Impact Assessment and Project Appraisal, volume 16, number 3, September 1998, pages 185–194, Beech Tree Publishing, 10 Watford Close, Guildford, Surrey GU1 2EP, UK.

Hierarchical classification

The importance of a hierarchical ecosystem classification for the biological evaluation and selection of least valuable sites

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This paper suggests that for assessment studies, divisions into a core region (ecoseries), an immediate surrounding (ecosecction) and a wider surrounding (ecodistrict) should be used in ecosystem classification. A methodology to classify sites was set up and, making use of ten sites for biological evaluation in Belgium, it was shown how a hierarchical ecosystem classification could improve categorisation. Often the visual characteristics of the surrounding landscape, such as diversity or connectivity, mask the features of the core zone itself (ecoseries). Using different hierarchic ecosystem levels is a direct and effective help to avoid this masking and to give more importance to existing nuances.

Keywords: ecosystem; biological evaluation; site-selection; EIA

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The authors thank NIRAS (Contract No 694-221-787-9) and the researchers for critical evaluation on the development of this methodology, in particular D Paelinckx (Belgian Institute of Nature Conservation), D van Straeten (University of Antwerp) and L Deronde, B Roelandt, U Sansen, F Vanlerberghe and G Weyembergh (Laboratory of General Botany and Nature Management).

DURING THE PAST 25 years, increasing attention has been paid to the decaying environmental conditions of natural valuable sites. In Flanders (Belgium) this degradation of the environment has been characterised with an intensive fragmentation of the natural landscape, resulting in small and isolated areas of biological value. These areas are now threatened by land-use, loss of connectivity between fragments and loss of ecosystem diversity. In addition, loss of genetic diversity in populations inhabiting the remaining land patches is a present threat for their survival (Baguette and Lebrun, 1990).

Environmental impact assessment (EIA) investigates the condition of nature and environment in relation to future disturbances, but also other systems are used such as cumulative impact assessment and socio-economic impact assessment (Devuyst, 1993). Often the emphases of evaluation or impact studies are merely restricted to the potential site of the impact, rather than to the wide surroundings of the site. Although both are undoubtedly important, there is a lack of integration of these different spatial scales into a complementary investigation.

The methodology presented here aims to include a hierarchic ecosystem classification when evaluating a large series of sites. The significance of remaining landscapes and biological inheritance in fragmented areas can be assessed much better by considering a hierarchical ecosystem classification. The extremely high diversity of ecosystem types and their value, spread over an entire country with different geology, pedology, hydrology, and so on makes an

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Table 1. Terminology for a hierarchic system of ecosystem classification on different spatial scales

	Indicative scale range Smallest cartographic unit
Ecozone	1:>50,000,000 >62,500 km^2
Ecoprovince	1:10,000,000–50,000,000 2,500–62,500 km^2
Ecoregion	1:2,000,000–10,000,000 100–2,500 km^2
Ecodistrict	1:500,000–2,000,000 6.25–100 km^2
Ecosection	1:100,000–500,000 0.25–6.25 km^2
Ecoseries	1:25,000–100,000 15,000–250,000 m^2
Ecotope	1:5,000–25,000 2,500–15,000 m^2
Ecoelement	1:<25,000 <2,500 m^2

Source: Klijn and Udo de Haes (1990)

unambiguous comparison of sites difficult. Standardisation at different hierarchical levels, thus could provide an outcome.

A number of assumptions are made in this study :

- The evaluation must be repeatable: when the evaluation is done by different persons similar results should be obtained. Hence, the methodology has to be standardised.
- Many alternative locations are to be considered (preferably more than ten).
- These sites must be selected for a single project type of infrastructure.
- The selection of a suitable site (for the project) is solely based on existing maps and published documents.

The methodological basis was optimised for application to a series of 98 sites in Belgium, selected as potential sites for nuclear waste deposit. A fictional purpose of the classification was the selection of a site suitable for such an anthropogenic impact, arbitrarily the construction of an industrial waste-deposit and associated infrastructure.

Hierarchical ecosystem classification

The methodology presented here is concerned with a multi-criteria evaluation of non-urban point sites, with reference to the existing situation. The main emphasis lies in the importance of different ecosystem levels introduced by Klijn and Udo de Haes (1990). They provide a terminology for a hierarchic classification of ecosystems based on spatial scales (Table 1). The concepts of ecodistrict, ecosection and ecoseries are fundamental to our approach.

The ecoseries is defined here as a part of the ecosystem which is to a certain extent homogeneous with respect to its biotic and abiotic components. When the resulting classification from this methodology is used for site-selection and implementation of projects, usually the ecoseries will correspond well with the area in which the project activities will be executed, both during and after the construction phase.

