

Identifying peatlands of international biodiversity importance

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This paper presents a general overview of **criteria** and **indicators** to value mires and peatlands and a checklist for identifying mires and peatlands of international importance with respect to biodiversity conservation. (For other reasons to conserve mires and peatlands, please refer to [The Wise Use of Mires and Peatlands](#)).

1. Natural biodiversity

The value of an area with respect to natural biodiversity has to be estimated by **two standards** of equal importance: **naturalness** and **biodiversity**.

1.1. Naturalness

· With regard to naturalness, areas with less human impact are more valuable than areas with more human impact. Areas without human impact have the highest value.

Naturalness of mire ecosystems and landscapes has to be measured by the criterion “degree of artificiality”. Indicators of artificiality are human **activities** (e.g. cutting, mowing, digging, planting, grazing of cattle) and **artefacts** (the result of activities, e.g. meadows, drainage ditches, tree plantations).

· Artificiality diminishes in the course of time.

As spontaneous (= natural) processes increasingly modify anthropogenic patterns, an older artefact (e.g. an overgrown ditch) is less artificial than a similar recent one.

· Artificiality diminishes with distance.

As effects become increasingly indirect, artificiality diminishes with distance from the place where the human activity has been taking place.

Artificiality of mires and peatlands can be rapidly assessed by using Table 1. This table presents a scale for valuing artificiality (A-value), that integrates former and current human activities and their indicators.

Four major groups are discerned:

- The categories A0 - A3 have the highest value with respect to naturalness and include all (largely) peat accumulating systems (mires).
- The categories A4 - A8 include peatlands, where peat is currently oxidizing or eroding.
- In the categories A9 - A11, peat has been or is being removed actively by extraction.
- Peat deposits covered with more than 30 cm of sand, concrete or asphalt, and deeply ploughed areas

(cf. A12) are not considered to be peatlands anymore (though the presence of peat may give these areas a peatland related, palaeo-ecological biodiversity value, s. 1.2).

Table 1: Artificiality (A) scale for mire and peatland areas (inspired by Dierssen & Dierssen in prep.):

	former and current human activities	current human activities/use	current plant cover	peatland substrate profile	current peat accumulation	remarks and examples
A0	none	none (merely some hunting/gathering)	spontaneous	undisturbed peat profile, (mostly) no pedogenesis	(mostly) > 0	virgin mires; virtually non-existent anymore because of world-wide anthropogenic atmospheric deposition
A1	only very indirect	none (merely some hunting/gathering)	spontaneous	undisturbed peat profile (mostly) no pedogenesis	(mostly) > 0	virgin mires without any anthropogenic drainage; some (often hardly visible) effect of atmospheric deposition;
A2	surficial drainage (both direct and indirect)	none (merely some hunting/gathering)	spontaneous	(largely) undisturbed, ±some pedogenesis	< 0 (> 0)	non-grazed moorlands, fallow meadows, secondary forests, recent anthropogenic mires, peat pits with ³ 30 cm new peat
A3	surficial drainage (both direct and indirect)	forestry, low intensity grazing or mowing	spontaneous	(largely) undisturbed, some pedogenesis	> 0 (± 0)	wet forests, wet grazed meadows and moorlands, wet hay- and straw-fields; no planted or sown plants; ± some fertilization
A4	former drainage and fertilization	none (merely some hunting/gathering)	spontaneous	(largely) undisturbed, rather strong pedogenesis	< 0	humid to dry spontaneous forests, productive fallow lands, artificially inundated

						peatlands
A5	drainage and fertilization	forestry, low intensity grazing or mowing	planted/sown or spontaneous	(largely) undisturbed, strong pedogenesis	< 0	forests and grasslands with strongly fluctuating water levels
A6	surficial drainage and ploughing	low intensity arable land	largely planted/sown	profile surficially disturbed, strong pedogenesis	< 0	active shifting cultivation (e.g. buckwheat fire culture), Deutsche Hochmoorkultur; vegetation only partly spontaneous
A7	former intensive drainage, ploughing, and fertilization	none (merely some hunting/gathering)	largely spontaneous	profile surficially disturbed, strong pedogenesis	<< 0	fallow, formerly intensively used arable land
A8	intensive drainage, ploughing, and fertilization	intensively used arable land	planted/sown	profile surficially disturbed, strong pedogenesis	<< 0	currently intensively used arable land; peatlands inundated for cranberry and fish cultivation; peatlands with thin sand cover
A9	former drainage and peat removal	none (merely some hunting/gathering)	spontaneous	profile decapitated, some pedogenesis	< 0	abandoned peat extraction sites without current peat accumulation
A10	intensive drainage, peat removal	peat extraction	largely absent	profile decapitated	<<< 0	active peat extraction sites
A11	former peat removal; intensive drainage	agricultural use	planted/sown	profile decapitated, pedogenesis	< 0	agricultural lands on former peat extraction sites with remaining peat layers in undisturbed profile
(A12)	complete peat extraction, deep	urban area, agriculture, forestry, pisciculture	not relevant	no peatland anymore	< 0	areas that do not meet the definition of peatland

