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Editor: **Paul Goriup**
Assistant Editor: **Martin Harvey**
Translations: **Patricia Almada-Villela (Spanish), Jackie Sharpe (French)**

PARKS, 36 Kingfisher Court, Hambridge Road, Newbury, RG14 5SJ, UK
Fax: [+ 44] (0)1635 550230
Email: 100347.1526@compuserve.com

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- maintaining and improving an effective network of protected area managers throughout the world, building on the established network of CNPPA
- serving as a leading global forum for the exchange of information on issues relating to protected area establishment and management
- ensuring that protected areas are placed at the forefront of contemporary environmental issues such as biodiversity conservation and ecologically sustainable development

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Editorial

JEREMY HARRISON

COMPARING THE REPORTS from the world parks congresses, which have taken place each decade since 1962, there has been a substantial increase in the complexity of issues covered. As protected area managers are expected to take account of more and more of these factors, their task gets increasingly complex.

At the same time, the multiple values of protected areas have been increasingly recognised, requiring social and economic dimensions to be incorporated more thoroughly within protected area systems. This has again led to an increase in the complexity of the task of protected areas management.

It is no wonder, therefore, that the need for improved support for managers has always been a key point for discussion. This issue of *PARKS* tackles management support, addressing the theme of *Parks and information technology*.

Information technology only provides us with a set of tools, and it is vitally important that those tools are used in both an appropriate and a cost-effective manner, in the context of the most important tool in the manager's kit – the management planning process. Mike Alexander describes this process, which he considers an "essential prerequisite to effective safeguard and management of protected areas".

Within the planning and management process there is a wide range of tools that can provide assistance, from complex computer-based decision support systems to simple libraries or databases. The other papers in this issue of *PARKS* cover three areas in more detail: finding information, managing information, and using information in decision support systems.

My own paper on finding information tries to address how protected area professionals can set about finding out what information already exists. In doing so, one has to recognise that the park managers of North America have access to a far wider range of resources than their counterparts in Central Africa, and the means they have available differ widely.

Much of the information available about protected areas is spatial in nature, in other words it can be related to a particular location on the ground. Computer systems that handle this sort of data are called "Geographical Information Systems" (GIS). Richard Aspinall gives an introduction to GIS and its links with related technologies. He also provides examples of the application of GIS to nature conservation issues.

Managers have always taken decisions, but the nature of those decisions has changed as multiple and conflicting objectives increasingly characterise the manager's job. Axel Kravatzky looks at decision analysis for environmental management, reviewing the application of computer programs to the complex issue of taking the correct decisions.

While not all managers will be able to employ all of the tools described, this issue of *PARKS* aims to provide information on what can be done. However, it is important to remember that simple solutions can be as powerful as complex solutions – a library on site is as important as the use of Internet, a map on the wall can answer many questions without the use of a computer, and a management seminar or workshop will provide many managers with all the decision support they require!

Management planning in relation to protected areas

MIKE ALEXANDER

Management planning has become widely accepted as an essential prerequisite to effective safeguard and management of protected areas. There would be considerable advantages in applying a standard approach and uniform planning structure to all areas. However, the size of a plan and, perhaps more importantly, the resources made available for its production should be in proportion to the size and complexity of the area, and also to the total resources available to safeguard and/or manage the area. Management plans meet several essential functions. These include the identification of the objectives or purpose of management, the description of monitoring and management required to achieve the objectives and the identification/justification of the resource requirement. Finally, a plan can be used to demonstrate that management is effective and efficient.

PLANNING is a fundamental prerequisite to the successful management of our natural heritage and protected areas. Over the past two decades considerable emphasis has been placed on the development, trial, and eventually the application of planning systems. There have been similar developments in several different organisations and countries.

The management of any protected area, or species, should be much more an intellectual than a physical process. There is a great deal to consider and there are many conflicts to resolve. Even on the most sensitive and important of our natural sites there will be interests that may conflict with the ideal objectives of management. The manager will often have to accept compromise in order to obtain the best possible management of a protected area while, at the same time, ensuring that the interests of others are accommodated.

Management planning is a flexible, dynamic and uncomplicated process; each part or section leads logically to the next. Planning begins with the preparation of a description. This is fundamentally the collation of information to provide a basis for evaluation. The purpose of evaluation is to place a relative or organisational values upon each of the site features identified in the description. This, in turn, enables the identification of objectives or the purpose of management. Even on the least complicated protected area there will be many factors which may affect our ability to meet the objectives. These factors are often unpredictable and uncontrollable. They must be identified and considered alongside each objective. This will help to formulate an action plan. The action plan describes the work to be completed. The condition of the site and the impact of management is monitored and reviewed. Management is adjusted as required and will vary in response to changing site conditions.