The ecosection consists of the immediate surroundings of the ecoseries and reflects the structure of the ecosystem in this study. The possible human impacts of a project to the ecosection correspond with a direct influence from the activities in the ecoseries.

Finally, the ecodistrict is the wider surroundings of both ecoseries and ecosection; it can be used when assessing aspects of the structure of nature and quality of the broader surroundings, such as fragmentation, types of ecosystem, amount of natural resources and corridors.

Criteria

The criteria for assessing the value of a site are characteristics which are directly or indirectly derived from data on the ecosystems. They will be referred to as ecological criteria. Each criterion is then subdivided into a number of indicators, which are directly observable characteristics in the field and which take a measure of the ecological criterion.

Use of the different spatial scales implies that the indicators within the ecological criteria may vary according to the spatial scale. For example, when considering the vulnerability of an ecosystem, this ecological criterion may depend on the presence of a rare animal species on a local scale, while it depends more on the possibilities for the particular species to migrate on a larger scale (= connectivity). Therefore an ecological criterion may evoke a different set of indicators when dealing with different spatial scales.

Criteria which are often used to assess the value of an ecosystem and which consequently will be inherent to this methodology are rarity, vulnerability, diversity and replaceability.

Rarity

Rarity is an ecological criterion which is quite easy to deduce from existing documentation; it excludes ambivalent interpretations. It can be supposed to correlate highly with threat, for instance, the probability of extinction in a country such as Belgium is high,

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even for a small threat. For many species this implies a restriction on just a few populations. Basic indicators to evaluate rarity usually can be assessed from a list of representative plant or animal species.

Vulnerability

The vulnerability of an ecosystem is concerned mainly with its sensitivity with respect to certain natural or anthropogenic disturbances. Because the scale of a possible impact is difficult to quantify, the measure of vulnerability can be estimated better using experience in ecological research. The changing hydrology of an ecosystem is among the most important indicators in the assessment of its vulnerability.

Diversity

Diversity has been defined in many different ways (Gaston, 1996a). In the framework of this study the definition as proposed by Fiedler and Jain (1992) is most appropriate:

> "Biological diversity [biodiversity]. Full range of variety and variability within and among living organisms, their associations, and habitat-oriented ecological complexes. The term encompasses ecosystem, species, and landscape as well as intraspecific (genetic) levels of diversity."

It is common for communities rich in species to be valued more highly than those poor in species. However, several less diverse communities, such as vegetation in dynamic environments, should also be valued highly. This is compensated for through other criteria such as rarity and vulnerability. Diversity alone is clearly not suitable in discussing the value of an ecosystem. Within the biodiversity criterion we can choose to assess more than one type of diversity, such as investigation of genetic, taxonomic, functional and/or ecosystem diversity, depending on the scale of the evaluation (see Gaston, 1996b).

Replaceability

Replaceability addresses the possibilities of establishing an ecological equilibrium similar to the previous situation at the same site. Not all species and ecosystems have the same requirements with respect to such a development. Depending on the emphasis and exact procedure of the investigation a related criterion, such as irreplaceability, can also be used (Belbin, 1995).

Connectivity

A fifth criterion, which should be treated separately, is what will be referred to as connectivity. This is defined by the presence of biologically valuable features, corridor zones and rural elements in the immediate neighbourhood. Generally a corridor zone is defined as a linear vegetated zone which may differ from the surrounding vegetation and which connects at least two patches, that were connected in historical time (Saunders and Hobbs, 1991; Merriam and Saunders, 1993).

This general definition is appropriate because it includes natural, remnant and cultural (such as, hedgerows) corridors, and does not state specifically that the primary purpose of a corridor is as a conduit allowing movement of biota, though it may well function as one (Hargitt, 1994). Consequently there is an existing risk for migrating species when corridors are interrupted. The importance of hedgerows in this context was illustrated a long time ago (Moore *et al*, 1967) and a large number of recent studies continue to emphasise the importance of corridors (Maelfait and de Keer, 1990; de Mers, 1993). Both the type and number of corridors are important data which should be considered in their evaluation.

Legal criteria

Apart from ecological criteria, sites may be the subject of existing legal agreements as to their future purpose. Therefore possible legal criteria must be considered carefully, since they have the largest value for politicians in decision-making. If sites are classified with the aim of site selection for particular projects, the legal aspects cannot be neglected; they have to be considered in the ecosystem classification.

The relevant legal regulations are not always of the environmental type (for instance, future purpose of areas). Wherever environmental protection is expressed in legal regulations, the most frequent basic principle is that of prevention (Madar, 1993). The fundamental form of prevention is the duty to request the consent of the government before conducting activities which could impair the environment (Madar, 1993).

