHAB / EBONE, EUNIS). Applied research is being conducted concerning implementation of remote sensing as a mapping technique.

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Legends

Figure 1: Relation of the legend units (except for urban and cultivated) of the Biological Valuation Map with reference to existing syntaxa.

Figure 2: The Biological Valuation Map (BVM) of a heathland area near Kalmthout, Belgium.

Figure 3: The Natura 2000 habitat map translated from the BVM (Figure 2).

Figure 4: Example of the application of the BVM for the manure action plan.