	ploughing or surfacing				(anymore) like built and deep-ploughed areas, or complete absence of peat
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1.2. Biodiversity

· With regard to biodiversity, phenomena that are “more different” are more valuable than phenomena that are “less different”.

Biodiversity has to be measured by the criterion “degree of difference”. In contrast to “artificiality” (with “pure nature” as zero-value), no absolute and scale-independent zero-value exists for “degree of difference”. In assessing “difference”, one has to take into account

- the spatial resolution of observation: e.g. do I compare sites, regions, or countries?
- the property: e.g. am I looking at forms or colours?
- the accuracy of distinction: e.g. do I distinguish between ten subtypes of “yellow” or only two?
- the level of organisation: e.g. am I looking at single pieces or at the mosaic?

Because all these things are interrelated, a clear and integrated hierarchy of biodiversity values is extremely complicated to make. In the following we will present some general rules.

· Phenomena constituting diversity in a larger area (e.g. on an international scale) are more valuable than phenomena constituting diversity in a smaller area (e.g. on a local scale).

A completely monotonous area, that shows no internal difference (= no alpha-diversity), may contribute considerably to international biodiversity (=beta- and gamma-diversity), when it is the only such monotonous area (example: Ispani II in Georgia, the only known ombrogenous percolation mire in the world). A distinctly patterned mire is nothing special in the boreal zone with its aapa and kermi mires, but a similar mire highly increases diversity in Central Europe.

The most important indicator of “difference” is **rareness**: the spatially restricted occurrence of plant or animal species, plant-communities, mire microforms, peat types, mire types (see below), peatlands of a specific degree of artificiality (cf. 1.1) etc.

Many other indicators are directly related to rareness: “uniqueness” (= the only one of its kind) is the ultimate form of rareness; “endemism” implies only occurring in one region; “representativeness” (= “typicalness”) refers to features that are normal/common in one region, when comparing to other regions.

Size is both a direct (as larger sites are rarer), and an indirect indicator of diversity (as larger sites may contain more (unknown and rare) elements, cf. MacArthur & Wilson (1967).

Because we are dealing with a **conservational** strategy, only properties can be used to assess “difference”, that have a temporal continuity.

· Diversity of individual organisms should be assessed by (genetical) taxonomy.

Genetic taxonomy provides a widely accepted criterion for assessing biodiversity. Genetic taxonomy prevails over “phenotypic” properties (like the colour of a flower), because the latter are more flexible and provide less guidance for classification. An intermediate position is constituted by properties like “the oldest / largest bog pine of Europe”.

· For mire micro-patterns, a morphological approach has to be taken.

The formation of mire micro-patterns is still too poorly understood to differentiate and classify them on the basis of causal processes (cf. Glaser 1999). Therefore they have to be classified by their forms. The same accounts for plant communities etc.

· Mire massifs can be distinguished into hydro-genetic types and subdivided into morphological subtypes.

The causal processes for the origin and development of hydro-genetic mire types are to such extent known, that they can be used for classification of mires. Finer subdivisions still have to take place on the basis of morphology.

· The archive value of peatlands has to be taken into account.

The archive value, a specific type of peatland diversity, has to be assessed by means of **age, completeness of the palaeo-ecological record, peat thickness**, and (both horizontal and vertical) **variation in stratigraphy**.

A special kind of distinctive elements of international importance are the scientific **type localities**, that must be used as references for assessing “difference”. Examples include geological and pedological type localities (also of national typologies!), and mire sites where classical studies have been performed like Augstumal (Lithuania), Komosse (Sweden), Lammin Suo (Leningradskaya Oblast), Silver Flowe (Scotland) etc.

· A detailed typology should be based on a combination of various criteria.