It is important, however, to separate the legal aspect of site classification from the purely ecological aspects, because of the different approach on which it is based. Legal aspects are the primary limiting factors of the site selection, since they are based only on the legal possibility of implementing a project. It is allowed or not allowed.

The legal criteria in the present study consist of three types of agreements. The RAMSAR Directive, for the protection and conservation of wetland areas, and the EC Directive for Threatened Birds have an international base. Regional maps are of federal origin and distinguish different facets of land use or land purpose, such as "residential areas", "agrarian areas", "industrial areas" or "nature reserves".

Scores

When all the criteria and indicators have been established, each indicator can be expressed quantitatively

Table 2. Ecological importance of the score distribution within a certain indicator

Number of facets	Score 0	3	5	7	10	Distribution
5	X	X	X	X	X	Neutral
4	X	X	X		X	Ecologically important
	X		X	X	X	Ecologically less important
3	X		X		X	Neutral
	X	X			X	Ecologically important
	X			X	X	Ecologically less important

Note: The scores are attributed in such a way to list the site which is best suited for the project (thus least biologically valuable) on top of the classification

by giving a score relative to the value of the ecosystem. The quantitative value and the range of the scores may depend on different factors. One of them is the variety of directly observable attributes on the field, which will be referred to as the number of facets of an indicator (for instance, the ecological criterion 'vulnerability' can be assessed by the indicator 'water quality' which in turn has four facets: 'non-polluted water', 'slightly polluted water', 'polluted water' and 'very polluted water').

Another factor on which the quantitative values and range of scores depend is the total number of sites to be classified. For the purpose of classifying 98 sites, a score range of 0 to 10 is appropriate to reach a good 'segregatability'. We define segregatability as the resolution with which a number of items can be classified. In other words, the greater percentage of the sites that can be classified unambiguously (thus with fewer *ex aequos*) the better the segregatability. The segregatability is influenced trivially by the number of criteria. We can either propose as many criteria as necessary such that no *ex-aequos* can possibly occur in the classification, or take a few criteria (just one at the lowest extreme) and evaluate them using score ranges equal to the number of sites to be classified, that is, from 1 to 100.

However, on one hand we have to avoid an oversimplification and on the other hand we must not build a wall of criteria. Therefore, the criteria were limited to the essential ones as illustrated above, and a simulation was performed to establish an appropriate score range — 1 to 10 seemed fair.

The distribution of the scores among the different facets can also take into account the importance of an indicator. The scores were assigned by careful consideration of the number of facets per indicator and the overall importance of the indicator (Table 2). In addition, the scores are attributed in such a way that the site with the eventual highest score would be best suited for the project, that is, the most valuable sites would get the lowest total scores. For example, when dealing with an indicator containing three facets and with the score range from 0 to 10 (10 means no ecological value; 0 means the highest ecological value), the facet scores can be evenly distributed over the range (0–5–10), or skewed towards either the low score extreme (0–3–10), when the ecological indicator is very important, or the high score extreme (0–7–10), when an indicator is less important (Table 2).

When indicators are of the present/absent form (for instance, representative animal or plant species lists in the 'rarity' criterion), the scores are respectively 0 or 10. Scores for legal criteria can be of the exclusion type, for example, when a site is partially located in a RAMSAR area the evaluation results in an exclusion of the site. The scores can also be rated according to different facets, for example, a site legally classified as an 'industrial area' for its future land-use or destination is considered arbitrarily as biologically less valuable than a site destined for nature development, thereby neglecting the real value of the still unexploited ecosystem existing now. ('Smoothing' of this negative score thus should be achieved by using the Biological Valuation Maps which display the real value of the ecosystem.)

The four sets of criteria (legal, ecodistrict, ecosection and ecoseries) can also be weighted according to their relative importance. In this study the sum of the weights of the ecological criteria equals the highest possible indicator score (10) in order to have a total result as a percentage. Before assigning the weights, it is important to recognise the existing hierarchy between the ecosystem levels outlined, and to reflect this in their weights. This hierarchy should be respected according to

ecoseries > ecosection > ecodistrict

where > is a 'higher importance than' function.

It is trivial that when dealing with point sites the ecosystem area immediately surrounding a certain point is most important and should be weighted higher. The importance decreases with an increasing distance from the site centre subsequently.

When certain criteria comprise many different indicators, it is also possible to attribute certain weights according to the relative importance among the indicators.

If listed or mapped presence/absence data are available for a large number of vertebrate species for instance, they can all be taken into account in the rarity criterion of the ecodistrict. Yet, amphibians might have to be valued higher than reptiles because of their restriction to wetland areas. This can be reflected in indicator weights. However, in the present study indicator weights are not used.

