RATIONALISATION OF THE PROTECTED AREAS SYSTEM OF HONDURAS

VOLUME VI: MANUAL MICOSYS, APPLICATION HONDURAS

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TABLE OF CONTENTS

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1. THE PROGRAMME

1.1. MICOSYS, A COMPUTER AIDED WEIGHTING TOOL

An important task of planners is to regulate land-uses to meet certain objectives, so that the results differ from those expected from spontaneous development. This usually comes with certain requirements or limitations as compared to unregulated use, and consequently it has an impact, particularly on local communities. In the case of conservation lands, conversion of natural habitat into productive land is usually prohibited, as well as non-regulated hunting and gathering. Once established, in the case of un-altered nature (as opposed to European ancient farming based systems) very little management of the land is required. Nevertheless, they cannot be left unattended, as they need continuous attention, such as public relations care, monitoring and patrolling, activities, which require equipment, buildings and staff. Each additional hectare involves additional costs. Such costs are not for a fixed period of time. Conservation does not make sense, unless it is targeted to prevent nature and species from being lost forever and therefore conservation involves an infinite time horizon.

Thus, by setting aside land, a society enforces certain limitations on local communities and assumes a long-term financial commitment to meet with the management requirements.

Once conservation lands have been designated, policy makers and managers have to make choices, such as, where to finance what activities, which areas need more attention, what locations can be used by the public and which areas should never be damaged as result of economic objectives. It is the job and responsibility of policy makers and managers to make such choices on the basis of factors of very different natures. They need to weight the importance of many different parameters, and usually management decisions are taken intuitively. As the numbers of variables grow, mental objectivity becomes increasingly more difficult. For complex multifactor planning, decision makers may benefit from a computer programme to help them in dealing with multiple variables in a consistent way.

The MICOSYS programme has been designed by Ir. Daan Vreugdenhil of the World Institute for Conservation and Environment to compare areas on the basis of scores for biological, socio-economical and cultural variables. Its acronym stands for "Minimum Conservation System" and its objective is to help in the identification of the minimally required protected areas for the durable conservation of the vast majority of species in a given country or region. Once identified a minimum conservation system, it can help design different alternative models with higher levels of conservation security. It can be used for integral prioritisation of protected areas for the purpose of delaring new lands or for management and financing purposes, or for partial tasks like: presence/gap analysis of ecosystem and/or species representation in protected areas systems; cost estimates and budgeting analysis; Monitoring & Evaluation exercises to evaluate management success or failure.

The programme was originally conceived in 1992 (Vreugdenhil, 1992), in the context of a World Bank forestry formulation programme for Costa Rica. It was developed as a simple and transparent programme in a "Lotus-123" spreadsheet for presence/gap analysis of protected areas, using the basic FAO protected areas selection and categorisation criteria for Latin America. The programme has evolved and matured through its application in many other World Bank and UNDP project formulation assignments.

The kind of data that are entered into MICOSYS nowadays are often managed in Geographical Information Systems, and it is possible to develop a programme linked to a GIS, such as the programme "SITES"1 developed for The Nature Conservancy (TNC) by the University of California in Santa Barbara, (Secaira, et al. 2001). WICE has the philosophy that a planning tool has to be user-friendly and transparent so that any regular PC user would be able to work with it. The principle of using a simple spreadsheet as the basis for MICOSYS has never been abandoned, as most scientists, planners and managers are familiar with the use of spreadsheet programmes but not with GIS programmes. In 1996 the programme as converted into the most flexible spreadsheet at the time, Quattro Pro and it now continues tooperates in Quattro Pro of the Corel 2000 Office Suite. Being a spreadsheet based programme, it is extremely flexible and can simply add columns with variables and rows with automatic calculations according to the specific needs of the country or task of its application. Arcview GIS has become an increasingly important, for the management of georeferenced data, prior to entry into MICOSYS, particularly for the calculation of ecosystems size and for defining the geographic location of species of special interest.

[1] "SITES" is a MS-DOS programme interfaced with ARCView. This has as an advantage that the results can be visualised in ARCView maps. However, the downside is that only very experienced GIS specialists with access to a ArcView/ArcInfo laboratory can operate the programme. Government officials and stakeholders alike, who lack such skills must sit back and watch how a non-professional in conservation planning handles the data that they should be manipulating and sorting themselves. Furthermore it should be noted that SITES is a model based on complex mathematic models that may make sense to mathematicians, but not to the ordinary conservationist. Therefore it calculates evaluation scores that cannot be fully understood by the user. Lastly it seems to lack a comprehensive financial costs tool, which is paramount in a conservation design tool.

1.2. EVALUATION PARAMETERS

The comparative weighting takes place on the basis of a selection of ecological, taxonomical and socio-economical variables. Each variable can be assigned a value or algorithm on the basis of a professional judgement; thus, each value by its very nature is subjective. But once established, the processing of each parameter is carried out mathematically and performed identically for each variable and each area. As the parameters become numbers, the MICOSYS facilitates the paradoxical exercise of "adding apples and oranges". In the end it comes up with a numerical score for each evaluated area, which has come about by a consistent computing method. Such scores allow relative comparisons between the different areas. Of course those values are indicative and should not be used in an absolute sense. The values should ideally be assigned by a panel of scientists and conservation planners and be subject to reiterative testing.

A protected area is defined by IUCN (1993) as " an area of land or water especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means." Although the primacy of biodiversity and natural heritage values in ascribing protected area status is preeminent, many protected areas also serve to provide environmental services, notably tourism, recreation, production of drinking water, research and education. Where appropriate, the programme assigns the potential of the most common services a value. For specific cases, additional value may simply be added by adding a value column, thus allowing great flexibility to design an evaluation process to optimally suit the specifics of each individual case.

Obviously, not all purposes can be served in a biodiversity conservation system and one must determine what is desired. Although MICOSYS allows the application for much broader concepts than biodiversity conservation only, its primary design has been focussed on the development and evaluation of *in situ* biodiversity conservation systems. The system starts with a number of management areas already existing in the country or region of analysis, going on to identify the gaps in conservation cover which would need to be closed, to provide an efficient conservation system. MICROSYS though capable of defining the nature of these gaps, it cannot define their exact geographic location.

The system does require however the availability of an ecosystems or natural vegetation cover map – preferably in a GIS format to calculate polygon sizes - with sufficient level of detail to distinguish between essential sets of species. Also, there must be an accurate digitized map of the protected areas system. In order to calculate which ecosystems are protected in the system, how often, where and how much in each area, the polygon parts of the ecosystems and protected areas must be combined. Similar actions may be performed for inhabitated areas, and utilized watersheds.

On the basis of such map, MICOSYS can analyze which areas are indispensable for nature conservation purposes and where biodiversity conservation management objectives must prevail. In those areas non-consumptive environmental services are possible, but those must always be subject to limitations set by the primary objective of the area, which is biodiversity conservation.

2. DESIGN

2.1. STRUCTURE

The programme has been organised into seven main Sheets:

A General data / Datos generales;
B Costs per area / Costos por área
C Costs of the system / Costos del sistema
D Quantification of caracteristics / Cuantificación de característicos;
E Sizes of Ecosystems per area in ha / Tamaños de los Ecosistemas por Area en ha
F Ecosystem scoring per area / Valoración de ecosistemas por Area
G Scoring of species of special concern / Valoración de especies de preoccupación especial

2.2. SHEET A, TABLE I: GENERAL DATA

Table 1 presents a quick overview of important management information:

Areas by category / Areas por Categoría
This column is repeated in each of the tables through cell reference. It only needs to be entered in Sheet A.