Various typologies of mires and peatlands exists, all based on different criteria. These criteria include e.g. hydro-genetics, trophy and base-saturation conditions, macro-morphology, micro-morphology, floristics, vegetation, physiognomy, and stratigraphy. An example of a combination is presented in Tab. 2: percolation mires can be found in mesotrophic acid, mesotrophic subneutral, and mesotrophic calcareous variants.

Table 2: Combination of “ecological” (based on trophy and base conditions) and hydro-genetic mire types in Central Europe (after Succow & Joosten 2001)

	C/N ratio > 33		C/N ratio < 4,8		C/N ratio < 20
	pH < 4,8		pH > 6,4		
	Oligotrophic acid	mesotrophic acid	mesotrophic subneutral	mesotrophic calcareous	eutrophic
Lowland bog					
Mountain bog					
Condensation mire					
Kettle mire					
Water rise mire					
Percolation mire					
Surface flow mire					
Terrestrialisation mire					
Spring mire					
Coastal flood mire					
Fluvial flood mire					

With respect to the accuracy of distinction the following criteria hold:

· Phenomena that are more distinct are more valuable than phenomena that are less distinct.

When observed in a sufficiently detailed way, everything differs from everything else, but some things differ more than others. To make the collecting, storage, and communication of information easier, things are usually grouped into “classes”, of which the members are regarded as non-different from other members of that class, and different from members of other classes. The result of such classification procedure is an (often hierarchical) typology.

Conservation of diversity and classification of diversity are fundamentally conflicting activities. As everything differs from everything else, the conservation of all diversity implies the conservation of everything. Classification leads to a conceptual reduction of diversity (see also <http://www.imcg.net/docum/greifswald/dialect.htm>). If we only distinguish two types of peatlands (e.g. “bogs” and “fens”), the conservation of these two types would be sufficient to conserve all peatland biodiversity. For the sake of biodiversity, the **finest possible (most detailed) (acceptable) typology** should be used.

Indicators for distinctiveness are **height in the taxonomical hierarchy** (a rare species is more valuable than a rare variety), **genetic difference** (a genetically isolated taxon or ecosystem is more valuable than one with many close relatives), **typicalness** (a clearly patterned area is more valuable than a vaguely patterned area), and **size** (larger mosaics are more valuable than smaller mosaics, all other things being equal).

· Diversity of mires and peatlands has to be judged on all levels of organisation.

This “multi-level approach” means that not only the rareness of individual species has to be assessed, but also the rareness of nanotope types, microtope types, etc., up to the supertope types (see Table 3).

Table 3: Organisational levels of mire entities (from Couwenberg & Joosten 1999).

organisational level	IMCG 1998*	synonymes **	indication of size (m ²)	Example
0 level			10 ⁻⁸	plant tissue, non tissue
1st level		elementary particle, Nanoform	10 ⁻²	single plant, moss clone, open water
2nd level	nanotope	mire-microform, feature, element	10 ⁻¹ - 10 ¹	hummock, hollow, pool
3rd level	microtope	mire-site, facies, element, segment, mikrolandšaft	10 ⁴ - 10 ⁶	hummock-hollow complex, pool
4th level	mesotope	mire-complex, massif, synsite, unit, mesolandšaft	10 ⁵ - 10 ⁷	raised bog (as a whole)
5th level	macrotope	mire-system, complex, coalescence, makrolandšaft	10 ⁷ - 10 ⁹	Stormosse (Sjörs 1948); Red Lake Peatlands (Glaser 1992).
> 5th level	supertope	mire-region, zone, district, province	> 10 ⁹	regional zonation of mires (Gams & Ruoff 1929; Ruuhijärvi 1960)

* proposed at the IMCG Workshop on Global Mire Classification, Greifswald, March 1998

** Masing 1972, 1998, Galkina 1946, Sjörs 1948, Ivanov 1981, Löfroth & Moen 1994, Yurkovskaya 1995, Lindsay 1995

A similar multilevel approach is followed by the Biodiversity Convention (cf. intraspecific, interspecific, and ecosystem biodiversity) and the Ramsar Convention (cf. paragraph 92 of the [Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands \(Ramsar, Iran, 1971\)](#)).

Also natural “processes” constitute natural biodiversity (cf. 1.1). For processes, the same rule applies as for patterns:

· Processes constituting diversity in a larger area are more valuable than processes constituting diversity in a smaller area.

