MINISTRY OF ENVIRONMENTAL PROTECTION AND NATURAL RESOURCES
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GAPS IN HABITAT PROTECTION IN THE CIRCUMPOLAR ARCTIC: A PRELIMINARY ANALYSIS

ARCTIC ENVIRONMENT

CAFF Habitat Conservation Report No. 5

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[1] CAFF is one of four programmes of the Arctic Environmental Protection Strategy (AEPS) adopted by Ministerial Declaration by Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden and the United States of America at Rovaniemi, Finland in 1991.

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1. INTRODUCTION

A key goal of the Programme for the Conservation of Arctic Flora and Fauna (CAFF) is to ensure the conservation and protection of Arctic habitat through the establishment of a Circumpolar Protected Areas Network (CPAN). A preliminary report prepared for CAFF in 1994 (CAFF, 1994) reviewed the status of protected areas in the circumpolar Arctic and resulted in the compilation of a relatively complete set of digital data for protected areas.

This report provides a preliminary assessment of the representativeness of CPAN, mainly in terms of habitat protection. It contributes to the CAFF Work Plan for 1994-95 which called for the compilation of information on proposed protected areas and an analysis of gaps in the network of existing and proposed protected areas using Geographical Information System (GIS) techniques. Russia has lead responsibility for this activity in cooperation with Norway, under the coordination of the CAFF Secretariat. The World Conservation Monitoring Centre (WCMC) and UNEP/GRID-Arendal were asked to assist with the technical aspects of the work. The gap analysis was discussed at a meeting of the CPAN Joint Russian-Norwegian Steering Group, Oslo, 15-16 May 1995 with a view to preparing a preliminary report in time for the IV Annual Meeting of the CAFF International Working Group, Moscow, 18-22 September 1995. The Ministry of Environmental Protection and Natural Resources, Russian Federation requested technical assistance from WCMC under the terms of a Agreement of Scientific and Technical Cooperation signed in 1993. Dr Igor Lysenko, Russian Institute for Nature Conservation, carried out the analysis with WCMC.

This report, presented in draft to the IV Annual Meeting of the CAFF International Working Group, is one of five CPAN documents prepared for submission to the Arctic Environmental Protection Strategy Ministerial Meeting in March 1996.

2. BACKGROUND

2.1 Arctic

There is intuitive appeal in protecting the world's remaining relatively pristine ecosystems. Some of the largest continuous areas of these are in the Arctic. Although the Arctic is low in overall species diversity, the permanently resident species are endemic to the region, and many of the migratory species breed only in the Arctic. Careful protection of the breeding sites and migration routes is therefore needed. The Arctic is particularly vulnerable to climate change and other impacts of global pollution. The depletion of the ozone layer is greatest in high latitudes and the impacts of ultra violet radiation on wildlife are poorly understood. Climate warming is likely to be accompanied by a reduction in snow and ice cover which will decrease the albedo, thereby accelerating the warming. The ocean and atmospheric circulation patterns are such that large parts of the European Arctic serve as a sink for pollutants from further south, while the drainage patterns of Northern Asia bring polluted river waters into the Arctic Ocean from well beyond the Arctic Circle.

Some of the threats are primarily the result of human presence: the construction of infrastructure, damage to tundra vegetation, disturbance of wildlife breeding colonies, and refuse disposal. Others result from local industrial activity: disposal of mine tailings, pollution of water courses or the atmosphere with heavy metals or sulphur, and oil spills. Others derive mainly from human activities in temperate latitudes: destruction of the ozone layer, long distance transport of pollutants in the atmosphere, sea or rivers, and global climate change. One recent example: the 7,714,940 ha Arctic National Wildlife Refuge on Alaska's coastal plain and coined 'America's Serengeti' is under immediate threat from a planned and approved oil industry development (C. Beretz *in litt.*, 1995). Direct exploitation of some of the large mammal populations, such as bowhead whale and polar bear, has been largely brought under control. The major problems of over-harvesting now concern commercial fisheries, which have seriously depleted stocks of cod and capelin, in turn affecting populations of seabirds. Overstocking of domestic reindeer has led to serious overgrazing in some areas.

The most serious threats to the Arctic identified by CAFF member countries are:

- local pollution from industrial development (oil, mining);
- over-harvesting of natural resources, particularly fisheries;
- long-range transport of pollutants in rivers, ocean currents and the atmosphere;
- global climate change; and
- loss of wilderness through human disturbance and infrastructure development (CAFF, 1994).

The development of the Arctic Environmental Protection Strategy provides the necessary international mechanism to address these threats and to coordinate conservation planning throughout the Arctic region under the CPAN initiative.

2.2 Biodiversity conservation

Biodiversity may be considered at genetic (within species, directly measurable by differences in DNA), species, and ecosystem levels. High genetic diversity is necessary to avoid inbreeding depression[2] and susceptibility of populations to factors such as disease. In order to maintain genetic diversity, geographically extreme parts of a species' distribution should be conserved, often within protected areas, and linked via corridors.

Species diversity, commonly equated with *species richness*, refers to the number of species occurring within a particular habitat. Centres of threatened, endemic, restricted range and relic species are an important focus for conservation. In the case of Arctic species, many are migratory and wholly dependent on the Arctic for their breeding habitat. Thus, particular emphasis needs to be given to the protection of: breeding, feeding and staging grounds; population centres; sites of high primary productivity; and migration/dispersal routes.

Consideration of biodiversity at the ecosystem level is more subjective, commonly being defined by differences in vegetation which, in turn reflect abiotic factors such as soil type, climate and topography. Terrestrial Arctic environments are close to or beyond the limits of existence of most organisms. The few species present are the only ones capable of surviving in these extreme environments. The characteristics which enable them to survive, therefore, are essential to ensure that these large areas of the globe are inhabited. Moreover, they are of disproportionately greater importance than those characteristics of organisms inhabiting more clement environments. Thus, it is preferable to consider conservation at the ecosystem

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[2] Inbreeding depression is the expression of deleterious genes as a result of mating between related individuals.

rather than species level as this avoids the bias against species-poor ecosystems, such as those of the Arctic.