Total size / Superficie total
The total size of the area is used in formulas for the calculation of scoring and for cost estimates. Sizes are usually acquired from GIS data.

Ecosystems / Ecosystemas
The combined size of the (semi-) natural ecosystems within the protected area is calculated and must not be entered. This column is informative and is not used in evaluation calculations, as other – more detailed information is used for that purpose.

Productive lands / Tierras agro-pecuarias
Lands primarily under productive use – agriculture, grazing, plantation forestry, food plantations, shrimp farms, mines, etc.) are generated as the difference between the total land size of the area and the combined ecosystem size. No data area entered.

Used watershed / Cuenca provechada
All land is part of one watershed or the other, and giving a value to all analyzed areas would merely lead to the repetion of the validation of the total land size. Therefore only those parts of watershed are taken into consideration, that are actually used to produce water for drinking water or hydroelectrical purposes. Sizes must be calculated as the watersheds above the intake points.

Private property / Propriedad privada
Land belonging to non-conservation landowners – pose severe management limitations to the managing administration. Legally it is possible to pose limitations on land use of privately owned lands, but in practice this is a difficult and delicate matter, and it is probably desirable to eventually buy out lands within the core areas of the conservation system. Data on private property are entered from field studies. If data are not available this column may be hidden.

Value of private lands / Valor de tierras privadas
The monetary values of the land are calculated on the basis of a nation – wide average, using a reference to a factor entered in sheet C, Table V: Basic Data. The column calculates automatically, but the calculation may be adapted for individual areas by replacing the cell reference by a region specific value or by entering the total land value in the cell if known.

Inhabitants / Habitantes
Habitation in protected areas renders a conservation programme much more difficult. Habitants require active attention by the management authority, and in many cases they require programmes of special assistance and cooperation, extra consultation and co-management procedures, etc., which adds to the management costs and staff requirements. This factor requires some experimenting, depending on the conditions of the country. In Costa Rica and Belize, where very few people inhabited the legally declared national parks and reserves a formula of 1 point per 100 inhabitants worked. In Honduras, where sometimes up to several thousands of inhabitants are included in the area that does not work, as most areas would get negative values. In such case a curved evaluation is needed. One may experiment with a formula CELL"area"^CELL"reference" and allow the reference to vary from 0.2 to 0.6. and see how that influences the overall evaluation. Default the programme for more fine tuning one may also try to vary the alternatives by dividing them by two. What is important however, is to recognise that we merely consider the actual land-using population. If a regular town is included, the impact of the inhabitants on the area is far less and may actually be discarded.

Current staff / Personal actual
Information is entered on the basis of information provided by the management administration. This column is informative and may be compared with the next column.

Personal requerido/Required staff

Management activities are particularly related to external factors, reason to calculate the number of required staff as a square root fraction of the landsize. The number of staff actually needed must be further reduced by dividing the outcome by the "national management factor" in Table V: Basic Data. The latter is a factor that is established by a national team of experts, taking into consideration the experiences of other countries and some national areas of known management requirements. This may require some experimenting with different factors until the evaluation team feels that the staffing requirements appear to be a realistic for some of the better known areas. The programme assumes average conditions and is likely to be more accurate for the system as a whole than for each individual area. It does not take into consideration factors as locally different levels of land pressure, differences in length of the periphery, etc.

Inclusion of productive land and inhabitants in protected areas significantly increases the required interfacing with the local population, in programmes to establish a level of acceptability, promote adaptive land-use practices as well as law enforcement. This may require higher densities of staff and thus higher management costs. MICOSYS does not estimate such increased factors as they may vary strongly from one area to the next. The total national staffing density factor should take such effects into consideration on a national level.

Ranger stations / Estaciones de guardaparques

Under most circumstances, field management activities can best be undertaken from ranger stations and the programme calculates the needs a 1 unit per 4 staff, which is generated from a factor in Table V. It assumes that each field station should be staffed with a minimum of 2 rangers and to reach a full time occupation one needs an average of 2 alternating teams. It is common practice to run staff on a "2-weeks-on – two-weeks-off" schedule. For different management traditions, this factor may be adapted in Table V. Under such schedule each station would be operated by 2 pairs of rangers.

Vehicles / Vehiculos

Transportation needs are estimated at 1 major unit (car, motorboat) per ten field staff. The factor is variable in Table V.

Multiple-use centers / Centros de uso múltiple

Many protected areas are not (yet) suitable for easy-access visitation, but it is desirable to promote some degree of visitation. Such areas may be remote and may require overnight facilities; such is the case of Parque Nacional Celaque. Such facilities may also accommodate researchers, a simple exhibition or a simple restaurant, as well as a basic visitor exhibition and are referred to as multiple-use centers. These centers have to be entered manually for the areas where they are desired.

Visitor Centers / Centro de visitantes

The protected areas with the best accessibility should be equipped to receive significant numbers of visitors, so that the protected areas system can be popularised and generate at least a part of its operational costs.

In order to popularise protected areas, the visitors need background information to help them relate to the highlights of the areas. Such highlights are best visualised in a visitor center. As world tourism is becoming more and more demanding on quality of facilities, it is quintessential that the visitor centers be of international standards and serve as the "visitor cards" of the protected areas. It does not make sense to have visitor centers in all of the protected areas. One should start out to prepare no more than 4 – 5 protected areas. Additional visitor will raise the management costs, but will not raise the total number of visitors to national parks, and it would thus increase the costs of the system without generating additional income. No additional visitor center should be added until the total system has reached a visitation level of 400.000 – 500.000 entries, after which each additional 100.000 visitors would allow for, but certainly does not require the construction of an additional visitor center. The addition of any visitor center should primarily be based on a micro-economic cost-benefit analysis, to assure maximum returns for the benefit of the minimum biodiversity conservation system as a whole.

Trails / Senderos

The need for trails is calculated in kilometers on the basis of land size. As the need for trails per hectare reduces with the increasing size of an area, the need is calculated as a square root fraction of the land size divided by a factor 10. The latter factor may be varied according to the vision of the management authority in Table V. Quality trails are foreseen around the entrances of the protected areas, while hiking trails are foreseen as leading into the interiors of the area.

Legal status / Base legal

Informative column, listing the date of establishment of the protected area. If proposed, enter the document on the proposition.

2.3. SHEET B, TABLE II: COSTS PER AREA / COSTOS POR AREA

Table II: Costs per Area / Costos por Area calculates the costs. According to the characteristics, the cost category may have a column for investment costs and recurrent costs. In the case of investment costs, another column is shown in which the realised/establecido units are entered, which in turn calculates pending costs/costos pendientes by deducting realised units from the required units in Table I.

Yearly returning operational or Recurrent costs / costos recurridos over equipment and infrastructure are calculated over the total investment costs on the basis of the factors write-off / amortigación and maintenance / mantenimiento as a percentages of the investment costs. In this table the recurrent costs don't include staffing costs. Unit costs and percentages come from references in Table V.