Resource implications

There has been a long, tedious and almost meaningless argument regarding the resources required to produce management plans, with both sides failing to appreciate that the opposition had a good case. Plans can begin as brief outline statements, but, as further information becomes available, the plan will grow. There can be no doubt that managers of all areas should recognise the need, over the long term, to produce an exhaustive and definitive site description. However, this realisation has lead many managers towards the production of over-large, pseudo-scientific documents. They are often produced at great expense and, in many cases, divert resources away from the real objectives of site management. The process is analogous to the production of clay sculpture. The sculptor begins by constructing a wood and wire armature or skeleton. To this clay is gradually added and slowly the form begins to assume its final shape. The planning process must begin with a similarly strong framework and, as with the sculpture, the detail is gradually added. There is, however, one fundamental difference. The sculptor eventually completes his work; planning is never complete. Habitats and species constantly change in response to natural and man-induced trends.

The resources made available for plan production must be in proportion to the size and complexity of the area, and also to the total resources available for the management of the area. Thus, for small, uncomplicated areas short, concise plans will suffice. A plan should be as large as the protected area, habitat or species requires and no larger.

Monteverde Reserve, Costa Rica. A Spanish version of the Countryside Management System software is used in management planning for this reserve. Photo: Mike Alexander.

Why do we need management plans?

We recognise that planning is an essential component of virtually every human endeavour; conservation or countryside management should be no exception. In order to appreciate fully the need for planning, and perhaps to convert some of the antagonists, we must consider the functions of planning. The following are some of the most obvious and important functions of a management plan.

- **To provide a baseline and eventually a definitive description of the area.**

It must be the long-term aim of all managers to produce, as far as is ever possible, a definitive description of their area. The planning process does not require, or depend upon, the definitive, but the process is used to locate and collate available information, and, thereafter, identify the shortfall of data and the need for further surveys etc.

- **To identify the objectives of management.**

This is perhaps the single most important and obvious function of the planning process. It is essential that the objective, or purpose, of management is identified and stated. In other words, why are we managing this area? Only then can we ask and answer the question: is the management process effective?

- **To resolve any conflicts and prioritise the various objectives.**

Occasionally there will be an apparent conflict of interest and priorities. However, once the facts are assembled and a little logic applied, it usually becomes apparent that features are only very rarely equal in importance. It is essential that the planning process is recognised as the forum for resolving conflicts of management and allocating priorities to objectives.

- **To identify and describe the management required to achieve the objectives.**

Having established that a plan identifies the purpose of management it follows that it must also identify the process. Whenever a protected area or species requires safeguard, some action, i.e. management, will be necessary. This function must, therefore, be met in all plans. It is important that a manager can, at any time, relate the work being carried out in an area to the objectives of management. If no such relationship exists, then for what purpose is the work being undertaken? One of the benefits of planning is that it will preclude the possibility of managers acting on whim.

- **To identify and define the monitoring requirement and thus measure the effectiveness of management.**

Monitoring must be recognised as an integral part of management and planning. Failure to monitor will lead to a failure of management followed by a failure to safeguard the area or species. If a plan does not identify the need to monitor then it is not a plan.

- **To maintain continuity of effective management.**

An often heard comment is "all good managers hold a complete management plan in their head". Clearly many do, but they also move, or even retire, and they are certainly not immortal. The planning process can be compared to a road map; it identifies our destination and shows the route. Whenever we deviate from that route we waste time and fuel. In other words, we cannot afford to make changes of direction unless we have unlimited fuel and time. The management plan provides a route or direction for existing and, more importantly, new staff. This is essential for smaller voluntary organisations where management is carried out by a succession of staff and volunteers. The long-term continuity of monitoring systems is no less important than continuity of physical management.

- **To obtain resources.**

A management plan, in draft form, should be regarded, and used, as a bid for resources. If an organisation decides that it will not, or cannot, meet the total resources required then the plan must be modified.

- **To enable communication within and between areas and organisations.**

The planning process is dependent on the management and utilisation of data. Our ability to assess the condition of an area can be dependent on information obtained from external sources. Elsewhere, management techniques and procedures may be being developed and improved. This information would increase efficiency if it were available. Data collected in respect of the management of one area is often the external data required by other areas. Thus, given that the need to collect and manage data is a common requisite for all areas, there would be obvious advantages to all areas if these data were shared.