As part of the CPAN Strategy and Action Plan, it has been recommended that at least 15% of each ecozone be relatively strictly protected, that is managed in accordance with IUCN Categories I-V. Gap analysis applied to a suitable vegetation classification system adopted by CAFF members will provide a means of monitoring progress towards this goal.

The importance of national protected area systems in the Arctic have been reviewed previously (CAFF, 1994).

2.3 Gap analysis

Conventional approaches to conservation have often focused on addressing threats to individual species. Such partial approaches are being challenged by a more integrated and proactive, ecosystem-level method, commonly referred to as gap analysis. This involves identifying whether or not target populations, species, and ecosystems are adequately represented within a network of protected areas. The aim is to fill the gaps through strategic planning and expansion of protected area systems.

Gap analysis is increasingly used in conservation biology to identify gaps in the protection of biodiversity. It can be used at different scales (local, national, global) depending on objectives. Gap analysis also serves as a baseline for monitoring environmental changes.

This rapid appraisal technique is inherently attractive in times of restricted budgets and ever-increasing environmental threats. In the Arctic, it can potentially contribute to long-term environmental monitoring, promote international collaboration in conservation planning and foster individual research according to national conservation priorities.

As a minimum, gap analysis can be based on a map of vegetation types or ecosystems. The level of detail depends on the maps available, the simplest relying on physiognomy or gross structure of the vegetation. Finer resolution would take into account floristic components of the vegetation to reflect biogeographic variations. Where species distributions are known, these can be included, taking particular note of sites of critical importance for breeding, moulting, feeding and other activities.

Gap analysis can be seen as a central, unifying feature of the CAFF Programme which draws together all of the information on populations, species and ecosystems to assist in planning CPAN. It is anticipated that information derived from the following activities will provide the basis for this analysis:

- Compilation of the **Circumpolar Arctic Vegetation Map** (CAFF Activity 1.3) is essential for providing a harmonised, fine resolution map of Arctic vegetation types.

- The **Rare, Endemic Vascular Plants Project** (CAFF Activity 2.1) will identify the distributions of those species of plants which are most in need of protection.

- The **Pan-Arctic Flora Initiative** (CAFF Activity 2.2) will provide information on the distribution of other species of plants.

- The **Rare, Vulnerable and Endangered Fauna Project** (CAFF Activity 2.3) will identify those populations and species of animals most in need of protection.

- The **Wildlife Habitat Mapping Project** (CAFF Activity 1.2) will identify the potential distributions of other species of animals.

- The **Circumpolar Seabird Working Group and Murre Conservation Strategy** (CAFF Activity 2.4) will identify the sites and size of seabird colonies.

- The **Indigenous Knowledge Mapping Project** (CAFF Activity 4.1) will identify those sites which are of critical importance for the conservation of various species of wildlife.

As yet, little of this information is currently compiled or available in a uniform format for the entire Arctic. Thus, the present study should be regarded as a preliminary analysis which will be progressively refined as more data become available.

3. METHODOLOGY

3.1 Circumpolar Arctic

The Arctic is defined by CAFF member countries according to the boundary shown in the Maps (1-3). The boundary is based on different criteria applied by individual member countries (CAFF, 1994), with the result that there are often anomalies or inconsistencies between countries when carrying out analyses at the circumpolar level. One example occurs along the Alaskan and Canadian border: to the west the vegetation is classified as the extreme northern limit of the tree line; to the east, it is shown as the northern limit of continuous forest. The Canadian Arctic, therefore, includes a large area of Northern Boreal and some Middle Boreal, which is similar, in this respect, to the definition applied in Russia. However, Northern and Middle Boreal are absent from Alaska for the reasons given above. The Scandinavian countries apply a definition based, in part, on the Arctic Circle and, therefore, include significant areas of Boreal forests (Map 1).

The 10°C July isotherm, floristic Arctic boundary, phytogeographic Arctic boundary, and continuous/discontinuous permafrost boundary are among a number of alternative ways of defining the circumpolar Arctic (CAFF, 1994).

3.2 Spatial datasets

At the CPAN Joint Russian-Norwegian Steering Group meeting in Oslo, 15-16 May 1995, it was agreed that the preliminary analysis of gaps in protecting biodiversity within the circumpolar Arctic should be based on overlaying the following spatial datasets:

- landscape
- vegetation
- species (e.g. polar bear, beluga whale, caribou, seabird colonies)
- wilderness
- protected areas

In the event, this preliminary analysis is limited to the representation of land cover or vegetation types and one target species (polar bear) within protected areas, as the other datasets could not be compiled for the entire circumpolar Arctic within the time available.

Identifying and documenting relevant spatial datasets and their sources, information overlap and transfer protocols are prerequisites to compiling circumpolar coverages for gap analysis. Details of potentially available land cover and target species datasets are summarised in Annexes 1 and 2, respectively. Within the limited time available, it was possible to utilise about 20 of these datasets for this preliminary analysis. A number of the datasets were already held by GRID-Arendal and WCMC, while additional datasets were located elsewhere and transferred to WCMC via the Internet.

From the available datasets, the following circumpolar coverages were compiled using WCMC's GIS:

- Distribution of major vegetation zones and protected areas (Map 1)
- National level of protection of major vegetation zones (Map 2)
- Distribution of polar bears and protected areas (Map 3)

3.2.1 Vegetation and land cover datasets

Schemes for classifying terrestrial vegetation have been devised at various scales, principally for mapping but also for statistical analyses, such as forest inventories or assessments. Some are exclusive classifications intended for use at local or national scales, while others are applied more widely at continental or global scales. From a biodiversity perspective, it is particularly important to be able to monitor changes in vegetation cover.