Use of criteria at three hierarchical levels

To evaluate the methodology independently, ten sites were arbitrarily chosen, that is, these sites were not considered for nuclear waste deposit but were chosen

The Biological Valuation Maps for Belgium created about 15 years ago contain geographical distribution of vegetation types and overall biological value of the entities: some changes may now be necessary, so a re-evaluation was done

so that different combinations of ecosystem types and structures were covered. The list of criteria was divided in four sets as introduced in the methodological basis.

Maps showing the biological value exist for Belgium. These Biological Valuation Maps (De Blust *et al*, 1985), constructed between 1979 and 1981, are on a scale of 1:25,000 and consist of mainly two types of information: geographical distribution of the vegetation types and overall biological value of the entities. The vegetation types considered comprise over 150 different associations. The overall biological value is estimated through rarity, vulnerability, naturality and replaceability of these vegetation types and are represented by three colours meaning biologically very, fairly or less valuable.

These maps are starting to become obsolete and, because a detailed ecological classification cannot rest only on this base, a re-evaluation of the vegetation types was made with respect to the ecological criteria used at the ecoseries and ecosection level. To illustrate how certain species may differ considerably compared to about 15 years ago, the rarity criterion can be used: many species and vegetation types which were not classified as rare when the Biological Valuation Maps were made are so today.

The re-evaluation was done by 'best professional judgement' after discussions with various specialists in the field, and in a similar way to methods proposed by Kuijken and Paelinckx (1992), Paelinckx *et al* (1992), Van Straeten *et al* (1993) or de Blust *et al* (1994). An updating of the information on the Biological Valuation Maps was also done in previous applications in the framework of biological evaluation of linear vegetation features (Devillez *et al*, 1995; Duran and Devillez, 1995).

At the ecodistrict level it was decided to make use of rarity, vulnerability and diversity as ecological criteria. Lists of representative herpetofauna (reptiles and amphibians) and avifauna (birds) were used as indicators to assess rarity. The more ecodistrict-bound aspect of these indicators is because these animals are seldom restricted to a local site. Yet, for rare species with low numbers, or declining species, human intrusion, disturbance and eventually displacement could reduce not only their reproductive success but also, ultimately, their presence in an area (Riffell *et al*, 1996).

As outlined earlier, the hydrological features of a landscape are important in assessing the vulnerability of an ecosystem. The indicators used here are: water quality based on existing data from the Flemish Environmental Society (*Vlaamse Milieumaatschappij*), and the groundwater dependence of several vegetation types.

At the ecosection and ecoseries level the common ecological criteria were rarity, vulnerability, diversity and replaceability. All these criteria were assessed through the updated vegetation types of the Biological Valuation Maps. For the ecoseries, the original overall biological value as mentioned on the map was included as well. Finally, connectivity was an ecological criterion based on the number of corridors and on the diversity in corridor types.

The attribution of the weights was also consistent with the most valuable sites receiving the lowest total scores. The weights for the legal, ecodistrict, ecosection and ecoseries criteria were therefore established as 2–1–3–4 respectively.

An example

The ten test sites were chosen in such a way that a variety of ecosystem structures could be covered: with or without biologically valuable patches in the ecoseries; with or without much diversity in vegetation types; with or without surface water in the ecosection, and so forth. All sites were located in Flanders.

The sites were assessed by means of worksheets on which scores could be filled in and the total score calculated readily. The actual values assigned to each facet need to be established so that a qualitative explicit basis for conclusions is secured. For this study the score values were established as presented in Table 3. Figure 1 shows the worksheet used for the assessment. The ecoseries consisted of a polygon with a surface of about 30 hectares (ha) while the ecosection was a buffer zone around the ecoseries with a cross section of about 1 km (Figure 2).

Before executing the evaluation according to the methodology proposed here, a subjective assessment, which was based purely on best professional judgement experience with the biological value of certain ecosystems, was made. After a rigorous sharing of opinions among three researchers the latter resulted in a 'hand-made' classification of the ten sites. This non-quantitative classification was then compared with the list resulting from application of the methodology. The largest variance recorded when testing the methodology for a particular site was 2.65 ($n = 2$; final results equal 57.4 and 59.7).

The results of the 'hand-made' classification and the methodological classification resulted in the lists presented in Table 4. Within the methodological classification, three clusters of sites can be recognised. Within each of the clusters two consecutive sites do not differ more than four units in their final score, but

Table 3. Actual values assigned to each score for each facet of each indicator under each of the criteria.