- **To demonstrate that management is effective and efficient.**

This is where we began. We must always be in a position to demonstrate that we are making the best use of resources. It is essential that we recognise the need for accountability.

Preparation and consultation

The preparation of all but the simplest plans should be undertaken as a team effort. No one individual will possess sufficient expertise in all the areas that require consideration. It is, however, essential that one person is given complete responsibility for the production of the plan. This role should be seen as editorial, and the most appropriate person for this position is, usually, the area manager. The author of the plan should have a good knowledge of the area, and understand the practical aspects of management and the interactions between different interests and features.

***Table 1.** CMS management plan contents.*

Preamble (policy statement)
Plan summary
Part 1 – description
1.1 General information
1.2 Environmental information
1.2.1 Physical
1.2.2 Biological
1.3 Cultural
1.4 Environmental relationships which may have implications for management
1.5 Bibliography
Part 2 – evaluation and objectives
2.1 Evaluation of features & Objectives
2.1.1 Evaluation
2.1.2 Summary of important features
2.1.3 The site in wider perspective and implications for management
2.1.4 Long-term/ideal management objectives
2.2 Factors influencing the achievement of long-term management objectives.
2.3 Operational objectives
2.3.1 Rationale and operational objectives
2.3.3 Limits of acceptable change
Part 3 – action plan
3.1 Outline prescription
3.3 Project register (descriptions)
3.4 Work programmes
Part 4 – project records and review
4.1 Project recording
4.2 Annual review
4.3 Long-term review
Appendices

Presentation

The need for a dynamic approach to planning has been discussed. It follows that if a process is dynamic, and subject to review and change, there can be little purpose in producing static, bound, permanent documentation. Many organisations have produced extravagantly-bound management plans; documents so precious as a result of the effort and cost of production that area managers are very reluctant to modify them. These documents are usually left on the shelf to gather dust. The best possible means of holding and presenting a plan is on a word processor. Ideally, there should be no need to print out the document. However, in reality people usually prefer reading text on paper. The organisation of the plan on a word processor is best achieved by creating a separate subdirectory for each individual plan. Within this subdirectory a separate file should be created for each section or subsection.

The contents of the plan should, whenever possible, follow the standard format (Table 1). It is important that the value of standardisation is recognised. A standardised approach provides a framework for consistent presentation and comparison between areas. It is important that individuals are not constrained by the format. There may be cases when it is necessary to include additional sections, and there will be cases where sections should be omitted.

Whenever appropriate, maps should be used to supplement the text. These may be included within the individual sections or, alternatively, placed at the end of a printed plan along with any appendices.

Recommended structure for planning

Figure 1 illustrates the structure of the most common and widely used management planning system. It is best described as having four main stages, but, in reality, is a continuum. The system is cyclical, but the loop is not closed to external influence, i.e. information from external sources will often be used to supplement or qualify local data. For example, an increase in a population of a rare species in a protected area can only be taken as an indication of successful management if the increase is restricted to that area and is not a general trend as demonstrated by global populations.

Part 1: description

This is fundamentally a collation exercise. All relevant data are located and arranged under various standard headings. This section does not call for the generation of data and need not be dependent on the completion of surveys or researches. Indeed, one of the functions of the section is to identify any short-fall in data. Collectively these data provide a definitive statement on the condition of an area. As with all survey data, they will only be good for a relatively short period of time. However, it is a crucial statement against which the effectiveness, or otherwise, of any subsequent management is measured.