Clearly CAFF member countries have an interest in the development of a common land cover and land use classification system for conservation planning and monitoring purposes. The CAFF Circumpolar Vegetation Mapping Project will result in the development of such a scheme. A meeting to agree on a legend for this map is scheduled in early 1996. For global comparisons, it is also important to be able to link this into a global vegetation classification scheme. At an Expert Meeting convened by UNEP/FAO in Geneva in November 1993 it was agreed to move towards establishing such a scheme. A project to produce comparisons between different national and regional land cover and land use classification schemes is underway (Schomaker, 1994).

It is important to recognise that vegetation comprises gradients and mosaics at all scales, with no discrete boundaries. Therefore, there will always be compromises within any vegetation classification system. Furthermore, the scale at which a classification is developed will influence its usefulness for other purposes. Typically, ecoregions (Bailey, 1995), ecozones (Wiken, 1986) and wildlife habitats (Mirutenko and Kaitala, 1995), which represent a combination of ecological factors, are more powerful than single-index classification systems.

Given the present absence of the Circumpolar Arctic Vegetation Map, an attempt has been made to identify datasets of actual vegetation cover rather than potential vegetation or ecoregion (Annex 1). The best available map of vegetation or land cover was obtained for each country and the legend from each was harmonised into a common, circumpolar classification system. Most of the available datasets covered the whole of the respective countries rather than only the Arctic region. Hence, the level of detail available for the

Arctic is low, resulting in the adoption of a fairly small number of classes in order to achieve standardisation. The harmonised legend has only six terrestrial categories (Table 1). Due to time constraints, it was not possible to obtain digital copies of all of the potentially available national vegetation maps. Where they were missing, a preliminary classification was derived from the greenness index (NDVI). The following sections describe the data sources.

Canada

The digital 1:7.5 million Canadian Vegetation and Land Cover dataset, based on satellite imagery, was obtained for the purposes of this analysis (St-Laurent *et al.*, 1995). A total of ten classes are distinguished. *Tundra* was not divided into Mountain and Lowland Tundra; *Transitional Forest* and *Coniferous Forest* were combined into Northern Boreal; and *Mixed Forest* and *Deciduous Forest* were combined into Middle Boreal.

Greenland

No vegetation map was available for Greenland other than the floristic units shown in CAFF (1994). Hence, the NDVI dataset was divided into three reflectance categories to correspond with reference areas in Canada, Russia and Alaska showing Glacier and Arctic Desert (not differentiated), Tundra and Northern Boreal.

Iceland

Although a vegetation map of Iceland exists, it could not be obtained in time for this study. Thus, the NDVI dataset was divided into three reflectance categories to correspond with reference areas in Canada, Russia and Alaska, showing Glacier and Arctic Desert (not differentiated), Tundra and Middle Boreal. It is not clear whether the greenest of these classes should be equated to Northern or Middle Boreal. The latter was eventually chosen, following the recommendation of Tuhkanen (1984).

Russia

Digitisation of the 1:4 million scale vegetation map of Russia (REF, 1990) could not be completed in time for this analysis and so a 1:16 million scale zonation map (Kurnaev, 1990) was used. The nine categories distinguished for the Arctic region were harmonised as follows: *Arctic desert* was equated to Glacier and Arctic Desert; *Forest Tundra, Sparse Forest Taiga, Northern Taiga* and *Middle Taiga* were combined into Northern Boreal; and *Southern Taiga* was equated to Middle Boreal.

Scandinavian mainland (Finland, Norway and Sweden)

The vegetation map of Holten and Carey (1992) was used. The *Alpine Zone* was equated to Mountain Tundra. Glaciers and Arctic Deserts were differentiated on the basis of the NDVI dataset.

Svalbard (Norway)

The vegetation of Svalbard has been mapped at a scale of 1:1 million in the National Atlas of Norway but was not available in digital form in time for this analysis. Consequently, the NDVI dataset was divided into two reflectance categories to correspond with reference areas in Canada, Russia and Alaska showing Glacier and Arctic Desert (not differentiated), and Lowland Tundra.

Table 1 Harmonised vegetation classification used in this study and its relationship to national vegetation and land cover classification systems. Legends used in developing this classification are listed in Annex 3.

Harmonised legend	Canada (St Laurent *et al.*, 1995)	Finland (Holten and Carey, 1992)	Greenland/ Denmark (EROS, 1992)	Iceland (EROS, 1992)	Norway (Holten and Carey, 1992; EROS, 1992)	Russia (Kurnaev, 1990)	Sweden (Holten and Carey, 1992; EROS, 1992)	USA/Alaska (Bailey, 1995; Gerasimov, 1964)	Svalbard, Norway (EROS, 1992)
1 Permanent snow and ice	Perennial snow and ice	not applicable	Glacier	Glacier	Glacier	Arctic desert	Glacier	more information required	Glacier
2 Arctic desert	Barren lands	not applicable	(included in glacier)	no data	(included in glacier)		(included in glacier)	more information required	(included in glacier)
3 Mountain tundra	More information required	Alpine zone	Tundra	Mountain tundra	Alpine zone	Mountain tundra	Alpine zone	Mountain Arctic tundra	more information required
4 Lowland tundra	Tundra (not divided on map)	not applicable	not identified	More information required	not applicable	Lowland tundra	not applicable	Bering tundra	High Arctic
								Arctic tundra	Middle Arctic
5 Northern boreal	Transitional forest	Northern boreal	Northern boreal	not applicable	Northern boreal	Forest tundra	Northern boreal	Outside CAFF boundary	not applicable
						Sparse forest taiga			
	Coniferous forest					Northern taiga			
						Middle taiga			
6 Middle boreal	Mixed forest	Middle boreal	not applicable	Oceanic middle boreal	Oceanic middle boreal	Southern taiga	Middle boreal	not applicable	not applicable
	Deciduous forest								
7 Marine									

USA (Alaska)
Although a prototype GIS environmental database has been compiled for Alaska (U.S. Geological Survey, 1994), this project has now ceased and the data could not be located. Instead, the ecoregions of Bailey (1995) were used. Glacier and Arctic Desert were not shown. *Bering Tundra* and *Arctic Tundra* were combined into Lowland Tundra.