Default, costs are given in US dollars, but may be provided in any other currency by changing the cell formats. The use of other currencies in only recommandable for relatively stable currencies, as the meaning of the figures may change rapidly for currencies with high inflation.

In the entire table, only realised units are entered. All other columns are calculated automatically and should not be touched.

Staffing costs / Costos de Personal
Costs are based on the number of required staff for each area, referenced from Table I. On top of that number 5% lower and 5% (both referenced from Table V) professional staff is calculated for a regional administration for administration and supervision tasks. Yearly wages for lower and higher staff are referenced from Table V. Administrative staff for the regional offices are a bit more expensive than for park rangers, but as the numbers are low, this will not lead to major differences of the total staffing costs. If desired, compensation may be achieved by slightly raising the base salary of the professional staff. For the field staff, the formula adds a uniform and boots by reference to Table V, assuming the need for yearly replacement.

Ranger stations / Casas de Guardeparques
The investment costs of ranger stations is referenced from Table V. Costs are calculated with standard equipment costs, solar energy units, including GPS, walkie talkies, binoculars, an amount for monitoring equipment, basic furniture (beds, table, chairs, kitchen gear, etc.). The total is summed up in Table V and may be changed according to need. Equipment write off and maintenance is included in the relevant factors of the buildings.

Vehicles / Vehiculos
The investment costs from vehicles is referenced from Table V. Recurrent costs consist of write off, maintenance and fuel, referenced from Table V.

Multiple Use Centers / Centros de Uso Múltiple
The investment costs of Multiple Use Centers is referenced from Table V. Costs are calculated with standard equipment costs, including a fixed radio, solar energy units, GPS, walkie takies, binoculars, an amount for monitoring equipment, basic furniture (beds, table, chairs, kitchen gear, etc.). The total is summed up in Table V and may be changed according to need. Equipment write off and maintenance is included in the relevant factors of the buildings.

Visitor Centres / Centros de Visitantes
The investment costs of Visitor Centers is referenced from Table V. Costs are calculated with standard equipment costs, including an interpretation exhibition, a computer and photocopy machine, a fixed radio, solar energy units, GPS, walkie takies, binoculars, an

amount for monitoring equipment, basic furniture (beds, table, chairs, kitchen gear, etc.). The total is summed up in Table V and may be changed according to need. Equipment write off and maintenance is included in the relevant factors of the buildings.

Trails / Senderos

The costs of trails are estimated on the assumption that they are built with local materials, mainly involving labor for construction. Occasionally, simple stairs must be built or muddy or swampy sections must be bridged with shelves or steps. For such conditions wood is assumed as construction material. A cubic meter factor per kilometer is given in Table V, as well as a percentage for maintenance.

Management Plans / Planes de Manejo

The costs of management plans are supposed to proportionately decrease per surface as the size of the area increases. They are estimated on the bases of the square root of the size of the area divided by a factor based on experience, assessed in Table V. If several plans have already been developed, one may calibrate the factor to approach realistic costs. Recurrent costs are calculated as the fraction of the validity of the management plans, which by default is set at ten years. This is diverges from the opinion of many advisors, as it is in the interest of the sector to generate more work by establishing a shorter planning cycle, often advised to be five years. The experience of WICE is that periodic adjustments for specific issues may be well carried out by own staff, thus considerably extending the validity of management plans. A new cycle should not be initiated until the area administration (being at a central level or local level) actually signals the need and specifies the problems that need to be addressed in a next planning cycle.

Total Costs / Costos Totales

The total and pending investment costs per area are calculated, followed by the recurrent costs as the sums of the relevant cost categories.

2.4. SHEET C, TABLE III - V: COSTS OF THE SYSTEM / COSTOS DEL SISTEMA

The system generates the recurrent, investment and pending investment costs of the categories calculated in Table II. Added to the investment costs are the costs for the regional administrative offices, listed at the bottom of Sheet B. It also lists the costs off the headquarters and regional offices.

2.5. SHEET D: TABLE VI, SCORING / CUANTIFICACIÓN DE CARACTERÍSTICOS

Sheet D, Table VI: Scoring lists and sums up the scoring factors per protected area.

Area size
The value is automatically generated by calculating the square root of the size referenced from Table I, divided by size validation factor from Table V. No data are entered.

Agro productive land / Tierras agropecuarias
Agroproductive systems in protected areas no longer support significant sets of wild species, and are deducted from the value for size of the protected are. Default the systems deducts half the score of area size for the surface of agro-productive systems. In the case that no data can be obtained for habitation, the system deducts with the same factor.

The formula tends to weight proportionately higher for small areas under cultivation, where the adverse effects of habitat conversion habitation tends to have a heavier impact on the ecosystems. No data are entered.

This score must be calibrated in relation to the score of privately owned land and inhabitants. No data are entered.

Harvested watershed / Cuenca aprovechada
The harvested watersheds are validated with the same formula as area size. This tends to validate small watersheds relatively highly, but that does credit to the importance of small scale use by smaller communities. No data are entered.

Privately owned land
Default the surface of privately owned land is validated as a half negative, but only applies to forested non-productive areas. This score must also be calibrated against the factor of habitation. No data are entered.

Species of special concern
The validation of species of special concern is directly referenced from Sheet G: Table IX, Species of Special Concern. No data are entered.

Outstanding geological formations
Ecologically outstanding geomorphological formations do not necessarily contribute to ecological distinction or species differentiation, other than through drainage, substrate composition and elevation. The latter however is already incorporated in the ecosystem differentiation. They are however, of great importance to our human appreciation of beauty and appreciation of nature. Default MICOSYS assigns up to 25 points to outstanding phenomena. Points assignment on professional judgement.

Geomorphological highlights
Most protected areas systems in the world include special or unique geomorphological formations. Such highlights are expressions of the physical environment and are not necessarily important for biodiversity conservation, but they do form an inseparable part of

nature and are highly valued for their aesthetic beauty. Such formations may include rocks of a remarkable coloration or shape, caves, water wells, waterfalls, canyons, etc. The site may be valued up to 50 points.

Archaeological remains
In some cases protected areas may host the last links with our past in the form of archaeological remains. They may vary from isolated pre-historical tools to unique monuments. to this category; sites of worldwide significance may be validated up to 50 points. Points assignment on professional judgement.

Extraordinarily scenic landscapes / Paisajes únicos
Under this category, the system assumes the aesthetical characteristics of a landscape, and not the ecological characteristics, which are already covered under ecosystems. Extraordinary landscapes are also different from the tourism value in the sense that they apply to conditions of a more generic nature. A protected area of extremely difficult access may still provide a beautiful landscape from a distance, while an area with great tourism potential may sometimes have lesser scenic landscape value. Areas are validated when they significantly contribute to the characterisation of the "landscape image of the country". Default the system assigns up to 25 points and are assignment on professional judgement.