Legal criteria

Regional map (*Gewestplan*)
- Nature areas (*Natuurgebieden*): exclusion
- Nature areas with scientific value or nature reserves (*Natuurgebieden met wetenschappelijke waarde of natuurreservaten*): exclusion
- Forest areas with scientific value (*Bosgebieden met wetenschappelijke waarde*): exclusion
- Forest areas or agrarian areas with particular value (*Bosgebieden of agrarische gebieden met bijzonder waarde*): score 1
- Exploitation areas (*Ontginningsgebieden*): score 3
- Park areas (*Parkgebieden*): score 5
- Buffer zone (*Bufferzone*): score 5
- Agrarian areas (*Agrarische gebieden*): score 7
- Others (*Andere*): score 10

RAMSAR area (*Ramsargebied*)
Exclusion from those parts of the area

EC-bird directive (*EG-vogelrichtlijngebieden*)
Exclusion from those parts of the area:
- N, R, forest areas from the Belgian regional map (*N, R, bos gebieden uit het gewestplan België*)
- Agrarian areas with particular value from the Belgian regional map (*Agrarische gebieden met bijzondere waarde uit het gewestplan België*)

Ecodistrict

Rarity
Representative avifauna
1 species present: score 1
no species present: score 10

Representative herpetofauna
1 species present: score 1
no species present: score 10

Vulnerability
Water quality

Flanders
- category 1 and 2: score 1
- category 3 and 4: score 5
- category 5 and 6: score 10

Wallonia
- blue: score 1
- yellow: score 5
- red or red*: score 10

Groundwater dependence
- Always dependent: score 1: Ce, Ct, Hf, Mc, Mk, Mm, Mp, Ms, Mz, Vb, Vm, Vn, Vo
- Sometimes dependent: score 5: Cm, Hc, Hj, Hm, Lh, Sf, Sm, So, Tm, Va
- Not dependent: score 10: all other units

Diversity
 # Breeding bird species / grid unit
- less than 50 breeding bird species / grid unit: score 10
- between 50 and 90 breeding bird species / grid unit: score 5
- more than 90 breeding bird species / grid unit: score 1

Ecosection and ecoseries

Biological Valuation Map (*Biologische Waarderingskaart or BWK*)
Overall value
- Biologically very valuable (*Biologisch zeer waardevol*): score 1
- Biologically valuable (*Biologisch waardevol*): score 3
- Biologically less valuable (*Biologisch minder waardevol*): score 10

(continued)

Table 3. *(continued)*

Connectivity
 # Corridors
- If the corridor is unique in the ecoseries or ecosection: score 1
- If there are 2 to 5 other corridors in the ecosection: score 5
- If there are more than 5 other corridors in the ecosection or if the corridors do not contribute significantly within the rarity criterion: score 10

 # Corridor types
- If the type of the corridor is unique in the ecoseries or ecosection: score 1
- If there are 2 to 5 other corridor types in the ecosection: score 5
- If there are more than 5 different corridor types in the ecosection or if the corridors do not contribute significantly within the diversity criterion: score 10

Rarity
Biological Valuation Map (BWK)
- Very rare: score 1
  Apo, Ao, Bc, Ce, Ct, Ctm, Da, Dd, Dm, Ds, Ef, Fl, Fs, Hc,Hd, Hf, Hfc, Hft, Hk, hmm, Hmo, Hug, Hv, Kh, Khw, Md, Mk, Mm, Mp, Ms, Qb, Ql, Qs, Ru, Rud, Sd, Sg, Sk, Sm, So, Sp, Sx, T, Tm, Vc, Vm, Vo, Vt
- Rare: score 5
  Aer, Aev, Bg, Bk, Cd, Cg, Cm, Ek, Es, Fa, Fe, Fk, Fm, Ha, Hj, Hr, K, Km, Mc, Mr, N, Qa, Qd, Qe, Qx, Se, So, Va, Vb, Vf, Vn
- Less rare: score 10
  Am, Ap, App, Bs, Bl, Dl, Dz, Hp, Hpr, Hx, Hz, Kb, Kk, L, P, Sz, U

Vulnerability
Biological Valuation Map (BWK)
- Very vulnerable: score 1
  Aev, Ah, Ao, Ap, Ce, Ces, Ct, Da, Had, Hc, Hft, Hm, Hme, Hmm, Hmo, Hn, Hpr, Hug, Kc, Kg, Kh, Kj, Kk, Kn, Kv, Kw, Kx, Md, Mk, Mm, Mp, Ms, Mz, Rud, Sgu, So, T, Va, Vb, Vc, Vm, Vo, Vt
- Vulnerable: score 5
  Ab, Ae, Aer, Am, App, Cg, Ctm, Cv, Dd, Dm, Ek, Es, Fa, Fe, Ff, Fk, Fl, Fm, Ha, Hd, Hf, Hfc, Hk, Hu, Hv, Ka, Kf, Khw, Km, Kr, Kra, Krc, Lhb, Lhi, Mc, Mr, Qa, Qd, Qe, Qk, Ql, Qx, Sd, Sf, Sg, Sk, Sm, Sx, Tm, Vf, Vn
- Less vulnerable: score 10
  Ad, Bc, Bg, Bk, Bl, Bs, Bu, Cd, Cm, Cp, Ds, Dz, Fs, Hj, Hp, Hr, Hx, Hz, Kb, Kd, Kl, Ko, Kp, Kpa, Kpk, Kq, Ks, Kt, Ku, Kz, Lsb, Lsh, Lsi, N, P, Qb, Qs, Ru, Se, Sp, Sz