3.2.2 Species datasets

Four types of record may be used to map species distributions:

- point records,
- grid-based occurrence records,
- hybrid point record and range maps, and
- range maps (Scott *et al.*, 1993).

Maps based on all of the above methods were identified, with the exception of grid-based maps. Of the species datasets identified in Annex 3, the polar bear distribution map was the most readily available for this preliminary analysis.

A number of additional datasets were originally identified for inclusion in the analysis, but were not available within the timeframe. These include:

- whale sightings from the International Whaling Commission;
- seabird colonies from the Circumpolar Seabird Working Group, including colonial seabirds from the Canadian Wildlife Service; and
- threatened plants from the Rare, Endemic Vascular Plants Project.

3.2.3 Wilderness index

A wilderness map has been produced by GRID-Arendal for the Barents Region, comprising northern parts of Norway, Sweden, Finland and European Russia. Wilderness is defined as contiguous areas greater than 4000 sq. km and more than 6 km from roads, railways, power lines and other human installations. This definition is similar to that used by the Sierra Club *et al.* (n.d.) but the latter use 5 km as the criterion.

Although it was originally planned to use a wilderness index for the circumpolar Arctic in this analysis, computing time has been excessive. Currently only Europe is complete, but GRID-Arendal is now generating the index for North American and Asia.

3.2.4 Protected areas

Spatial data were derived from WCMC's Biodiversity Map Library and from previously compiled material (CAFF, 1994). The analysis was restricted to protected areas larger than 1,000 ha and assigned to IUCN Categories I-V, which are defined in Annex 4. It should be noted that the old 1978 categories system has been used because protected areas have not yet been classified according to the new system. A significant constraint is that the locations and boundaries of some protected areas are not known. Thus, estimates of protected area coverages are conservative. In the case of Russia, the analysis is limited to IUCN Categories I and II (i.e. national parks and zapovedniks) since data on zakazniks (IUCN Category IV) were not available.

3.3 Priority setting

The preliminary GIS analysis of gaps in CPAN was carried out using the overlay functions of ARC/INFO (Version 7). The harmonised vegetation classification and protected areas coverages were superimposed to generate statistics on the level of protection of each vegetation zone.

In order to identify priorities for conservation action, the percentage of a vegetation zone within a country (or region) was plotted against the level of its protection within that country (or region). The plot is divided into four quadrants, each with the conservation implications shown in Figure 1. The arrow indicates the direction of increasing priority for conservation action. For example, a data point, labelled with the appropriate country name, in the bottom right of a plot indicates that most of the zone lies within that country where little of it is protected.

Throughout this preliminary analysis, protection is considered adequate if at least 15% of a zone lies within protected areas (Categories I-V). This threshold is based on the CPAN Strategy and Action Plan (Section 2.2).

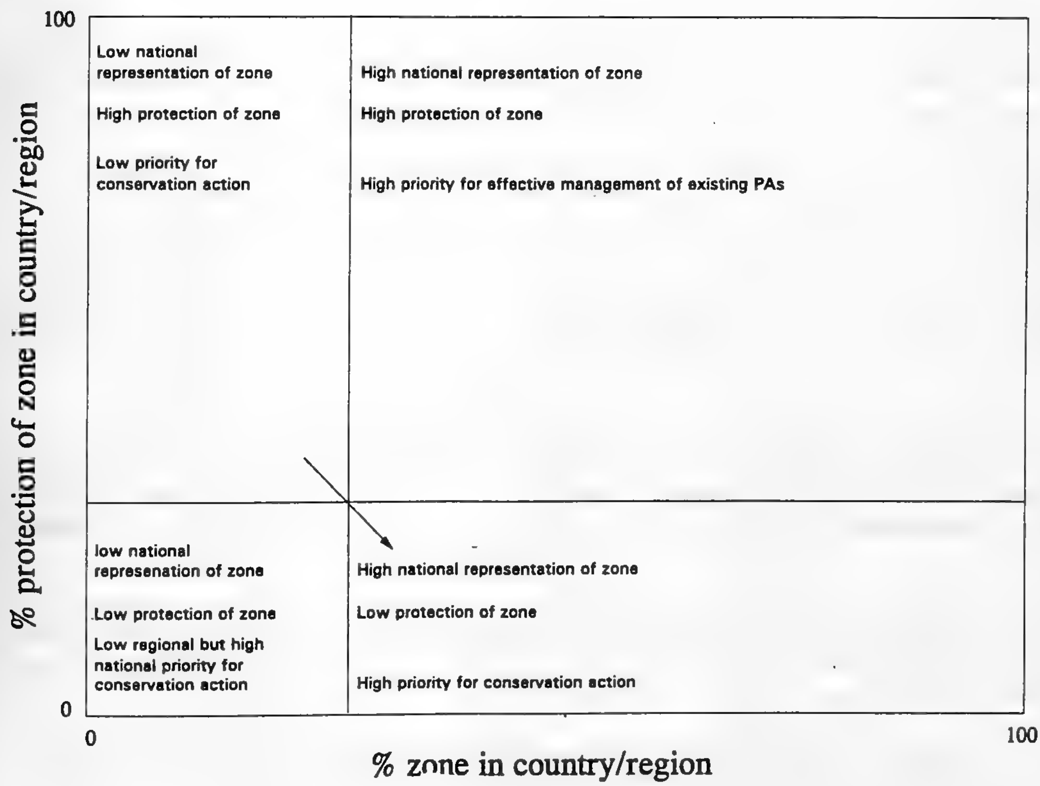

Figure 1 Definitions of quadrants used to identify priorities for conservation action

4. RESULTS

4.1 Vegetation

The extent to which the major vegetation zones are protected is summarised in Table 2 and Map 1. In total, 13.2% of the circumpolar Arctic is protected in accordance with IUCN Categories I-V. Highest protection is afforded to Arctic Desert and Tundra, and least to Northern Boreal and inshore waters. In the case of Northern Boreal and Middle Boreal, it should be noted that the results are somewhat artificial, reflecting the position of the CAFF boundary. Boreal zones do not occur in Alaska, and Middle Boreal is only marginally present in any of the countries. Boreal vegetation is much more extensive outside the CAFF region, where a significant proportion of it is protected. Thus, this analysis does not indicate the overall global extent of protection of these two zones. It should also be noted that all vegetation types could not be differentiated for all Arctic countries. For example, Arctic Desert could not be distinguished in Alaska.