Tourism value / Valor Turístico
National parks, who's secondary objective is "to provide enjoyment for present and future generations", may have important tourism values. Their values for society include:
Shared environmental learning among parents and children;
Shared enjoyment of nature leads to family building and society strengthening;
Political back-up from politicians and the commercial tourism sector;
Direct income to support management costs
Employment

Protected areas may be among the key factors for promoting a country as a tourism destination in the international market. The attraction value for marketing purposes usually far exceeds the direct economic use of the areas themselves. Foreign tourists select their destinations on photographs of highlights of historical buildings, landscapes, beaches and diversion opportunities. The beauty of natural landscapes highly influences the destination choice and thereby attracts foreign tourists, even though they may never actually set foot in a protected area. At the same token, more and more foreign visitors want something different besides just beaches, golf courses and dancing and they are looking for accessible national parks, where they can actually see the tropical jungle that they have heard so much about.

The programme makes a distinction between immediately recruitable eco-tourism values and the ones that may have value in the future after some critical conditions are met (such as the construction of road-access).
On the basis of professional judgement, tourism may be validated for both the current situation and future potential with a maximum of 50 points.

Education / Educación
Although education is generally covered under tourism value, a few cases stand out well above the average conditions of tourism potential. This applies to areas with easy access at a very short distance from a major city and may be granted up to 25 points.

Research Station / Centro de investigación
The benefits of scientific research for society are too evident and broad to even make an attempt to list them in this brief paragraph. However, there are some beneficial opportunities of research in protected areas that are often overlooked. Protected areas attract foreign researchers that can only study tropical biology in the tropics. Particularly interesting are research stations that are established in cooperation between a national and a foreign institution are of great interest. Such stations create permanent local employment opportunities and exposure of national scientists to foreign knowledge, increased scientific output, influx of foreign currency, etc. A realistic opportunity may be granted up to 25 points.

Special considerations / consideraciones especiales
In some cases an area may have conditions that are very different from all other areas. Such conditions may be positive (i.e. some organisation is willing to provide a large donation that can make the area financially self-sufficient in perpetuity), or negative (a local community strongly resents the protective status of the area and continuously sets it on fire). In such case the evaluators may grant a positive or negative value, which needs to be specifically motivated.

Size of the reserves / Tamaño de las reservas
The size of a protected area is important for its effectiveness as an *in situ* conservation instrument for the following reasons:
The number of species present in an ecosystem increases with size until it approaches 100% and consequently the number of species of a protected area, increases with size;
With increasing size, a protected area is likely to harbor more different ecosystems;
Some species migrate within their range during their life cycle or during a season cycle (different parts of a watershed, different elevations). Larger areas are more likely to foresee in all requirements of such cycles.
The population sizes of organisms in larger territories are greater and are therefore more resilient to fluctuations and support greater genetic flow; this is particularly relevant for species in need of large territories.
Large areas have a more favorable surface/periphery ratio and as a result, negative external effects have less of an impact on the area as a whole. Also management is relatively cheaper, as management is particularly directed at prevention and mitigation of external effects.
We must bare in mind however, that while the importance of a protected area increases with its size, these benefits do not increase in a straightforward fashion, they rather follow a declining curve. The programme assigns the value by calculating the square root of the size of the protected area divided by the size factor, which is set by default at 4.

2.6. SHEET E, TABLE VII: SIZE OF ECOSYSTEMS PER AREA / SUPERFICIE DE ECOSYSTEMAS POR AREA

Ecosystem classes are entered by a code to keep the columns narrow. The sizes of the ecosystems as they occur in each one of the protected areas are entered in hectares. The system calculates:

- How often each ecosystem class is present in a protected area
- The total size of each ecosystem class within each protected area
- The total size of each ecosystem class within the country
- The size of each ecosystem class outside of protected areas
- The total percentage of each ecosystem class within protected areas
- The total size of natural or semi natural ecosystems per protected area
- The total size of productive lands per protected area

Conservation of communities of species that co-occur and interact has become the objective of most biodiversity conservation programs, rather than the conservation of individual species. According to Grossman et al. (1998), ecological communities constitute unique sets of natural interactions among species, provide numerous important ecosystem functions, and create part of the context for species evolution. In addition, many species not specially targeted for conservation are protected as well. While, directing conservation at communities rather than at species has become the most commonly applied approach in conservation, one must not shy away from the interest in species. Biodiversity conservation assumes an effort to integrate the survival of a representation of as many native species of a country as possible. As both communities and species representation are important, WICE looked for a method that could integrate the information on both communities and presence / absence of species. The question was raised, whether biological communities can be (1) classified into units that can be efficiently identified, (2) described for common features, (3) biologically sufficient distinctive and (4) mappable.

Vreugdenhil, et al., (2002, in press), argue that the ecosystem classes mapped in the Central American Ecosystems Map represent fairly distinct – though often partially overlapping – sets of species. Faunistic elements are not considered in the UNESCO classification system. In terrestrial ecosystems, fauna always makes up a small proportion of the biomass of an ecosystem, although great concentrations may sometimes be conspicuous. Many animals are difficult to observe and they are mobile. Therefore, fauna elements are difficult to include in the classification of in any form of community mapping system. However, since we assume that the UNESCO classes, particularly if extended with diagnostic species, represent sets of species and their mutual interrelationships and processes, fauna elements are intrinsic to the ecosystem classes of the Central American Ecosystems Map (Vreugdenhil, et a., 2000, in press). …. Et al., (2001) Corroborates that position for reptiles and amphibians, which also show how sets of reptiles and amphibians changes with the different levels of elevation. This collaborates that the species sets of ecosystems vary with altitudinal levels. Additionally House, (97) shows that in 3 adjoining broadleaved forest ecosystems in the Mosquitia in Honduras, species composition varied depending on the levels of drainage, to the extent that from 30% to 50% of the species differed between the plots.

Thus, the ecosystem classes mapped and classified using the UNESCO classification system are currently the closest proxy available to provide a differentiation of species sets that is not biased by such common factors as road access or routine study locations chosen by universities. Vreugdenhil, et al. (2002, in press) also feels that the level of detail allows for responsible representation/gap analysis.

When using a physiognomic ecosystem classification (like the UNESCO system) as a proxy to distinguish different species sets, one must be very careful with the use of the data from areas with environmental stress or human intervention occurring with intervals of several years. After the occurrence of each stress occasion (like fire, periodic insect plagues, shifting cultivation) the habitat recovers and may show a wealth of physiognomic diversity, resulting from regeneration stages, while the species composition for the different phases may be very similar, and usually much poorer than for the similar habitat that have developed under different ecological conditions.

2.7. SHEET F, TABLA VIII: ECOSYSTEM SCORE PER AREA / PUNTAJE DE ECOSISTEMAS POR ÁREA

No data are entered in this sheet. It calculates an ecosystem score from the data in Sheet G and it adds them up into a total score per protected area.

The scoring is based on the following assumption. An area that protects an ecosystem that only occurs once or twice in the system is considered more important than an area that covers an ecosystem that occurs much more often. Therefore the scoring takes into consideration how often an ecosystem is present in the protected areas system. At the same token an area that protects half of the total size of an ecosystem is more im portant than an area that only has 10 porcent. Default, the total scoring of an ecosystem is set at 50 for all ecosystems alike.

> This is not a reality, as some ecosystems have far more species than others. This is particularly the case for wetlands, which are typically species poor compared to tropical lowland forests and wetlands usually score on the high side. In practice, not differentiating between ecosystem values has always worked, particularly, when protected areas have a broader range of ecosystems. If the scoring turns out to be too unbalanced, one may go into the separate weighting of ecosystems on the basis of a professional judgement. Species poor ecosystems may be set at 25 points and the most species rich systems at 75 or 100. To achieve this one must change the formula of the relevant cell of the first protected area and copy-paste it down.