As processes cannot be observed as such, but only via the resulting “patterns”, **rare patterns** (species, vegetation, micro-relief, recent peat deposits, etc.) are to be used as indicators for rare processes. The best indicator complex for actual peat formation, for example, is the combination of the following “patterns”:

- the presence of a normally peat producing vegetation,

- the presence of recent peat deposits formed by that vegetation type,
- and the presence of largely waterlogged conditions.

The above only applies for concrete processes, like peat formation, erosion, predation, speciation, etc. If the general aim of an area is “the most natural development possible” (cf. wilderness areas, 1.1), “**the absence of human activities**” is the best indicator. This negative indicator can indirectly be assessed by the presence of organisms that are highly sensitive to anthropogenic disturbance.

1.3. Actual versus potential values

· Potential values are of international importance, if the realization of the potential would contribute to the re-installment or the origin of phenomena of international importance.

· With respect to phenomena of equal international importance, actual values are more valuable than potential values.

1.4. Naturalness versus biodiversity

For the sake of naturalness, nature conservation should apply instruments with the lowest possible “degree of artificiality”. Also the Biodiversity Convention (UNCED 1992, art. 8d) prescribes to “promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in **natural surroundings**”. Therefore the next general guideline holds:

· Biodiversity should be conserved by doing as little as possible.

All conservational activities are artificial, but some are more artificial than others. Three levels of increasing artificiality can be distinguished:

- “doing nothing”: the *passive*, defensive measures necessary to prevent injuring of existing values (= external management, veto-regulation of the type “may not be done”), e.g. prohibition of digging drainage ditches in a mire;
- “doing once”: *once-only* active measures to improve biodiversity conditions, e.g. the blocking of drainage ditches in a bog to stop further drainage;
- “doing continually”: the *continual* active measures necessary to maintain favourable conditions (= internal management, prescriptive regulation of the type “must be done”), e.g. annual mowing.

In many countries, it has become impossible to conserve biodiversity by “doing nothing”, as too little space is left for all necessary natural processes. Active management may then assure the survival of biodiversity, but only at the expense of “naturalness”. A central question in nature conservation is therefore the **weighing between naturalness and biodiversity**: which activities are allowed to maintain/reach which diversity?

To optimise between naturalness and biodiversity on an international scale, the following guidelines may be considered:

- Biodiversity may only be conserved by measures with equal or less impact (cf. 1.1) than before the start of the conservational measures (e.g. continuing the mowing of hayfields).
- “Doing once” is an acceptable technique for biodiversity conservation, because on the long run the situation will return (but asymptotically) to the level of “naturalness” that existed before the

intervention.

- “Doing continuously” is acceptable for biodiversity conservation
 - if the intensity of the management technique is decreased, e.g. replacing mowing twice per year by mowing once per year;
 - if a change to a less artificial management technique takes place, e.g. by replacing mowing by grazing.
- The introduction of management practise of the type “consciously doing continuously” is not acceptable, because that would lead to a permanently decreasing “naturalness.” Exceptions can be made for the conservation of elements that would otherwise vanish completely from the Earth.

2. The assessment of international importance

2.1. Introduction

From chapter 1.2 follows that an entity (pattern, process, system) is of international biodiversity value, when it is rare on an international scale, i.e. when a country has an international responsibility for the conservation of that entity.

For some species groups, a lot of information on their international distribution exist that enables an assessment of “rareness” and “international importance”. For many mire/peatland phenomena (communities, microtopes, macrotopes, etc.), however, such information is currently still lacking.

In this chapter, some practical rules are presented to assess the international importance of species, habitat types, and sites, based on widely accepted criteria. For other phenomena, a similar approach can be followed. A site has to reach the qualifying standard in only one category to be considered as of international importance.

2.2. International treaties and conventions

Many international treaties and conventions stressed the international importance of various entities. These agreements do not (only) have a scientific, but (also) a political background. As international political agreement exists on their content, they can be used for identifying “international importance”. This chapter presents an overview of these treaties and their consequences for peatland conservation. Although not all countries may have signed the treaty, we consider the content of the treaty to be universalisable for the area involved.

An overview of mire and peatland species mentioned under the following legislation can be found [here](#).

2.2.1 Global legislation

Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention, 1971).