Table 2 Degree of protection of major vegetation zones in the circumpolar Arctic

Vegetation zone	Total area sq. km	Protected area	
		sq. km	%
1 Arctic Desert	4,098,591	1,125,335.11	27.5
2 Mountain Tundra	1,604,735	214,038.12	13.3
3 Lowland Tundra	2,942,559	360,540.96	12.3
4 Northern Boreal	4,830,572	125,170.47	2.6
5 Middle Boreal	439,332	31,829.12	7.2
6 Inshore Waters	189,268	3,924.18	2.1
7 Unclassified lands	9,160	747.34	8.2
Total	14,114,217	1,861,585.30	13.2

The level of protection of vegetation zones within each country is shown in Table 3 and Map 2. Most countries or regions (as in the case of Scandinavia) have at least 20% of their circumpolar Arctic protected, notable exceptions being Canada (6.5%) and Russia (3.6%). Protected areas coverage is highest in Svalbard, Norway (64.8%) and Greenland, Denmark (40.9%).

On the basis of data presented in Table 3, national priorities for conservation action are shown in Figure 2 with respect to each of the major vegetation zones. These can be summarised as follows:

- **Arctic Desert** Over 90% is distributed almost equally between Canada, where protection is afforded to only 7.5%, and Greenland (Denmark), where much of it lies within Greenland National Park, the world's largest protected area.

- **Mountain Tundra** Nearly 70% occurs within Russia, very little of which is protected within national parks and zapovedniks (nature reserves).

Table 3 Distribution of major vegetation zones and their level of protection within circumpolar Arctic countries. Marine protected areas are excluded from this analysis.

Country	Vegetation zone	Area sq. km	Protected area	
			sq. km	%
Alaska	Mountain Tundra	237,024	166,509.38	70.2
	Lowland Tundra	373,974	139,093.63	37.1
	Unclassified	54	2.00	3.7
	Total	611,052	305,605.01	50.0
Canada	Arctic Desert	1,780,966	133,834.08	7.5
	Lowland Tundra	1,281,162	119,039.93	9.2
	Northern Boreal	1,902,196	75,543.55	3.9
	Middle Boreal	268,321	21,776.18	8.1
	Water	189,268	3,924.18	2.0
	Unclassified	3,266	0.00	0.0
	Total	5,425,179	354,118.48	6.5
Denmark/ Greenland	Arctic Desert	1,964,235	874,530.12	44.5
	Mountain Tundra	167,853	738.52	0.4
	Northern Boreal	6,721	0.00	0.0
	Total	2,138,809	875,268.64	40.9
Iceland	Arctic Desert	12,187	3,055.78	25.0
	Mountain Tundra	31,413	10,357.24	32.9
	Middle Boreal	58,017	9,569.11	16.4
	Unclassified	346	47.78	13.8
	Total	101,963	23,029.91	22.5
Russia	Arctic Desert	285,019	69,329.10	24.3
	Mountain Tundra	1,080,327	18,493.44	1.7
	Lowland Tundra	1,256,791	91,084.45	7.2
	Northern Boreal	2,755,438	16,451.46	0.6
	Mountain Boreal	86,687	0.00	0.0
	Unclassified	5,440	697.56	12.8
	Total	5,469,702	196,056.01	3.5
Scandinavian mainland (includes Norway, Sweden and Finland)	Arctic Desert	1,310	537.94	41.0
	Mountain Tundra	88,118	17,939.54	20.3
	Northern Boreal	166,217	33,175.46	19.9
	Middle Boreal	26,307	483.27	1.8
	Unclassified	54	0.00	0.0
	Total	282,006	52,136.21	18.4
Svalbard	Arctic Desert	54,874	44,048.09	80.2
	Lowland Tundra	30,632	11,322.95	36.9
	Total	85,506	55,371.04	64.7
Grand total		14,114,217	1,861,585.30	13.1