To distinguish between representation and size, the total score is divided by two. One half is divided by the number of times it occurs in the system and the other half is divided by the proportion of the area that the ecosystem occurs in the protected areas system. In this scoring we are not considering the proportion as it still exists in the country, as we are comparing the areas of the protected areas system among each other.

2.8. SHEET G, TABLE IX: SPECIES OF SPECIAL CONCERN

Default, **species of special concern** are entered with the value of one point per species per area. **Endemic species** are entered with a cell reference to Table V, where the endemic species factor is set at default of 2**. Species of extraordinary concern** can be set with another cell reference to Table V, where it is set default at 10. The total species points per areas is calculated at the bottom of the table.

Since the beginning of conservation, species conservation has always been an important issue in motivating conservation, and still is. In previous paragraphs we have argued that the ecosystems maps based on the UNESCO classification system serve as proxies for species in a represence/gap analysis. In theory they would include all the sets of species of special concern and the ecosystem classes would distribute them equitatively without sampling bias. Nevertheless, the developers of the programme never were fully comfortable with this assumption and decided to build in an additional biological evaluation of what was coined by Vreugdenhil, (1992), as "species of special concern". In the use of MICOSYS the concerns reflect a mixture of some of the following concerns:

- top predators that need large territories;
- endemic species;
- species that have been greatly reduced because of deforestation (many trees);
- congregatory species
- species that are particularly appealing to people (flag species) and therefore may have political conservation appeal.

One should be particularly careful with the use of distribution data of individual species. Species observation and data collecting rarely happens at random and often follow patterns of habit or convenience of the collectors. In many cases species are collected along roads of access. This can be very clearly shown when one plots the endemic plant species of Honduras, that are clearly concentrated along the road route (with feeder roads) from Tegucigalpa to La Ceiba. Another example: The protected areas Cerro Uyuca and Cuero y Salado have been chosen by the EAP and UNAH respectively as working areas and therefore have the largest lists of known for protected areas of the country, in spite of their limited sizes and status of human intervention. Their lists make up respectively 8 and 11% of all the species of Honduras.

The species lists of these two areas clearly demonstrate that species lists cannot be used to impartially validate protected areas. The data of these areas would completely overvalue them as compared to extremely valuable other protected areas for which no such lists exist. If weighted only for its eleven endemic plant species, Cerro Uyuca would be among the top priority protected areas and Rio Platano at the bottom, and so would be all the coastal wetlands. Wetlands are typically low in endemic species as they are characterised by very effective waterbound ecological connectivity, which prevents species from becoming geographically isolated.

The developers of MICOSYS have had lengthy debates on how to deal with this phenomenon. They have come up with the following solution, which has found very common acceptance in the countries of application:

Species of special concern are too important to be ignored in a weighting system. However, given their inheritively biased and unevenly distributed sampling, they may only obtain a low pointscore per species, so that the impartial data of ecosystem distribution are not overshadowed by records from over/under-sampled areas. In general, MICOSYS assigns 1 point to the species of special concern; endemic species are valued at 2 points.

Endemic species

The concept of endemism is often poorly understood and it has been a source of frequent misconception in conservation practices. Therefore we like to spend some extra text to its concept and its significance to conservation. The definition of an endemic species: a species which is only found in a given region or location and nowhere else in the world. This definition requires that the region that the species is endemic to, be defined, such as a site endemic (e.g. just found on Mount Celaque), a national endemic (e.g. found only in Honduras), a geographical range endemic (e.g. found in the Mosquitia region, which however covers both Honduras and Nicaragua and therefore is not a national endemic), or a political region endemic (e.g. found in countries of Central America). A cosmopolite is endemic to Earth!

From these examples it is clear that the use of the term endemic needs to be qualified by defining geographic area otherwise it is rather vague and without too much value. National and political region endemism of large countries or regions has far less significance than endemism of small countries and very limited range endemism. In the context of this study, we mostly take into consideration national endemic species. There is a thorough justification for that. First of all, Honduras is a relatively small country, and the concept of national endenism in Honduras automatically means that nationally endemic species have very limited ranges. Furthermore, conservation can only be carried out legally under national legislation, and a national endemic depend exclusively on the effort and success of conservation in the country where it lives. In a few cases we have included very limited ranges endemics.

One must be aware however, that the concept of endemism depends on the knowledge of the geographical range of a species. Usually, a newly discovered species has only be found in one single location, and with the knowledge of that moment, it should be considered a site and national endemic, until the moment that someone, aware of the new description, discovers it somewhere else, and the its original status of endemism will be lost. This is bound to be the case for many endemic organisms which are difficult to be noticed or recognised, such as species from very large and complex groups (plants, arthropods) or small organisms. Endemic species of well studied, conspicuous taxa with overseeable numbers of species (birds, mammals, herpetofauna, icthyofauna), tend to be more stable; they are also more appealing to the public.

Other species of special concern

Categories of species of conservation concern by the IUCN:

Threatened: General term indicating that a species is either extinct, endangered, vulnerable, rare or indeterminate.

Extinct(Ex): Species not definitely located in the wild during the past 50 years.

Endangered (E): Taxa (species and sub-species) in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that are possibly already extinct but have definitely been seen in the wild in the past 50 years.

Vulnerable (V): Taxa believed likely to move into the "Endangered" category in the near future if the causal factors continue operation. Included are taxa of which most or all the populations are decreasing because of overexploitation, extensive destruction of habitat, or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are under threat from severe adverse factors throughout their range.

Rare (R): Taxa with small world populations that are not at present "Endangered" or "Vulnerable" but are at risk. N.B. in practice, "Endangered" and "Vulnerable" categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category. These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Some species of special concern from a more national perspective

In addition to aforementioned IUCN categories, this study also recognises *"Flag Species"*, conspicuous species, that are usually known to the public and that may carry political weight in conservation issues. It is unlikely that the conservation of a spider or even a group of arthropods will ever become a political concern. Under very special circumstances, the conservation of the famous endemic toad, just may become a political issue. But, if the now famous Honduran Emerald which is threatened with immediate extinction, has become important enough to acquire some additional lands in the context of a road construction. Often, flag species also fall into one of the IUCN categories. If not already qualifying under one of the previous categories, these species should be used with great reservation in a weighing system, particularly if their distribution is wide spread.

Species of extraordinary concern

There area a few cases however, in which one point is clearly not enough. Species that occur in very small areas and are heavily threatened, or that form seasonal congregations on sites that are vital for their survival. These species are not necessarily rare, but their specific sites of congregation may not score adequately in the system. Those are dubbed special of extraordinary concern. Typical examples are harpey eagles and frigate birds if nesting and marine turtle on significant nesting sites.