Diversity
Biological Valuation Map (BWK)
- Very diverse: score 1
  Ae, Aev, Da, Dd, Ek, Es, Fa, Fe, Fk, Fm, Hc, Hd, Hk, Hu, Kk, Ks, Mk, Mp, Qa, Qe, Qk, Qx, Se, Sg, Sk, Sp, Va, Vc, Vf, Vm
- Diverse: score 5
  Aer, Am, Ao, Ce, Ct, Cv, Dl, Ds, Dz, Ff, fs, Ha, Had, Hf, Hfc, Hft, Hm, Hn, Hr, Hv, K, Kd, Kh, Khw, Kr, Kt Kx, Mc, Md, Ms, Ql,Qs, Sd, Sf, Sm, So, Sz, T, Vn, Vo, Vt
- Less diverse: score 10
  Ap, Apo, App, B, Cd, Cg, Cm, Cp, Ctm, Dm, Hj, Hp, Hpr, Hx, Hz, Ka, Kb, Km, Ku, Lh, Ls, Mm, Mr, Mz, N, P, Qb, Qd, R, Sx, Tm, U

Replaceability
Biological Valuation Map (BWK)
- Replaceable with difficulty: score 1
  Aev, Ao, Ce, Ces, Ct, Cv, Da, Ek, Es, Fa, Fe, Ff, Fk, Fl, Fm, Had, Hd, Hft, Hk, Hme, Hmm, Hmo, Hn, Hug, Hv, Kg, Kk, Km, Kr, Kra, Krc, Kv, Md, Mk, Mm, Mp, Ms, Mz, Qa, Qe, Qk, Qx, Rud, Sm, So, Sx, T, Tm, Vc, Vm, Vo, Vt
- Replaceable: score 5
  Ah, Cd, Cg, Cm, Ctm, Dd, Dm, Fs, Ha, Hc, Hft, Hm, Hpr, Kd, Kj, Kf, Kp, Kpa, Kpk, Ks, Kw, Kx, Mc, Mr, Pmh, Pms, Pmb, Ppmb, Ppmh, Ppms, Qb, Qd, Ql, Qs, Ru, Sd, Sgu, Va, Vb, Vf, Vn

(continued)

Table 3. (*continued*)

- Easily replaceable: score 10
  Ad, Ae, Aer, Am, Ap, App, Bc, Bg, Bk, Bl, Bs, Bu, Cp, Dl, Ds, Dz, Hf, Hj, Hp, Hr, Hu, Hx, Hz, Ka, Kb, Kc, Kh, Khw, Kl, Kn, Ko, Kq, Kt, Ku, Kz, L, N, Pa, Pi, Ppa, Ppi, Se, Sf, Sg, Sk, Sp, Sz

Note: To obtain additional information about the water quality of surface waters for Flanders refer to Vlaamse Milieumaatschappij (1992) and for Wallonia refer to Descy *et al* (1981) and Belgisch Staatsblad (1995);
To obtain additional information about the representative avifauna and the number of breeding birds/rectangle refer to Devillers *et al* (1988);
To obtain additional information about the representative herpetofauna refer to Wielewaal (1990a;b;c);
To obtain codes and additional information about the Biological Valuation Map (NL: *Biologische Waarderingskaart*) refer to Ministerie van volksgezondheid en van het gezin *et al* (1985).

between two consecutive clusters there is a clear leap in final score. The three clusters can be classified respectively as 'well suited for the project', 'less suited for the project' and 'not suited for the project'.

As we can see in Table 4, the outcome of the classification within the three clusters is somewhat different from the 'hand-made' approach, even though the general trend is the same. Locality B (Figure 2a) was ranked as most valuable by the researchers because of the high number of biologically fairly valuable areas in the neighbourhood. However, if the cause of the difference is traced, it becomes clear that the reason why, according to the methodological approach, Site E (Figure 2b) is ranked in front of Site B is that there is a single biologically very valuable area within the ecoseries. The higher importance for the ecoseries as stressed before is thus reflected here.