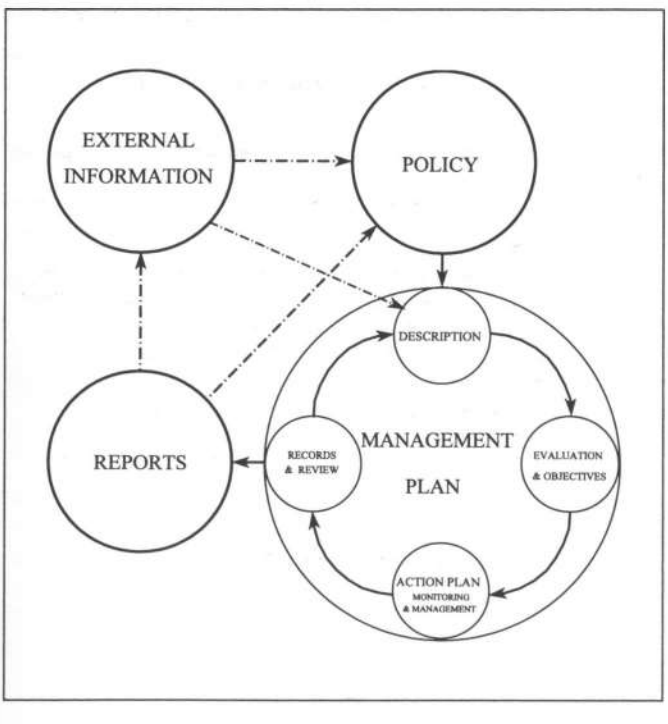

***Figure 1.** Typical management plan structure.*

Part 2: evaluation and objectives

This part of the plan begins with a statement on the recognised status of the area and proceeds through a structured evaluation process (Table 2). The evaluation criteria are based on the specified policies or requirements of the organisation responsible for managing an area. The evaluation is followed by the identification of the ideal objectives. Ideal, because at this stage the constraints which may prevent the achievement of objectives are not considered. The ideal is important; it may not be achievable within the short term, but will identify the long-term goals. Objectives should never be prescriptive; they are a statement of purpose and not process. The ideal objectives should stand for a very long time. However, the process by which the objective is obtained will often change even in the short term. Ideal

Table 2. Simplified data for one objective, taken from the management plan for Llaregub nature reserve, Wales, UK.

Summary description

Llaregub nature reserve is a grazed ancient oak woodland and boulder-strewn heathland with rock outcrops, situated on the northern slopes of Mynydd Mawddach.

It exhibits both geological diversity and topographical variety. The oak woodland is unique in West Wales for the way it overgrows numerous rocky tors of gabbro and dolerite. The site is of outstanding national importance for its lichen flora, being classified by the British Lichen Society (BLS) as a Grade 2 site (i.e. of highest national importance, grade 1 sites being of international importance) and described as an oceanic valley woodland with a rich western-type Lobarion community and exposed oak woodland of acidic character. Thirty recognised epiphytic and saxicolous communities and 363 species are recorded, including eight Red Data Book species and numerous regionally scarce species. Oceanic bryophytes and ferns are well represented. Invertebrate and vertebrate fauna are typical for this habitat in the region and include a number of Nationally Notable insects and populations of badgers and dormice.

There are numerous archaeological artefacts in the area including an iron age fort within the reserve and the adjacent Cwm Ifan Cromlech. These and the nature of the ancient woodland contribute to an atmosphere of great antiquity and long association with man.

Management is mainly directed at maintaining the woodland and associated communities. A programme of controlled grazing is a key component of management.

Management objectives and action plan

Objective 1 – Woodland

To maintain the nationally important semi-natural woodland and associated communities with main emphasis on safeguarding the nationally important epiphytic and saxicolous lichen flora.

Limits of acceptable change

Current representation of age classes (from coppice regrowth or natural regeneration) is not acceptable in terms of long-term woodland perpetuation. Management operations will provide suitable conditions for full range of age classes without compromising current status of lichen communities and species.

Detailed targets to be set for achievement of coppice regrowth/natural regeneration in next management plan review (1995). Woodland cover will be maintained at c. 34 ha. Alien tree species will be removed. Rank grass/scrub shading tree boles and rock outcrops within the wood will not be tolerated.

Positive management for associated fauna and flora will be undertaken without compromising the status of the lichen communities.

Note: It is not possible to set limits relating directly to lichens because i) they are affected by factors beyond control through site management, e.g. acid rain, and ii) lichen ecology is not completely understood.

Factors affecting achievement of objective

Positive:

Regeneration potential apparently good – seedlings of main tree species established in areas of woodland where stock excluded in spring.

Negative:

Stock grazing ultimately controls all regeneration at present (except in one small exclosure in north-east corner of NNR).

Continuing background levels of acid rain with sporadic peaks of industrially/agriculturally sourced atmospheric pollutants.

Neighbouring agricultural operations (potential eutrophication).

Main areas of work

Monitoring:

Monitoring programme for full range of epiphytic and saxicolous lichen communities.

Fixed point photography.

Tree enumeration (age class monitoring) programme, including regeneration monitoring.

On-site SO_2/NO_x monitoring programme.

Management:

Controlled grazing programme.