In all of Central America, the Harpy Eagle and Kingvulture are extremely vulnerable to habitat destruction. These birds can only survive in large areas of natural tropical forest. Frigate birds and some other pan-tropical oceanic birds only breed on small islands. More and more these islands are infested with feral animals, like cats, pigs, goats and rats. Suitable sites have diminished in all oceans and colonies have been decimated. De Korte & Vreugdenhil (1991). For their reproduction the marine turtles depend on undisturbed beaches. As beaches become more and more converted into recreational lands and their nests are often severely prayed on by local communities as well as pigs and dogs, their survival is becoming rather worrisome. Depending on their numbers, the marine turtles may score 10 points if their nesting sites occur as follows over a distance of less than 10 km: Green turtle more than 10,000 clutches and the other marine turtles more that 1,000 clutches.

3. MODELS FOR AN *IN SITU* CONSERVATION SYSTEM

3.1. DEVELOPMENT OF MODELS WITH DIFFERENT LEVELS OF CONSERVATION SECURITY

When all the data have been entered into the system, it will be possible to compose different conservation models. This process requires that the evaluators pass through various steps of evaluation and it is very important that the protected areas management leadership is involved in the process at the highest level so that they are fully aware of the different choices and in the end are comfortable with the results of the final selection. After all, they will have to live with the selected model and defend it both politically and to the public.

The first step in the selection of models is the elimination of non-essential areas. Criteria for elimination will vary from study area to study area, depending on the status of conservation. It has become common practice in the application of MICOSYS to recognise three levels of quality, based on the final scores. Those levels are set at twice the maximum ecosystem value for areas of probable national importance and once the maximum ecosystem for areas of no national importance:

Level 1: areas whose scores suggest that the areas may be of major importance for conservation of the biodiversity of the country.

Level 3: areas whose levels suggest that they be of very limited relevance to the conservation in the country (areas of merely local or regional significance). Those areas should be eliminated;

Level 2: areas whose conservation significance to the country is not yet quite clear.

The level 2 areas should be evaluated individually by examining from where they obtain the scores. If their scores come from an abundance of species of special concern, that merely reflect the fact that the area has been better studied than others, while factors like size and ecosystems score low values, the area probably is not of national significance for biodiversity conservation and is a candidate for elimination. If in doubt, however, leave the area in.

Once the levels are determined, the level-3 and non-essential level-2 areas must be eliminated[2] by deleting the rows in Sheets A – F and the columns in Sheet G containing the relevant area information, by marking the entire column and pressing the minus button for row/column elimination. Once the areas have been eliminated, one must press F9 for recalculation of the system. Given the complexity of the programme, system errors may creep in, and it is recommended to check the formulas of the top row, correct them if nessary and copy and repaste them into the entire corresponding column.

[2] It is possible to go through a somewhat more automated process, but the experience is that this simple methodology give the opportunity to consider the elimination decisions individually.

An area that has at least one high score for an ecosystem should not be taken out at this phase of the process, as a high ecosystem score means that the area either has the largest portion of that ecosystem or that it occurs in no more than 1 or two other areas. Such area may be of national significance for biodiversity conservation.

When the non-essential level-2 areas are selected, they should be taken out together with the level-3 areas. The Reduced selection of areas has all areas, which may be of national importance, but it may still contain an overrepresentation of ecosystems, which may result in heavy maintenance costs of the system.

A next step involves the selection of the minimum number of areas that still contain all ecosystems in the country: the "minimum conservation system". All areas that only contain ecosystems that are found elsewhere are eliminated. Even well-known and well established areas are eleminated if their ecosystems are non-essential.

Even though the minimum conservation system is complete in its representation of ecosystems, it is highly probable that many ecosystems are poorly represented and highly vulnerable. To deal with this situation, the poorly represented ecosystems are analyzed and areas that can substantially contribute to their viability are added to the minimum conservation system model. This is the most economical viable model.

The composition of the most economical viable model does not take into account the realities of every day. Every country has highly appreciated well-established or renown protected areas, that can never be ignored, even if their ecosystems turn out to be non-essential in the most economical viable model. Such areas should be added to the system in what may be considered the realistic or rationalised model. This model still needs completion with ecosystems that are not found in the system. As this involves not-yet protected areas, their inclusion usually requires new field study and planning, the study will have to limit itself to general recommandations.

As the programme evaluates all the ecosystems and species of special concern both registered in the country and registered in the protected areas system, it is possible to carry out a presence-gap-viability analysis. This will establish which ecosystems and/or species of special concern are missing, underrepresented and assess in which ecosystems the survival of species is less secure.

3.2. CRITERIA FOR PRESENCE / ABSENCE ANALYSIS

Species representation

The UICN argues that 12 % of the original habitat of a given territory covers about 70 % of the species belonging to that habitat (or ecosystem in the sense being used by WICE). On the basis of species sets of a large number of ecosystems, Dobson (1996) developed a graph that plots the percentual increase in size of an ecosystem against the percentual increase of species. He found that the percentual increase of species ranges between two curves, irrespective of the type of ecosystem, climatic conditions, geographical position or its species density. Some interesting positions on the optimistic curve are: 3 percent of the area would conserve 50% of the species, 12 percent conserves 70 percent of the species and 30 percent protects 80% of the species. Above 30 % even large increases in total area would add proportially very few species. The pessimistic curve would lead to somewhat lower but still impressive conservation results. The International Union for the Conservation of Nature (the IUCN, which unites both conservation NGOs and most national governments of the world through membership) targeted to legally protect 12 % of the world's ecosystem in protected areas in the year 2000. Following Dobson's curve that would conserve about 70% of the world's species.

WICE fully endorses this assumption and expects that with more detailed ecosystem mapping information, very realistic and cost-effective biodiversity conservation systems may be composed that warrant extremely high representation of the remaining species in any given study area or country. In most study areas, using the criterion of 12% of the original habitat is very difficult to assess at the level of detail that WICE is working with its ecosystem mapping approach. Therefore WICE has a slightly different approach, which allows it to arrive at optimal results from currently still existing conditions. First it targets to set aside a minimum of 12 % of land of any country for biodiversity conservation in a coarse distribution over its territory, hoping to include most of the large-scale macro-ecosystems or landscapes of the country with an average of 12 % of their original territories. Some of those landscapes may be over-represented while others are underrepresented, but probably this would lead to inclusion of more than 50% of the species that were historically present in the country assuming the optimistic curve that needs about 3% of the territory to include 50% of the species. In most of the cases percentages are probably much higher, because large-scale landscapes usually include a number of less common small-scale ecosystems at percentages of 12% or more of their historical presence. Particularly in the case of mountain ecosystems, those small ecosystems may represent very high and highly distinctive biodiversity.

To increase inclusion of species, one should strive after a second target, which is the inclusion of a sample of every ecosystem still existing in the country. Given the great level of detail in ecosystem mapping demonstrated to be feasible for large regions with the UNESCO classification system (Mueller-Dombois 1974), the application of maps based on this method would significantly boost the percentage of inclusion of species still alive in the country, as could be demonstrated for Costa Rica, Belize and Honduras as we will see in this study. At that level of detail however, it is rarely possible to target 12 % of the historically present territory of the ecosystems, and the authors feels that targeting 12% of the currently still surviving ecosystems is more realistic. This mixed objective will lead to a presence of a remarkably high percentage of the originally occuring species of a given country.