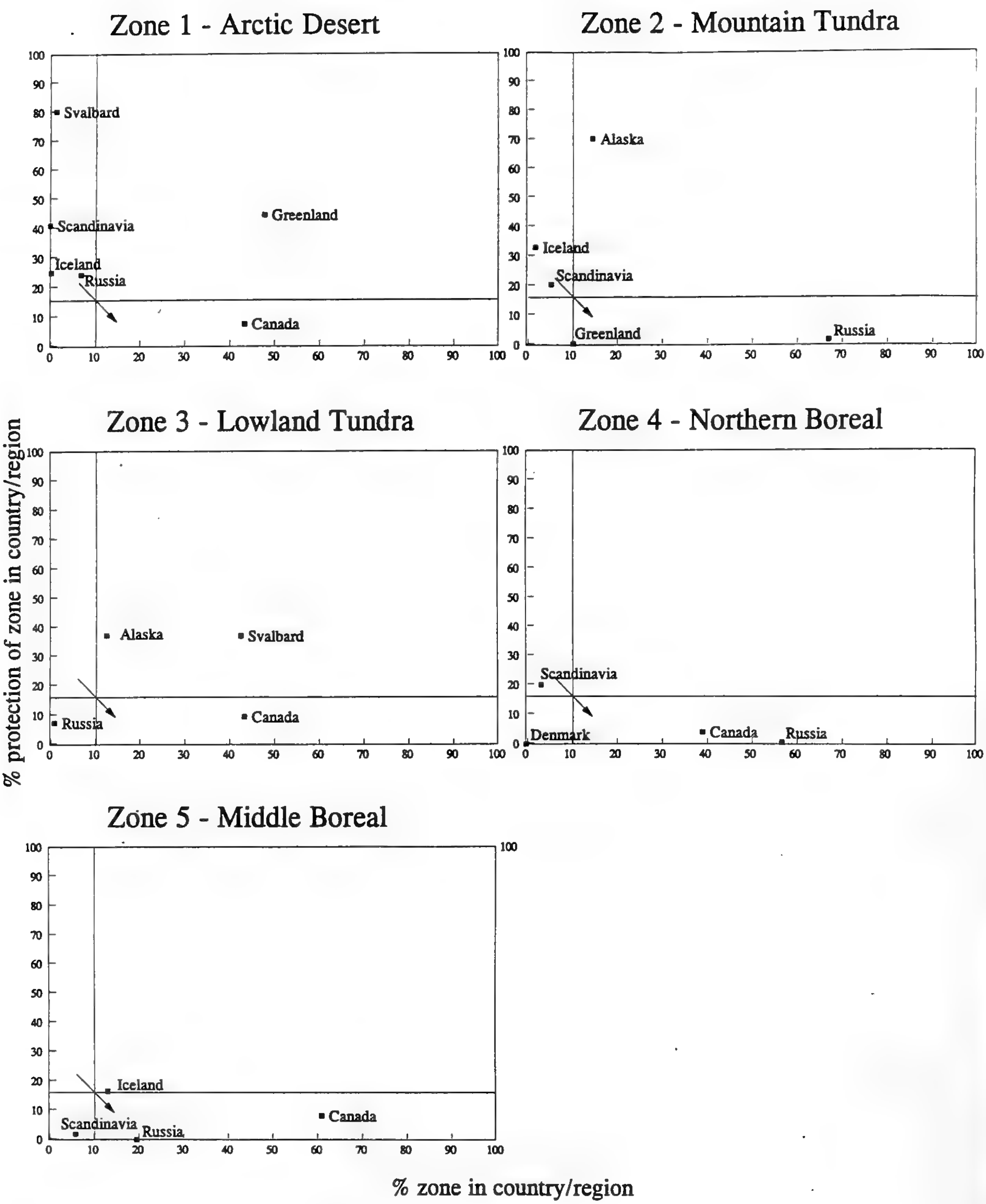

Figure 2 National priorities for conservation action, prioritised according to the extent of major vegetation zones and their protection within each country. The direction of the arrow indicates increasing priority for national conservation action.

- **Lowland Tundra** Over 85% lies within Canada, where only 9.3% is protected, and Svalbard (Norway) where representation within protected areas is adequate (37%).

- **Northern Boreal and Middle Boreal** As discussed above, Boreal vegetation is more extensive beyond the CAFF boundary, where a significant amount is protected. Within the CAFF region, it occurs mostly in Canada and Russia where representation within protected areas is low. In the case of Northern Boreal, which comprises 34% of the vegetation in the CAFF region (Table 2), there is a high priority to increase its representation within protected areas.

Further analyses, based on more refined classifications, are required to identify gaps in habitat protection more precisely, as shown in the example for forests in the former USSR (Table 4). This particular example is for illustrative purposes only as it treats the former USSR in isolation from the rest of the CAFF region.

Table 4 Extent of protection of forests in the former USSR

No.	Vegetation zone	Total area sq. km	Protected area*	
			sq. km	%
1	Lowland Tundra	14077	0	0.0
2	Mountain Tundra	12294	3412	27.7
3	Forest Tundra	28105	121	0.4
4	Meadows and Sparse Forest/Meadows	7184	326	4.5
5	Sparse Taiga	21973	0	0.0
6	Northern Taiga	219171	15687	7.2
7	Middle Taiga	448376	5269	1.2
8	Southern Taiga	261076	3235	1.2
9	Mixed Forest, Coniferous Dominated	124060	2680	2.2
10	Mixed Forest, Broadleaves and Coniferous Equal	187183	4320	2.3
11	Broadleaf Forest, Northern subzone Monodominant Forests	171536	3360	2.0
12	Broadleaf Forest, Southern Polydominant Thermophilic Forest	4988	1563	31.3
13	Forest, Steppe	65514	1356	2.1
14	Steppe, Northern Subzone	1964	220	1.1
15	Steppe, Southern Subzone	1190	2	0.2
16	Northern Semidesert	725	20	2.8
17	Southern Semidesert	293	0	0.0
18	Northern Desert	19400	0	0.0

* IUCN Categories I and II only

4.2 Fauna

The estimated range and known breeding sites of the polar bear *Ursus maritimus* is shown in Map 3 with protected areas overlaid to illustrate how gap analysis can be applied to individual species. This particular example shows that some polar bear breeding sites lie within protected areas, but very little of the species' core range is protected.

4.3 Constraints

A number of constraints have been identified as a result of this preliminary exercise on gap analysis. They are as follows:

- It is often a challenge to acquire data from government sources, particularly for regions where there is provincial (or state) and federal jurisdictional overlap.

- Data ownership and copyright restriction issues, which vary from country to country, may need to be negotiated.

- Compiling a circumpolar vegetation map from a variety of national sources that use different classification systems can be overcome using technical applications, site knowledge and interpretation. However, it should be recognised that some 'smoothing' of the data is required. Areas of particular concern include the boundaries between adjacent datasets which, in the case of CAFF, often coincide with national boundaries.

  Future gap analysis should benefit from the new vegetation map being compiled under the CAFF programme.

- The limitations of gap analysis should be realised, particularly if data originate from a variety of sources and have been interpreted differently. It should also be recognised that such generalised data do not reflect habitat quality. Gap analyses should be complemented by ground-truthing.

- St Laurent *et al.* (1995) suggest that further consideration should be given to the interpretation of land cover classes in the case of the Canadian data. The Canadian land cover classes were selected after careful consideration of the image analysis and classification challenges inherent in mapping such a diverse and spatially extensive area. For example, it was not feasible to differentiate wetland areas. In addition, vegetation zonation in the Arctic is poorly represented, with the result that areas dominated by low erect shrubs, dwarf and prostrate shrubs, and by herbs appear in the same class. Moreover, reflectance values were not sufficiently distinct to differentiate barren land from sparse vegetation, with woody plants, herbs and non-vascular plants (lichens and mosses). Further refinement of classification techniques will improve the product.