Thinning/coppicing/pollarding programme.

objectives are formulated to cover all aspects of management and include those which relate to cultural and religious values, landscape management, habitat management, species management, study and research, education and interpretation, and access and recreation. The objectives do not relate exclusively to the requirements of an individual area. They will also reflect a wider conservation strategy or policy.

Next, all the constraints and trends which may influence the ability to achieve the ideal objectives are identified. These include natural trends, external factors, legal constraints and resource limitations. All significant constraints are applied to the various ideal objectives. Discussion focuses on how the operational objectives may be achieved and the identification of appropriate management regimes. Occasionally, the factors affecting our ability to achieve the ideal objectives are so overwhelming that it may also be necessary to modify the ideal objective. At this point, the objectives are restated, with any modifications, and become operational objectives.

Traditionally, objectives have been rather vague statements. 'To maintain and improve', are words most often associated with objectives. Unfortunately, such statements beg the question – how will we know when the objective has been obtained? The objectives are statements which must clearly and unequivocally identify the required condition of all features of interest in an area. This means that the rather simplistic approach described above will not suffice. A further level of definition is required, it is at this stage that the Limits of Acceptable Change (LACs) are applied. LACs are used as a means of expressing a range within which a feature may be regarded as acceptable. Limits are used to define the condition of a feature or tolerance levels for factors which may affect a feature. For example, limits can be used to provide a range for a population or quantify the tolerance of an invasive alien plant species in an area.

Part 3: action plan

This part of the plan is used to describe all the work required to meet each individual objective. It commences by dividing the work into specific areas, called outline prescriptions. Each outline prescription is further divided into several clearly defined units of work called projects. These projects are used as the basis for the production of detailed work plans. All work, including recording and monitoring, carried out on the site, and all significant events, are recorded under the appropriate project headings. Projects are selected from a master list which provides a unique standard title and code for each project.

Llaregub nature reserve – see Table 2. Photo: Mike Alexander.

Part 4: records and review

This provides storage for project records and, consequently, all the data required for planning reviews. It is essential to review the management plan at predetermined intervals. The effectiveness of the plan must be measured by comparing achievement against the objectives.

The interval between major reviews will reflect the degree of confidence that managers have in their ability to manage the site effectively, or their confidence in the management plan. Thus, for robust areas with adequate resources and a good tried and tested plan the interval may be 10 years, but for fragile, under-resourced sites a review will be required at more frequent intervals. The plan should also have a minor review at annual intervals.

The Countryside Management System

Any successful management planning system will require the support of quite sophisticated data management systems. Computer databases provide an obvious solution. The remainder of this paper describes the Countryside Management System (CMS). Development of CMS commenced during 1989 with the intention of providing a database which could be used to support all major UK management planning systems. In response to extensive trials, within the statutory and voluntary conservation organisations, a much improved and refined version of the program was introduced during 1993. The development was, in part, funded from European sources with the intention of providing an international system. The system has been successfully trialled in several European countries and in Central America and Tanzania.

During 1993 a partnership comprising all major UK nature conservation and countryside agencies was established to provide, maintain, develop and promote CMS, and to set up and maintain a Support Unit to carry out the above objective. The functions of CMS are:

- To identify and describe, in a standard way, all the tasks of work required to achieve the objectives of management for a site or species
- To produce various work plans, for example, five year plans, annual plans, financial plans and plans for a specified category of staff
- To provide a recording system for all relevant data collected as part of the planned process
- To provide a site/species monitoring system and to monitor the effectiveness of the plan against the achievement of the objectives
- To facilitate the exchange of site management information within and between sites and organisations.

CMS is a project-based planning and recording system. A project is simply an unit of work, for example, 'construct a footpath', 'monitor a species' or 'patrol an area'. Each project is provided with a description of the work to be undertaken or, when a project has been completed, a report of the work which has been accomplished. A link is provided between