· [All Ramsar sites are of international importance.](#)

The list of Ramsar Sites can be found under:

http://ramsar.org/key_sitelist.htm

· [All sites that satisfy the Ramsar criteria are of international importance.](#)

These criteria can be found under:

http://ramsar.org/key_criteria.htm and the most recent under http://ramsar.org/key_guide_list_e.htm#v

Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention 1972).

[All World Heritage Sites are of international importance.](#)

The list of all World Heritage Sites can be found under:

<http://www.unesco.org/whc/heritage.htm>

Convention on International Trade in Endangered Species (CITES - Washington Convention, 1973).

[All species of Appendix I and II of CITES are of international importance.](#)

For Appendix I and II species of CITES, see our selection of peatlands species in Appendix A or for the complete list:

http://www.cites.org/eng/append/I&II_0700.shtml

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979).

[All species of Appendix I and II of the Bonn Convention are of international importance.](#)

For appendix I and II species of the Bonn Convention, go to the selection of peatlands species [here](#) or for the complete list:

http://www.wcmc.org.uk:80/cms/cms_app1.htm and

http://www.wcmc.org.uk:80/cms/cms_app2.htm

2.2.2. Pan-European legislation

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979).

[All species of Appendix I and II of the Bern Convention are of international importance.](#)

For appendix I and II species of the Bern Convention, go to the selection of peatlands species [here](#) or for the complete list:

<http://www.ecnc.nl/doc/europe/legislat/bernapp1.html> and

<http://www.ecnc.nl/doc/europe/legislat/bernapp2.html>

The Bern Convention (Recommendation No. 16, 1989) furthermore defines Areas of Special Conservation Interest. These areas fit one or several of the following conditions:

- the area contributes substantially to the survival of threatened species, endemic species, or any species listed in Appendices I and II of the convention;
- the area supports significant numbers of species in an area of high species diversity or supports important populations of one or more species;
- the area contains an important and/or representative sample of endangered habitat types;
- the area contains an outstanding example of a particular habitat type or a mosaic of different habitat types;
- the area represents an important area for one or more migratory species;
- the area otherwise contributes substantially to the achievement of the objectives of the convention. The

aims of the Convention are to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the co-operation of several States, and to promote such co-operation. Particular emphasis is given to endangered and vulnerable species, including endangered and vulnerable migratory species.

The List of Endangered Natural Habitats Requiring Specific Conservation Measures (adopted by the Standing Committee of the Bern Convention on 6 December 1996) with may contain mire/peatland components can be found under our Appendix C.

The total list can be found under:

<http://www.ecnc.nl/doc/lynx/publications/emerald.html#reso4>

The European Network of Biogenetic Reserves (Council of Europe Resolution (76) 17).

[All reserves belonging to the European Network of Biogenetic Reserves are of international importance.](#)

The European Diploma of Protected Areas (Council of Europe Resolutions (65) 6 and (98)29)

[All reserves having the European Diploma of Protected Areas are of international importance.](#)

For recent list: see

<http://www.nature.coe.int/english/cadres/reseaux.htm>

2.2.3 European Union legislation

Directive on the conservation of wild birds (79/409/EEC) (Birds Directive, 1979).

[All species of Annex I and all Special Protection Areas \(SPA's\) of the Birds Directive are of international importance.](#)

For Annex I of the Birds Directive, see our selection of peatlands species in Appendix A or for the complete list:

<http://www.ecnc.nl/doc/europe/legislat/birdann1.html>

The list of SPA's can be found under:

<http://europa.eu.int/comm/environment/nature/spa/spa.htm>

Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC (1) (Habitat Directive 1992).

[All Special Areas of Conservation \(SACs\) of the Habitat Directive are of international importance.](#)

[All sites that contribute significantly to the maintenance of a Annex I habitat type or of a Annex II or Annex IV species of the Habitat Directive and/or contribute significantly to the maintenance of biological diversity within the biogeographic region or regions concerned are of international importance.](#)

For Annex I habitats see our selection of habitats with possible mire/peatland components in Appendix D or for the complete list

<http://europa.eu.int/comm/environment/nature/hab-en.htm> or

<http://europa.eu.int/comm/environment/nature/hab-an1en.htm>

For Annex II and Annex IV species see our selection of peatlands species in Appendix A or for the complete list:

<http://europa.eu.int/comm/environment/nature/hab-an2en.htm> and
<http://europa.eu.int/comm/environment/nature/hab-an4en.htm>

Criteria for selecting “sites of community importance” can be found under:

<http://europa.eu.int/comm/environment/nature/hab-an3en.htm>

2.3. Red Lists

As an indicator of **international rareness**, the presence of a taxon (or other phenomenon) on international and national Red Lists can be used.