Number and name of the zone:	
Communc:	
Topographic reference:	

AREA	CRITERION	*Indicator*	Score	Weight	TOTAL
LEGAL CRITERIA	RAMSAR				
	EC DIRECTIVE				
	REGIONAL MAP				
		subtotal	0		
		average	0	2	0
ECODISTRICT	RARITY	*Repr. herpetofauna*			
		Repr. avifauna			
	VULNERABILITY	*Water quality*			
		Groundwater			
	DIVERSITY	*#Breeding birds/grid unit*			
		subtotal	0		
		average	0	1	0
ECOSECTION	CONNECTIVITY	*#Corridors*			
		# Corridor types			
	RARITY	*Biol. Valuation Map*			
	VULNERABILITY	*Biol. Valuation Map*			
	DIVERSITY	*Biol. Valuation Map*			
	REPLACEABILITY	*Biol. Valuation Map*			
		subtotal	0		
		average	0	3	0
ECOSERIES	CONNECTIVITY	*#Corridors*			
		#Corridor types			
	BIOL. VALUATION MAP	*Overall value*			
	RARITY	*Biol. Valuation Map*			
	VULNERABILITY	*Biol. Valuation Map*			
	DIVERSITY	*Biol. Valuation Map*			
	REPLACEABILITY	*Biol. Valuation Map*			
		subtotal	0		
		average	0	4	0
			FINAL RESULT		0

COMMENTS:

Figure 1. Worksheet used for the assessment of the sites

Note: Also refer to Table 3.