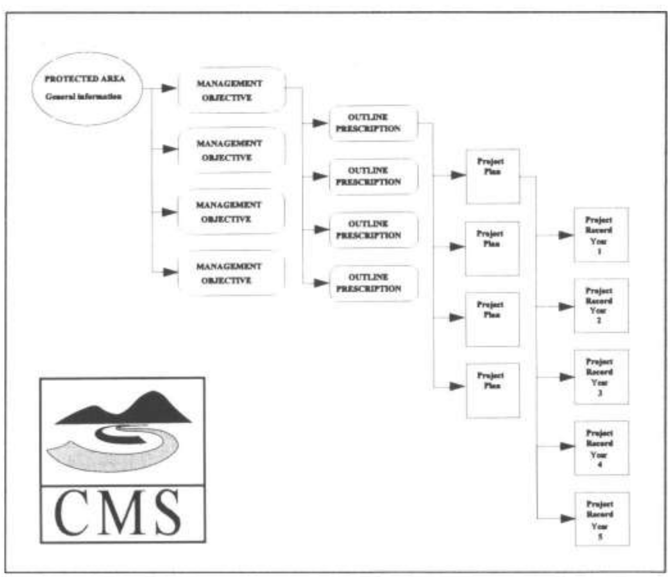

Figure 2. An outline of the main data structure used by CMS.

objectives and planned projects. Project records are retained in the system to provide a register of all site projects and also a project archive.

Data are entered on the computer as soon as they become available. The system can take care of all site recording, or be integrated with existing recording systems. Once data has been entered under the various project headings the computer can be used to generate a wide range of reports. These reports, including completed project record sheets and various work programmes, will more than adequately cover most reasonable requirements for site management information.

CMS is not conceptually complicated and is very easy to use. There is no requirement for previous computing experience. Full on-screen and supporting written documentation is available. Users familiar with the concepts of management planning can be trained to use the system in less than a day.

Even with the benefits of modern database application tools (such as fourth generation languages), the development of a relatively simple database application such as the Countryside Management System represents a considerable investment in terms of development time. Equally, for such a system to be worthwhile, it is essential that reserve managers find it of benefit and so are keen to use it, despite the initial time required to learn it. Experience with the development of CMS has shown that with the appropriate initial training, even reserve managers who have never used a computer before, and are against the idea, can become convinced that there are direct benefits to be gained from using such a system. This is of fundamental importance, as no 'directive' will make site managers enter data into a computer as carefully as if they are themselves convinced of the benefits.

In recent years, conservation and countryside organisations have begun to appreciate the importance of planning. If the lessons learnt by individual organisations are to be shared among countryside managers in general, then information must be made accessible. The first step is to get a standardised system that enables the information to be stored in a retrievable form. This is now starting to happen as site managers in different organisations use systems such as CMS for planning and recording on their sites. The next step is to combine some of this information so that it is accessible to a wider range of people working in conservation management.

CMS is simply a tool which aids and improves the way in which we manage sites and/or species. Its prime function is to promote efficient and effective planning and recording, and also to enable the exchange of information within and between organisations. These are essential components of any management process. An efficient system removes much of the tedium and can considerably improve the performance of site staff. This provides them with more time to devote to management and recording.

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Mike Alexander is employed by the Countryside Council for Wales, UK. Working closely with colleagues he led the development of CMS from concept and development to the production of the current version. He has delivered management planning training courses in the UK, Spain, Holland, Denmark, Eire, Costa Rica and Tanzania. The Countryside Management Support Unit, 60 Ffordd Pentre Mynach, Barmouth, Gwynedd, LL42 1EN, United Kingdom.

Finding the information

JEREMY HARRISON

Over the last few years there has been a revolution in the availability of information and in the development and application of tools for managing information. More and more organisations and more and more countries are being drawn into the so called *information superhighway.* Yet, at the same time, others are unable to get the information they need to do their jobs. This paper is concerned with the process of locating information, summarising some of the key methods for finding out what information is where, and obtaining it.

WE LIVE in an increasingly information-rich society. More books have been written than we can ever read, scientists have published more papers in more journals than most of us realise exist, and few understand the enormity of the information resource developing on computer networks. But sadly this information resource has several shortcomings.

- It is *neither uniform not comprehensive*; there is plenty of available information on the natural resources of some parts of the world, and very little on others
- It is *not equally available* to all, a protected area manager in North America can get hold of far more information than his counterpart in Central Africa
- It is *not appropriately organised* for many of the purposes to which it could be put.

Protected area managers meeting at the Fourth World Parks Congress recognised that individuals and organisations involved in protected areas work need better information on which to base their decisions (IUCN 1993). They went on to recognise that information on protected areas must be equally accessible to all interested parties and integrated with other relevant information, and made a range of recommendations concerning the need for better information and information management practice.

This paper is about accessing information, and is addressed chiefly to those trying to develop the information resources necessary to improve management of protected areas and protected area systems. The paper is general in its scope, because the range of experience of managers is so wide, and the resources available to them varies so widely. The paper is not concerned with setting up new research programmes to derive primary information, but in finding out what information already exists. It is hoped that the following sections give some useful pointers to those seeking information to support their activities.