The following guidelines can be used:

- If a taxon occurs on the Red List of the IUCN, all areas where it is occurring are of international importance.

For our selection of peatlands species of the IUCN Red Lists, click [here](#) or for the complete list:

http://www.wcmc.org.uk:80/species/animals/animal_redlist.html and
<http://www.wcmc.org.uk:80/threatened-plants/plants.by.taxon.html>

- If a species occurs on one of the following international lists, all areas that support a substantial population of that species are of international importance:
 - Appendix I and II of CITES ([click](#))
 - Appendix I and II of the Bonn Convention ([click](#))
 - Appendix I and II of the Bern Convention ([click](#))
 - Annex I of the Birds Directive ([click](#))
 - Annex II or Annex IV of the Habitat Directive ([click](#))
- If a species occurs on the national red list of a country ([click](#)), all sites are of international importance and should be protected, which are regularly used (for reproduction, feeding, migration or wintering) by species, which are nearly extinct, critically endangered or endangered. For species with another threat status, all sites should be protected, which are important for the reproduction, feeding, migration or wintering of a substantial part of the population (>1 % of the geographical population; see Ramsar-Convention).
- Of international importance are all endemic taxa (and other phenomena), i.e. taxa who's distribution is limited to one country (or a limited group of countries). In the case that such taxon is not threatened (and hence does not appear on the Red List of these countries), only a selection of mires/peatlands where that taxon occurs can be considered of international importance (see also chapter 3).

This topic is also dealt with elsewhere on this website. Click [here](#) for further guidelines and actual Red List databases of mire related plant and animal species in Europe.

3. Extent, number, and arrangement of conservation areas

If objects of international conservation importance have been identified, the questions arise how large should the protected area be, how many individual objects have to be conserved, and how should the conservational areas be arranged?

The long-term preservation of valuable mire phenomena requires the protection of the whole mire massive.

Many mire phenomena require a **critical minimum area**. Some patterns may only develop (cf. rareness of processes!, 1.2) and can only be preserved when the mire exceeds a certain minimal area (e.g. bog lakes). Various mire microforms and microtopes, themselves being small, can only persist in large mires (Couwenberg & Joosten 1999). Because of the strong hydrologic relations between mire parts, the long-term preservation of valuable micro- and meso-patterns and associated organisms requires the protection of the whole mire massive.

Wherever possible, sites of international importance should contain complete watersheds.

A mire reserve should include all **surroundings** of the mire that play a role in its maintenance, including groundwater recharge areas, hydrological retention zones, immission resistance zones etc. The surrounding area should also enable continuous development and expansion of the mire. Larger protected areas also have the advantage of relatively smaller edge effects.

The conservation of mire elements and mire types “in perpetuity” requires that several duplicates are protected in various areas.

Because of natural fluctuations and anthropogenic threats, it is not enough to conserve only one specimen of a rare entity. “Contagious” agents of catastrophic extinction and destruction (disease, fire, exotics, climatic catastrophes) can devastate the conservational objects when concentrated in a single area.

Populations can only be retained if the favourable areas are large enough or form a sufficiently dense network.

For plant and animal species, the **minimum viable population** (MVP) has to be taken into account. The MVP is a population so large, that the chance of extinction of the species is neglectibly small. The MVP lies often in the order of magnitude of a few hundred to several thousand genetically effective individuals, which, for larger animals, may translate into very large areas necessary for conservation.

If one area is too small to contain a MVP (as often is the case), an **ecological network** of several areas is necessary to guarantee the long-term survival of the species (meta-population). An ecological network is a system of areas, between which dispersion can take place. In such networks, a minimum number of core populations must occur. A core population is a population that has a low chance of extinction (< 5% in 100 years) under the conditions of little exchange and that provide a nett flux of individuals to other parts of the network. To give an impression of the sizes involved, table 4 presents recent estimates of core population size and ecological network characteristics of some wetland birds.

Similarly, networks are necessary for migratory animals.

Table 4: Core population and ecological network characteristics of selected wetland birds in the Netherlands (after Foppen et al. 1998).