5. RECOMMENDATIONS

This study is a preliminary attempt to evaluate CPAN from a regional perspective. While it provides an overall picture of conservation status of the circumpolar Arctic, it is necessarily crude due to limitations in data availability, time and resources. However, it demonstrates the value of gap analysis and the need to carry out more detailed and elaborate evaluations as more datasets become available.

In line with priorities identified in the CAFF Annual Work Plan for 1995-1996, it is recommended that additional gap analysis be undertaken, focusing particularly on using the wilderness index and distribution data for key plant and animal species. Use should also be made of the new vegetation map being compiled for the circumpolar Arctic once it becomes available, but this is unlikely to be in 1996.

Other initiatives include the following:

- Support the development and use of classification systems such as ecoregions (Bailey, 1995), ecozones (Wiken, 1986) and Russian landscapes (Kurnaev, 1990) that combine a number of variables (e.g. geology, climate and vegetation). Promote their application in land use planning and management.

- Expand and update Annexes 1 and 2. Include comments on quality and additional sources, with a view to creating a meta-database of resources that would support further gap analysis work.

- Identify ways and means of repatriating enhanced datasets to those who provided them, as well as to CAFF members. Make datasets readily available to third parties via the Internet.

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ANNEX 1 Preliminary list of ecological spatial datasets for the circumpolar Arctic, their sources and scales

Country	Vegetation		Ecoregions		Wetlands		Soil		River Basins		Wilderness Index		Protected Areas		Greenness Index	
	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital
Canada		(DOE and DNR 1995) 1:7.5 M	(DOE and DNR 1995) 1:7.5 M	(DOE and DNR 1995) 1:7.5 M	(DOE 1995) 1:7.5 M	• (ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-A 1995) (GRID-SF 1995)			(Parks Canada 1992) 1:1 M	(WCMC 1995) 1:1 M (SOE, 1995) 1:1		(EROS, 1992)
Finland		• (GRID-A and ESRI 1993) Barents Region 1:1 M • (1997) Finnish Forest				(ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
Greenland/ Denmark	(Berthelsen *et al.* 1990) various scales	(ESRI 1993) 1:1 M				(ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
Iceland		(GRID-A 1995)				(ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
Norway		• (Edin, U. *et al.*, 1995) 1km pixel • (ESA 1995) 1km pixel				(ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)		(GRID-A 1995) www data		(WCMC 1995) 1:1 M		(EROS, 1992)
Russia	• (Kurnaev, 1990) 1:20 M (Gribova and Karamysheva, 1990) 1:4 M	(Lysenko 1995) 1:4 M		(Kurnaev 1990) 1:4 M		• (ESRI 1993) 1:1 M • (WCMC BML 1995) Nature Protection Map 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
Sweden		(Edin, U. *et al.*, 1995) 1km pixel				(ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
United States			(Bailey, 1995)	(Bailey, 1995)		Bailey, 1995 1:250,000 and (ESRI 1993) 1:1 M		(GRID-A 1995) (FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)
Arctic	• (Gerasimov, 1964) various scales • (Yurtsev, 1994) no scale	(GRID-A 1995) Permafrost 1:1 M	Bailey, 1995			(ESRI 1993) 1:1 M Important Bird Areas (IBAs)		(FAO, 1994)		(GRID-SF 1995)				(WCMC 1995) 1:1 M		(EROS, 1992)

Underlined datasets were not included in this preliminary analysis.

ANNEX 2 Preliminary list of spatial datasets for circumpolar Arctic species, their sources and scales

Country	Polar bears		Whales		Walrus/Seals		Caribou		Seabirds	
	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital	Paper	Digital
Canada	(Parks Canada, 1994) no scale	(SOE, 1995)		(IWC, 1995) (SOE, 1995)	(Parks Canada 1994) no scale	(SOE, 1995)[1]	(CWS, 1995)	(CWS, 1995)	(CWS, 1995)	(CWS, 1995)
Finland				not applicable		not applicable			not applicable	
Greenland/ Denmark				(IWC, 1995)					(Weslawski 1995)	(Weslawski 1995) Barents Sea and Greenland
Iceland				(IWC, 1995)						
Norway				(IWC, 1995)					(Norwegian Polar Institute, 1994)	(Norwegian Polar Institute, 1994)
Russia	• (Weslawski 1993) Franz Joseph Land • (Matishow 1995) Novaya Zemyla 1:2 M			(IWC, 1995)	• (Matishow 1995) Novaya Zemlya 1:2 M • (Weslawski 1995) Jamal Peninsula	(Weslawski and Malinga 1993) Franz Joseph Land	(Matishow 1995) Novaya Zemlya 1:2 M	(Matishow 1995) 1:2 M Novaya Zemlya	• (Weslawski & Malinga, 1993) Franz Joseph Land 1:2 M • (Matishow, 1995) Novaya Zemlya Region 1:2 M • (Weslawski et al., 1994) • (Norwegian Polar Institute, 1994) incls. Russia and Svalbard	
Sweden				(IWC, 1995)	not applicable	not applicable			not applicable	
United States	(USDA 1993) 1:7.5 M	(USDA, 1993) 1:7.5 M		(IWC, 1995)						
Arctic	(Atlas Arktiki) various scales			(IWC, 1995) and (Weslawski, 1995)					• (Norwegian Polar Institute, 1994) European Arctic seabird colonies	• (Weslawski 1995) Barents Sea and Greenland

Underlined datasets were not included in this preliminary analysis.

[1] Ringed seal, bearded seal, harbour seal, harp seal, and hooded seal.