Basic resources

Since much energy can be expended in compiling and managing information, it is first essential to identify what information is required. This will clearly depend on the purpose. Several papers in this issue of *PARKS* (Vol. 5 no. 1) identify information that may be required for management planning and decision making, and UNEP (1994) identifies the main types of information that may be required at the national level for effective management of protected area systems.

Compilation of this information may require the establishment of data collection programmes but, equally, much relevant information may already exist. There are four basic sources of information.

- The *management agency and its staff* will, between them, have a significant body of unpublished information on natural resources, their management, the effect of management practices, the impact of various external factors, and the value of the resource they are managing.
- *Scientists and other researchers,* both from within the country and elsewhere, carry out research within protected areas (or relevant to protected areas planning and management), and have been doing so in some cases for many years. Much of this information is published (see below) but equally much is not.
- Much of the information derived by both scientists and managers can be found in either *published literature* (books or journals), or the *'grey' literature* of unpublished reports. In the future we can expect to see an increasing proportion of this literature published in electronic formats.
- *Other agencies and citizen groups* also have much information that is of direct relevance to protected area management, although this may not be available in forms that can be easily used.

The easiest group to collect information from is those responsible for protected areas management past, and present. Even an unqualified ranger or labourer is likely to have spent considerably longer in a given protected area than many scientists, and will have information that can be useful. This is valuable information based on personal experience, and must not be lost through a lack of appreciation of that value. Mechanisms must be identified for obtaining and organising information from past and present employees, whatever the form of that information.

Having benefited from working on a particular site or group of sites, scientists and other researchers have a moral obligation to support management objectives by allowing the information they have collected to be used in planning and management. Managers must ensure that, as a matter of good practice, scientists working in their areas provide copies of all publications, and other useful materials derived from their work (such as species lists or habitat maps). In the longer term, they can also encourage scientists and other researchers to carry out research that provides the information required (see, for example, Harmon 1994).

Mackinnon *et al.* (1986) recommended that park managers maintain a *reference centre (or collection)* which would include the information collected by parks staff and visiting research workers over the years. This remains a sensible recommendation, and one that, while it requires no great outlay of resources, provides a resource for use by managers and researchers alike.

In theory, published literature is easy to obtain. It is held in libraries, and information on available literature is accessible through a range of bibliographic tools ranging from abstract and index journals to major databases (see, for example, Box 1). There are also a number of very useful bibliographies covering certain themes or regions (for example RBG/WCMC 1990). In practice, in many

Box 1.

Dialog

Dialog describes itself as "the world's most comprehensive online information source". It comprises over 450 databases containing over 330 million articles, abstracts and citations, covering a wide range of topics with particular emphasis on news, business, science, and technology.

The Dialog services which are of potential relevance to park managers include:

- References to and abstracts of articles from more than 100,000 international publications on science and technology, social sciences, and humanities
- Full text of articles from more than 2,500 journals, magazines and newsletters
- Full text of over 60 newspapers and stories from a range of wire services.

This information is accessible over computer networks through a search language common to all databases on Dialog. Dialog is also available through many libraries, and can be contacted directly to provide information on particular subjects. All these services are charged for at standard rates.

parts of the world, published literature is less available than we would like to think, either through distance from library facilities or through cost.

Information from other agencies and citizen groups may be very pertinent, and pooling information provides a powerful synergy. This is covered in the next section. However, such information is not always easy to obtain as a result of differing priorities and inter-agency rivalry or mistrust.

National information strategies

A majority of countries have now signed the *Convention on Biological Diversity* (UNEP 1992). The convention explicitly recognises that the conservation of biological diversity requires the development and implementation of national strategies and action plans (Article 6). In turn, development of these strategies and action plans requires the development of improved mechanisms for information collection and management (Article 7), since without adequate information it is difficult to develop effective strategies and action plans and without information on the implementation of those plans it is impossible to assess how well they are being implemented, or what adjustments in the actions may be necessary.

Nations therefore have the motivation, if not the means, to develop national information management strategies which address information needs, the source of that information, the means of collecting it, the means of managing it, and mechanisms for delivering it to those who need it. Those managing protected areas at both site and system level have a significant role to play in the development and application of such an information strategies, and these will in turn increase the information available for protected area management.

No country yet has a perfect information management system, with the appropriate information available to whoever needs it, but there are some significant developments.