Species survival requirements

While presence of species in a conservation system should be the first selection criteria, it certainly is not the only one. After all, it would be of little avail, if we would select a system of protected areas in which many of the species that we target to conserve will not be able to survive. The most efficient way of setting up and maintaining a conservation system is by composing an integrated system which includes the maximum number of species on the minimum area of land and water. Having just one example of each existing ecosystem would thus provide the highest biodiversity on a minimum area of land and at a minimum cost. However, having just one example of each ecosystem would provide a low level of security for continuity, as over time, ecosystems get exposed to serious disturbances and mishaps. Large proportions of sets of species belonging to a certain ecosystem may become locally extinct when stricken by natural disasters such as fires and hurricanes, while individual species are subject to terminal fluctuation risks, inflicted by such causes as diseases, predation and pollution.

Spreading of extinction risks

De Boer (1977) coined the term "spreading of risks" for survival strategies in Carabid Beetle populations, and analogaly Vreugdenhil (1992) looked for risk spreading strategies for whole ecosystems. In dialogue with de Boer (personal communications, 1992) they argued that the ideal level of protection for ecosystems would be the occurance at 5 different locations of any given ecosystem in a national protected area system. The argumentation is as follows: Statistically, stochastic (unpredictable and randomly occuring) extremes (which may be a mix of mankind induced and natural disasters) tend to occur in groups of maximally of 3 or 4 events. The first higher number of representation of an ecosystem in a protected areas system would provide a significantly higher level of security against extinction. In practice, such level of representation is never feasible for all ecosystems. Some ecosystems may only occur once or twice in the country and have a 100% representation in the protected areas system. The authors feel that the spreading of risks against extinction is reasonably secure if an ecosystem occurs in 3 different protected areas. This would particularly be the case if the same ecosystem would occur in a neighbouring country or if an ecosystem occurs in smaller – non-mappebele – patches in other ecosystems, while one and two occurances are considered under-represented.

A side effect of plural representation is that the wider the geographic range of protected ecosystems the higher the probability that the system would be able to conserve geographic variations of species sets found within them.

Viability

Another question is how big an ecosystem must be, to conserve its species. To address this question one must deal with several premises. The first one is, whether an ecosystem is a closed entity in which each species for its survival depends on the other species that "belong" to that system, or whether it should be regarded as a spot in which a set of species has congregated and coexists. We assume that it is a mix of both, and that the local conditions will always attract an interesting set of species that may survive over a long period of time if those conditions may be continued. The presence of one set of species will however create new ecological conditions that allow for other species to establish themselves and thus a new ecosystem may develop. Once consolidated, a large selection of species may continue to survive in a given ecosystem if further external disturbance like fire, deforestation and hunting can be avoided.

The smaller an area, the more likely it becomes that populations of species will get extinct. Many conservationists are concerned about the viability of an area. We rather like to think that all ecosystems – even the very small ones - are viable, but not each size is suitable for maintaining all the species that we associate with a defined ecosystem. As the system decreases in size we must expect more species to get extinct, but an ecosystem continues to be viable for the remaining species. Therefore “viability” rather relates to the individual species belonging to an ecosystem. When we relate to “viability” we refer to the viability of the majority of the species set of that ecosystem, but not to the ecosystem itself. The question is, how big must an area be for a species to survive. This is different for every species.

The mountain top of Montaña Uyuca en Honduras is just a bit under 1000 ha and it provides shelter to about a dozen of endemic plants which probably have developed there on the spot and have been present on only that small location for who knows how many hundreds of thousands of years. In the USA, various fishes and other aquatic animals survive under desert conditions in pockets of water of no more than several cubic meters in size. These are relicts of lakes that have disappeared in prehistoric times. On the other hand, a number of animals need very large undisturbed territories, like the birds of prey, particularly the monkey eating crested eagles (Harpy Eagle, Philippine Monkey Eating Eagle). Those animals need large territories of forest, albeit not necessarily of only one class in the UNESCO system. They may happily survive in large protected areas of mixed ecosystem composition. These examples show that every organism has different requirement with regard to its size and its distribution over one specific or more ecosystems.

As different requirements apply to different organisms, we have searched for common trends. We found an interesting attempt by TNC (Secaira et al, 2001), which observes that natural ecosystems occur in different typical sizes – e.g. mountainous forests on isolated mountain tops are typically small, while lowland humid tropical broadleaved forests are typically large. They argue that species that are used to living in typically small ecosystems are more resilient to surviving in small territories than species in large systems. We think that the concept is valid and practical. In its elaboration Secaira, et al (2001), are not very practical. They argue that if the typical area is less than 2,000 ha, the minimum size should still be 2,000, for areas from 2,000 ha to 200,000 ha they suggests that the minimum size should be 5,000 and a next level up one should take 10.000ha. These sizes are not coroborated with any criteria and are as good as any other guess. Furthermore, following this reasoning, we miss the point that if the minimum size is smaller than 2,000 ha, that one still needs a minimum area of 2,000 ha for an area to be viable. WICE has eleborated a balanced set of considerations and criteria.

Typically small terrestrial ecosystems
With regard to natural terrestrial ecosystems, few are typically smaller than 1,000 ha, even in mountainous regions. For terrestrial ecosystems (not belonging to islands and not embedded in larger ecosystems) of a characteristic size of up to 5,000 ha, we think it would be wise to strive for a minimum area of 1,000 ha if such ecosystems are isolated in small protected areas; embedded ecosystems however are usually not considered to have of a minimum size.

Embedded ecosystems
While we tend to associate species with one specific ecosystem, in practice many species live in a mosaic of ecosystems in different densities. Most mapped ecosystems are artificially cut up, while many species are distributed along gliding scales of gradual changes. As a result individual species distributions usually deviate in part from the mapped ecosystems and many species belonging to small ecosystems also occur in parts of neighbouring ecosystems, albeit in different densities. Furthermore, it is very likely that small ecosystems embedded in larger ecosystems consist of finer-grained mosaics that allow species to live in much larger territories than the mapped ecosystems suggest. We therefore expect that embedded small ecosystems usually provide viable conditions for the populations that have established themselves long ago.

Populations of terrestrial species on small islands
Island populations have been successful at establishing themselves at the scale of the island where they live, and we expect their survival to be subject to the size of the island, rather than to a "typical" ecosystem size. Rules on minimum size for island ecosystems are hard to give.

Typically large terrestrial ecosystems
With regard to very large ecosystems, in the level of detail of the Ecosystems Map, very few ecosystems in Central America are of a typical size of more than 200,000 ha or 500,000 ha on the tropical continents. More often than not, large natural areas consist of mosaics of several different ecosystems, of much smaller characteristic sizes, meaning that even for large-scale ecosystems, a minimum size of 10,000 ha of stand-alone large scale ecosystems should be enough for the survival of most species[3]. This might be a practical indication, assuming that smaller patches are viable if embedded.

Typically medium size terrestrial ecosystems
Somewhere between typically large and small terrestrial ecosystems are medium size ecosystems. After reviewing sizes of ecosystems in Central America, we arbitrarily defined them to be between 5,000 and 50,000 ha, and we assessed their minimum size at 5000 ha, unless embedded.

[3] These criteria need reconsideration for areas with migrating ungulates and possibly the low-diversity macro-habitats of the Northern Arctic.