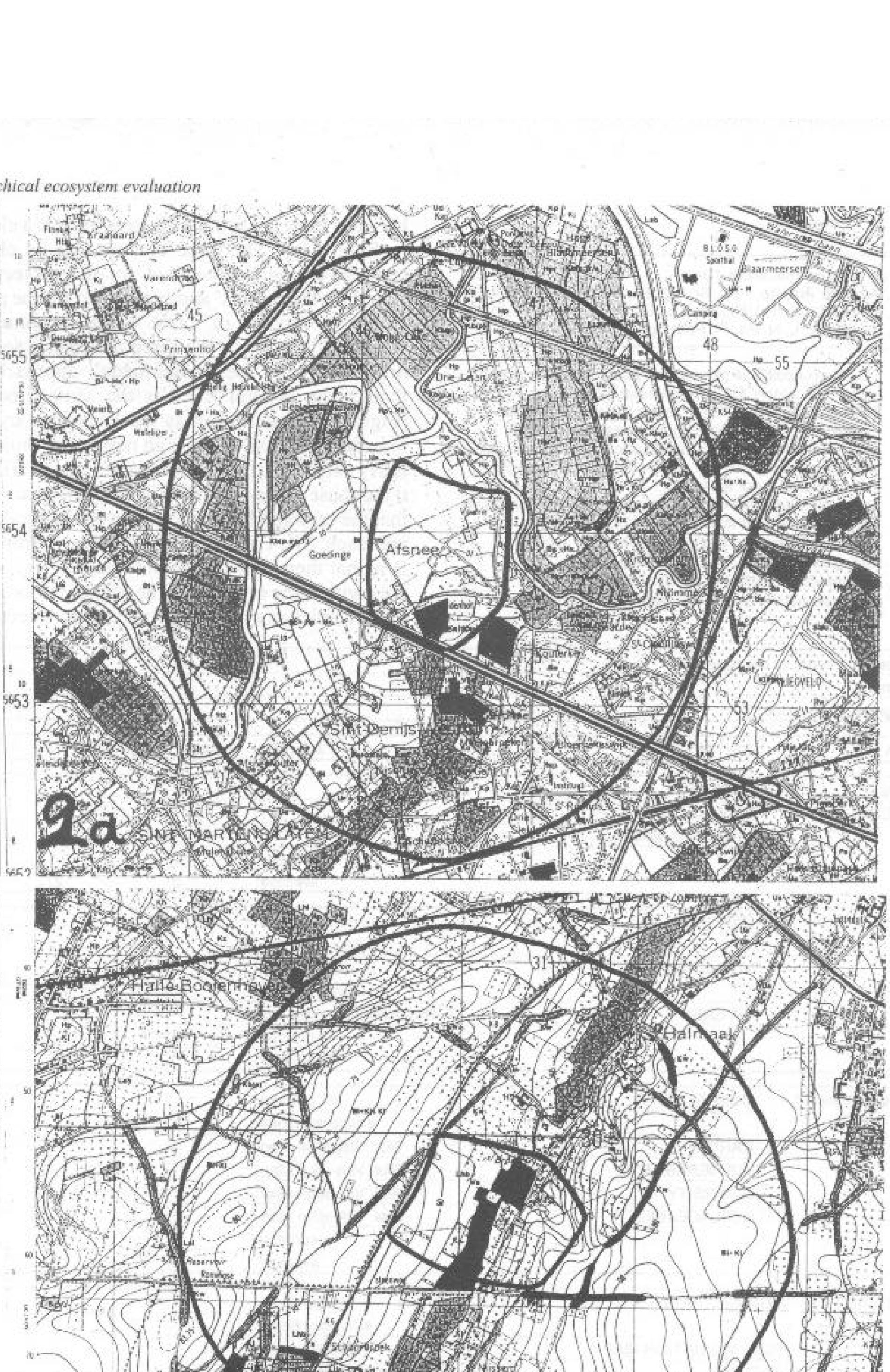

Figure 2. Part of a Biological Valuation Map showing test-Site B (2a) and E (2b)

Note Belgian Biological Valuation Maps are based on 1:10 000 topographic maps from the Belgian National Geographic Institute. The three grey shades (green shades on the original maps) are identified as: biologically very valuable (dark grey), biologically valuable (light grey) and biologically less valuable (white). Lettercodes correspond with particular associations in the vegetation (Ministerie van volksgezondheid en van het gezin *et al* 1985). The inner polygon represents the ecoseries (about 30 ha), the outer one the ecosection (1 km buffer zone).

Table 4. Classifications of the sites resulting from 'hand-made' and methodological approaches

Rank	Hand-made classification	Methodological classification		
1	Site H	Site H (83.7)		
2	Site D	Site A (79.7)		
3	Site F	Site D (76.8)		
4	Site G	Site G (73.8)		
5	Site A	Site F (71.0)		
6	Site C		Site C (55.3)	
7	Site I		Site J (52.2)	
8	Site E		Site I (52.0)	
9	Site J		Site B (51.3)	
10	Site B			Site E (44.4)

Notes: Scores obtained from the methodological approach are between brackets
Higher scores reflect a better suitability of the site for the project and consequently lower scores reflect biologically higher value

A comparable situation occurs for Site J, which seems to be rated biologically more important in the subjective classification because of its very diverse mosaic character. Yet, Site B and Site I similarly contain biologically fairly valuable areas within the ecoseries itself, which is valued higher in the methodology.

At the other extreme of the table Site A shows a higher evaluation in the subjective than in the methodological classification, where Sites D, F and G precede A (Table 4). The reasons for this are the number and shapes of the biologically more valuable areas in the ecosection of Site A, but once more, the ecosection is valued lower than the ecoseries in our study. The ecoseries (and to some extent also the ecosection) of Sites D, F and G contain species which are more vulnerable and more difficult to replace. These features do not show, though, unless the different hierarchical ecosystem levels presented here are studied separately and weighted according to their relative importance.

Differences between the 'hand-made' and methodological classification are due to the fact that, when evaluating the sites by best professional judgement only, it is too easy to be tempted by visual ecological criteria in the overall neighbourhood. Nevertheless, it is a clear that, apart from the most valuable site, the clusters from the methodological classification are also reflected in the 'hand-made' arrangement.

Perspectives

Policy-makers have to be convinced about the rigidity of biological criteria. Figures from a multi-criteria analysis should be more acceptable than, for instance, informal best professional judgements. The division into ecoseries, ecosection and ecodistrict in environmental impact assessments for classifying sites is a direct help to the ecologist to avoid failing to recognise nuances in the classification accounted for by the respective importance of these different spatial scales.

Often the visual characteristics of the surrounding landscape, such as diversity or connectivity, succeed in masking the features of the core zone itself, that is, the ecoseries. Evaluating the ecological characteristics at different levels of a hierarchical ecosystem classification is an effective way to avoid this and to give more importance to the nuances which in some cases might even be decisive.

The methodology adapted here is also particularly useful for projects which simultaneously require assessments in different disciplines from exact sciences (ecology, geography, hydrology, and so on), socio-economic sciences and jurisprudence. The different spatial scales used in the approach allow better comparison with the other disciplines, at least on one of the hierarchical ecosystem levels. The assessments done in a hydrological context, for example, are often situated in a wide area, which can be compared adequately with the ecodistrict here. The methodology can be adapted to assess the carrying capacity of the environment.

As is often the case for multi-criteria analyses, the methodology will serve mainly to reduce a large number of potential sites to a certain number of acceptable ones on ecological grounds. If the sites classified as 'suited for the project' still satisfy the needs of the project, and if the objective is to select just one site, in a second phase the sites must always be the subject of fieldwork and environmental impact assessment. To identify a top x % from the list for further evaluation, scoring or iterative approaches can be adapted (for instance, Pressey and Nicholls, 1989).

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