- A: number of (potential) breeding pairs per core population
- B: minimal area for one core population (km²)
- C: minimal number of core populations
- D: number of (potential) colonies
- E: minimal number of breeding pairs per colony
- F: wetland breeding area needed per colony (km²)
- G: additional forage area per colony (km²)
- H: total wetland area needed for sustainable network (km²)

	A	B	C	D	E	F	G	H

territorial species:								
<i>Acrocephalus arundinaceus</i>	80	4 – 7	5					20 - 35
<i>Cyanosylvia svecica</i>	120	4 – 13	5					20 - 65
<i>Acrocephalus schoenobaenus</i>	300	5 – 15	5					25 - 75
<i>Rallus aquaticus</i>	120	6 – 40	5					30 - 200
<i>Anas querquedula</i>	40	10 - 40	5					50 - 200
<i>Netta rufina</i>	60	20	5					100
<i>Circus aeruginosus</i>	80	16 - 65	5					80 - 325
<i>Crex crex</i>	120	13 - 120	5					65 - 600
<i>Porzana porzana</i>	80	26 – 65	5					130 - 325
<i>Panurus biarmicus</i>	600	18 – 240	5					90 - 1200
<i>Galinago gallinago</i>	200	50 - 100	5					250 - 500
<i>Botaurus stellaris</i>	60	48 - 120	5					240 - 600
<i>Ixobrychus minutus</i>	120	60 - 240	5					300 - 1200
<i>Locustella luscinioides</i>	400	20 – 500	5					100 - 2500
<i>Podiceps ruficollis</i>	40	20 - 500	5					100 - 2500
<i>Asio flammeus</i>	40	40 - 400	5					200 - 2000
<i>Circus cyaneus</i>	40	100 - 400	5					500 - 2000
colonial species:								
<i>Nycticorax nycticorax</i>				5	20	5	5	50
<i>Ardea purpurea</i>				10	60	5	10	150
<i>Chlidonias niger</i>				15	60	5	5	150
<i>Platalea leucorodia</i>				20	40	5	200	4100

4. Conservation economic and strategic criteria

Attention should be paid to the conservation of non-threatened systems.

An important conservation economic criterion is **threat**: saving the most beleaguered species and ecosystems first. It should, however, be realized, that the nature and degree of threat is likely to change over time, so that also attention has to be paid to the conservation of non-threatened systems.

Reserves should be capable of being effectively conserved and managed.

Another economical criterion is **practicality of conservation and management**. The reserves should be free from the immediate threat of external pollution, hydrological interference, intensive land use or industrial practises. Priority can be given to mires that border already protected sites. Where possible, reserves and corridors between reserves should be located in low intensity used lands (e.g. forestry rather than intensive agriculture). Reserves should preferably be drawn from publicly owned lands to minimise costs of acquisition. **Naturalness** is also an economic criterion, as continual “internal management” is expensive and vulnerable for changes in economic conjuncture. A larger **size** may make management relatively cheap. **Recorded history** (allowing monitoring of temporal changes) enables the evaluation of management practises and may contribute to conservation management efficiency.

Research and educational value can support the selection.

It is wise to look for allies for the establishment of concrete mire reserves. Few activities are, however, compatible with the conservation of mires. One of them is **research and education**. This criterion includes

mires that are particularly well suited for research and education (due to biological features or proximity to universities or research stations), well studied and documented over many years and with a continuing programme of research. Key sites (sites of particular importance to the understanding of ecological processes) and classic sites (“type localities” with classic scientific records) are valuable examples of this criterion (cf. 1.2). These qualities also offer special opportunities for promoting public understanding and appreciation of mires.

Cultural importance, recreation, and sustainable use can support the selection.

Public support can be mobilized for mires of cultural importance, and mires that are suited for recreation and sustainable use (landscape diversity, scenic beauty; abundance of berries, mushrooms, and medicinal plants).

Conservation strategic criteria should not be used in primary assessment of conservational value. They may, however, play an essential role in a final decision on conserving a site.

5. Concluding remarks

The most important criteria for identifying mires of international conservation importance are similar to those on a local/national scale. The local criterion “representativeness” identifies “rareness” on an international scale. The local criterion “rareness” normally identifies mires and mire elements that on an international scale are either rare, or at the margin of/outside their main distribution area. Such marginal occurrences are “distinctive” and have a high conservational value. International “networks” can, of course, only be identified on an international scale.

Application of objective selection criteria, and the use of optimally efficient selection strategies indicate that a very large number of reserves (and a very large area) seems necessary to secure biological diversity.