ANNEX 3 Legends used to compile a harmonised vegetation map for the CAFF region

ALASKA (UNITED STATES OF AMERICA)

Domain	Division	Lowland Ecoregions		Highland ecoregions	
		Province	Section	Province	Section
1000 Polar	1200 Tundra	1210 Arctic Tundra		M1210 Brooks Range	
		1220 Bering Tundra			
	1300 Subarctic	1310 Yukon Parkland		M1310 Alaska Range	
		1320 Yukon Forest			

(Bailey, 1995)

ALASKA (UNITED STATES OF AMERICA)

100	**Polar Domains**
120	**Tundra Division**
124	Arctic Tundra Province
125	Bering Tundra (Northern) Province
126	Bering Tundra (Southern) Province
M120	**Tundra Regime Mountains**
M121	Brooks Range Tundra - Polar Desert Province
M125	Seward Peninsula Tundra - Meadow Province
M126	Ahklun Mountains Tundra - Meadow Province
M127	Aleutian Oceanic Meadow - Heath Province
130	**Subarctic Division**
131	Yukon Intermontane Plateaus Tayga Province
135	Coastal Trough Humid Tayga Province
139	Upper Yukon Tayga Province
M130	**Subarctic Regime Mountains**
M131	Yukon Intermontane Plateaus Tayga - Meadow Province
M135	Alaska Range Humid Tayga - Tundra - Meadow Province
M139	Upper Yukon Tayga - Meadow Province

(Bailey, 1995)

CANADA

Field Code	Description	Number of Polygons	
		Veg_East	Veg_West
1	Mixed forest	514	911
2	Deciduous forest	256	378
3	Water	351	665
4	Transitional forest	228	137
5	Coniferous forest	565	597
6	Tundra	78	994
7	Barren land	102	1051
8	Permanent ice or snow	0	204
9	Agriculture - cropland	71	100
10	Agriculture - rangelands	0	133
11	Built-up area	55	1

(St Laurent *et al.*, 1995)

FOREST LAND CLASSES

Forest land	Land on which trees are the dominant vegetative cover with tree crown cover of 10% or more. Includes land where trees are stunted owing to site limitations, undetectable owing disturbance, or temporarily absent.
Continuous forest	Land cover type where forest land occupies more than 50% of the area.

TREE COVER

Coniferous forest	Continuous forest in which 76-100% of the canopy is composed of coniferous trees.
Broadleaf forest	Continuous forest in which 76-100% of the canopy is composed of broadleaf (deciduous) trees.
Mixed forest	Continuous forest in which 26-75% of the canopy is composed of coniferous and broadleaf trees.

TREE/SHRUB/HERB/NONVASCULAR

Transitional forest	A mixture of land cover classes where tree cover is discernible but forest land occupies less than 50% of the area.

SHRUB/HERB/NONVASCULAR*

Tundra	Low arctic or alpine vegetation with discernible cover. Although generally located beyond the tree line, low woody plants (ericaceous shrubs, willows, etc.) and patches of stunted trees may occur.

AGRICULTURAL LAND CLASSES

CROPS

Cropland	Cultivated land with crops, fallow, feedlots, orchards, vineyards nurseries, shelter belts and hedgerows.

NON-CULTIVATED (SHRUB/HERB)

Rangelands and pasture	Land supporting native vegetation, shrubs, grass and other herbaceous cover with less than 10% tree cover. Includes improved land dedicated to the production of forage, and upland and lowland meadows.

NON-VEGETATED LAND CLASSES

Perennial Snow or Ice	Perennial snow fields and glaciers.
Barren Land	Land without discernible vegetation cover. May include sand, rock, bare soil and open pit mines.
Built-up area	Cities and towns of sufficient size to be depicted at the scale of mapping.

NON-LAND CLASSES

Open water

Sea-ice Minimum Cover

Nonvascular — Plants lacking an internal vascular system (e.g.mosses, lichens).

GREENLAND/DENMARK

	Description
1	Glacier
2	High Arctic
3	Dry low Arctic
4	Humid low Arctic
5	Northern Boreal Zone

(CAFF, 1993)

SCANDINAVIA

	Description
1	Alpine zone
2	Northern boreal zone
3	Mixed southern, middle and northern boreal subzones
4	Middle boreal subzone
5	Oceanic middle boreal subzone
6	Southern boreal subzone
7	Hemiboreal zone
8	Hemiboreal zone
9	Temperate zone

(Holten and Carey, 1992)

SCANDINAVIA

	Description
1	Background
2	Forest
3	Open land
4	Urban
5	Open waterbodies
6	Glacier
7	Unknown land type

(EROS, 1992)

SOVIET UNION, FORMER

	Description
1	Arctic desert
2	(a) Lowland tundra
	(b) Mountain tundra
3	Forest tundra
4	Meadow and sparse forest
5	Coniferous forest
6	Sparse forest taiga
7	Northern taiga
8	Central taiga
9	Southern taiga

(Kurnaev, 1990)

ANNEX 4 Categories and management objectives of protected areas (after IUCN, 1978)*

I. *Scientific Reserves/Strict Nature Reserve.* To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.

II. *National Park.* To protect natural and scenic areas of national or international significance for scientific, educational, and recreational use.

III. *Natural Monument/Natural Landmark.* To protect and preserve nationally significant natural features because of their special interest or unique characteristics.

IV. *Managed Nature Reserve/Wildlife Sanctuary.* To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment where these require specific human manipulation for their perpetration.

V. *Protected Landscapes.* To maintain nationally significant natural landscapes which are characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal life style and economic activity of these areas.

VI. *Resource Reserve.* To protect the natural resources of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning.

VII. *Natural Biotic Area/Anthropological Reserve.* To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology.

VIII. *Multiple-Use Management Area/Managed Resource Area.* To provide for the sustained production of water, timber, wildlife, pasture, and outdoor recreation, with the conservation of nature primarily orientated to the support of economic activities (although specific zones may also be designated within these areas to achieve specific conservation objectives).

IX. *Biosphere Reserve.* To conserve for present and future use the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends. These are internationally designated sites managed for research, education and training.

X. *World Heritage Site.* To protect the natural features for which the area is considered to be of outstanding universal significance. This is a select list of the world's unique natural and cultural sites nominated by countries that are Party to the World Heritage Convention.

* IUCN has introduced a new system of management categories (IUCN, 1994).