Aquatic ecosystems
For aquatic ecosystems, one must rather consider the quantitative and qualitative viability of the water system (ranging from watersheds, estuaries, coastal waters to minuscule isolated pools) as a whole, in which many recognised ecosystems are important but inter-dependent ecologically connected subsystems. Such sub-systems – often linear in shape - may be very small and specific species may be associated with them. Even though such species have specific ecological preferences, many populations of aquatic species cover much larger areas than the ecosystems where the majority of them are found. In other words, most small aquatic ecosystems will always be embedded ecosystems, which may viable in very small sizes, if part of a healthy integral water system. On water systems, no minimum size can be suggested. Protected areas rarily encompass complete water systems, and their viability must be assessed on a case by case bases, taking into consideration the human activities that take place in the water system. Usually integral water management of such systems is required to warrant the integraty of flora and fauna of gazetted wetlands.

With regard to connectivity between subsystems in water systems, it should be noted that connectivity is far better than among terrestrial ecosystems. Theories on biological corridors for terrestrial ecosystems often do not apply to aquatic ecosystems, as virtually all aquatic organisms in a watersystem are connected through swimming, flying or currents. Non-territorially connected “stepping stones” are usually sufficient to connect populations over large distances.

Most terrestrial ecosystes are transversed by rivers and thus include aquatic ecosystems. These aquatic elements in predominantly terrestrial ecosystems are usually part of watersystems that reach far beyond the protected area, and consequently the viability of the aquatic species in such areas are subject to the integraty of those entire watersystems.

Genetic flow
A further point of consideration is the concern of genetic flow in small populations of animals requiring large areas. In the past, several almost extinct animals were feared to have become extinct (Mörzer Bruijns, 1972, pers. com.) because their severely reduced populations would be genetically too impoverished to survive. The case of the Przwalski Horse was given as a showcase. In 1999, during one of his missions, Vreugdenhil learned that the Przwalski Horse was successfully reintroduced on the Mongolian highland prairies. Nowadays, several species have gone up from world wide populations of a few hundreds to several hundreds of thousands or more (the American Bison, Vicuña) and several species are hanging in at less dramatic but comfortably safe numbers after having recuperated from one or two dozens of individuals. What we don’t know is how long a drain on genetic diversity may last, but the resilience to severe genetic diversity drain is fortunately bigger than we feared previously. But that does not mean that we should take this concern lightly. The size of a country allowing, one should strive for at least one area of at least 100,000 ha, preferably considerably larger, in which large birds of prey and mammalian predators may keep up a healthy population and where large herbivores may roam. Such areas are usually not determined by criteria of composition of ecosystems but rather by mere availability.

Many of these larger animals – particularly the mammalian predators are not fully dependent on natural habitat. Many may leave natural habitats and roam through rural areas. If left alone, individuals may connect with populations of their kind in other protected areas, thus breaking their genetic isolation. In most rural societies, farmers are inclined to hunt down every predator that roams the region. This habit might be diverted if farmers are compensated for the occasional kill of a domestic animal. It is recommended to create a modest (1 percent of the national biodiversity conservation budget) predator kill compensation fund that operates under a clear set of rules in combination with a campaign to leave predators alone.

3.3. ECOLOGICAL CONNECTIVITY

During a geological time scale, all populations will go extinct, and in nature, local extinction does occur (de Boer 1977). Under natural circumstances, ecosystems, which have lost a species, will usually be re-stocked. Whether or not members of another population eventually will replace a locally extinct population depends on many factors, such as the mobility of the species, distance from the nearest population that might re-stock and ecological connectivity. In the larger protected areas, many of the smaller species may re-stock from within.

Biological corridors potentially offer a passage for re-stocking and exchange of genetical material among populations, but in principle, an area only serves to that purpose for all organisms of 2 connected areas if it is ecologically identical to them. An inhabited terrestrial biological corridor with mainly intervened arboreous cover does provide connectivity to those species that can also survive in the corridor, but that is a very limited selection of species compared to those in the natural ecosystems. Additionally it probably connects populations of animals of intermediate mobility that are capable to pass through that habitat even though they may not live there permanently. Furthermore, connnectivity becomes restricted between ecosystems of different nature, even more so if the connecting ecosystem is still of another type. An extended marshland is a poor biological corridor for most terrestrial organisms and a savanna provides limited connectivity for forest-dwelling species, while a lowland forest does not provide connectivity for the vast majority of high elevation species.

Some other species groups may benefit from biological corridors of even non-connected stepping stones, but may not strictly need them. Those include many flying species and aquatic organisms.

We have to realise that we live in an era in which species will disappear forever and not everything can be done to prevent that. We have to search for the best possible solutions in the setting of the societies where we live and work. That means that some ecosystems can only be conserved as isolated islands surrounded by production lands. In those areas certain species can survive others are bound to be lost. If such ecosystems are the last remnants remaining in a country, they still need to be conserved, even though their habitats cannot be connected to others, because at least a part of them will turn out to be resilient to ecological isolation.

When ecological connectivity is not feasible, occasionally, human interference may be required in the form of artificial exchange of individuals among populations or assisted re-stocking.

Considering the former issues, we suggest to strive after meeting the following criteria to compose a biologically viable conservation system that is broadly representative of at least the presently surviving biodiversity at a minimal cost:

- 12 percent of the national territory protected under strict biodiversity conservation legislation and management with no human occupation or land use other than non-consumptive environmental services;
- 1 protected area should have a minimum size of 100,000 ha;
- Incorporate 2 to 3 examples of each ecosystem in different areas;
- Typically small terrestrial ecosystems should have a minimum of 1000 ha;
- Typically large isolated terrestrial ecosystems should have of a minimum of 10,000 ha;
- Typically medium sized isolated terrestrial ecosystems should have of a minimum of 5,000 ha;
- Each ecosystem should occur twice at or above its minimum size or as embedded ecosystems;
- The entegraty of water systems encompasing protected aquatic ecosystems should be conserved through adequate management measures.

3.4. COMPLEMENTARY MEASURES

- Create a predator kill compensation fund of 1 percent of the national biodiversity conservation budget;
- Create a endangered species management fund of 1 – 5 percent of the national biodiversity conservation budget;
- Botanical gardens should set up collections of the nationally endemic and restricted distribution species.

4. AN EYE ON THE FUTURE

When working for conservation in situations where nature is continuously being destroyed, many conservationists become desperate and give up.

Signs of hope:
Population pressure will decrease with increased levels of education. Leads to
Migration away from rural settings may leave extended areas eventually to recovery, particularly extremely poor production lands like steep mountains, deserts, and wetlands.

A well-defined protected areas system will boost support on all levels of society, which may effectively stop habitat destruction in the selected areas.

An infinite time horizon does not require that all elements need to be put in place for perpetuity. With the passage of time, society changes and so do visions. New opportunities as well as threats will come, such as climatic change. But we don't know the way it will express itself and much less so, its effects and it is difficult to prescribe solutions for problems of uncertain nature and uncertain dimensions. We cannot "rule" infinitely beyond our graves. We can only hope that future generations in some way will share our views. But in the end, we must realise that future generations will take over the torch and decide if they will keep it burning and also how they will fuel the flame. To allow them to do so, we should strive to hand over the greatest treasures of the world to the following generation – the one of our children - in such a fashion that they will have the opportunity to care for and look after these treasures. We can hand over our ideas and hope that they become partly or even fully integrated into their societies. But they must find their own solutions to address the challenges of their times.