- The Environmental Resources Information Network (ERIN) in **Australia** has developed a valuable information centre in the Australian context (see Box 2), but even more valuable has been much of the conceptual work they have done on how to develop such information networks.
- The National Biological Service and the National Biodiversity Information Centre in the **United States** are both struggling with some of these issues, while the State Heritage Programs developed by The Nature Conservancy maintain significant information on the distribution and status of natural features right across the country.
- In **India**, the Indira Gandhi Conservation Monitoring Centre is beginning to draw together information from the many programmes around the country working in natural resource management and inventory.

All these efforts, and those in many other countries, are moving towards the improved availability of information. Under the auspices of the *Convention*

Box 2.

Environmental Resources Information Network (ERIN)

The Australian Prime Minister, in his 1989 Statement on the Environment "Our Country, Our Future", announced the establishment of ERIN "to draw together, upgrade and supplement information on the distribution of endangered species, vegetation types and heritage sites".

ERIN aims to provide geographically related data of an extent, quality and availability required for planning and decision-making. Their programme is based on cooperative efforts with those agencies interested in environmental information and effective decision-making.

Through its computer network, ERIN is progressively building up a holistic picture of the current state of knowledge about the Australian environment, drawing data together from a wide range of disciplines. This information is available for use in many subject areas including policy definition, education and research.

on Biological Diversity, UNEP is working with a range of organisations to facilitate this process – to provide assistance to countries working to improve their information management processes. The first stage of this has been to work with WCMC in the development of four key products.

- *Guidelines for Conducting an Institutional Survey*, which provide guidance in the assessment of the capacity of existing national institutions to support biodiversity information management. These guidelines cover cataloguing existing data holdings, description of the flow of data between institutions, and assessment of information management capability.
- A *Generic Data Flow Model*, to place biodiversity information management in an overall framework, and to show the relationships between the different components of biodiversity data, from its collection through to its use in national strategy development, planning, and monitoring.
- *Guidelines for Good Biodiversity Information Management Practices*, which take the form of a set of generic information management principles, with examples of approaches and standards in various key areas of biodiversity information management.
- A supporting materials *Resource Inventory*, which will provide improved identification of and access to information on relevant organisations, standards, software, information sources, tools, technology, models and methodologies. The Inventory will take the form of a series of meta-databases (i.e. databases holding information about other datasets; see "Relevant datasets" below) and directories accessible electronically and as printed and/or digital media.

All these products build on existing experience, seeking to promote the best practices and to share lessons learnt. They also promote the concept of commonly accepted information management standards, which is key to the sharing of information.

International information 'centres'

There are various international centres which have specialist knowledge and experience that can be accessed by managers of protected areas and protected area systems. Some of these, such as WCMC, are established as information centres. Some, such as BirdLife International, have a thematic specialisation that ensures that they have key information in certain areas. Some, such as the European Environment Agency, have information relevant to particular international agreements and their implementation.

- **WCMC** provides information services on the conservation and sustainable use of species and ecosystems (see Box 3), and supports others in the development

Box 3.

WCMC Protected Areas Programme

WCMC is continuing a programme of activities begun in 1981 to maintain and network information on the world's protected areas. This work is carried out in close collaboration with the IUCN Commission on National Parks and Protected Areas, and with the secretariats of several international initiatives including the World Heritage Convention and the UNESCO MAB Bioshphere Reserves Programme.

WCMC compiles the *UN List of National Parks and Protected Areas* (IUCN 1994), published *Protected Areas of the World* (IUCN 1992) for the World Parks Congress in Caracas, Venezuela, and publishes a range of regional and thematic protected areas directories. These are based on an extensive database and library, developed through the Centre's collaboration with a wide range of contacts in all countries.

The information collected as part of this programme forms the basis for an information service on protected areas that supports the work of others. This service ranges from the provision of single statistics to briefing material on the protected areas of particular regions. WCMC also helps national agencies to find the information they need, on one occasion even providing a national park with a copy of the management plan it had lost!

of their own information systems. WCMC is established and jointly managed by IUCN, the World Wide Fund for Nature, and UNEP.

- **BirdLife International** aims to promote the conservation of birds. Three key areas of their work require substantial information resources: identification of threatened species, identification of important sites for the conservation of those species, and identification of mechanisms for conserving birds in the wider landscape.
- The **European Environment Agency** is responsible for monitoring the implementation of the European Union's directives of birds and habitats. This requires the collection of certain information from national authorities, adding to the substantial database developed as part of the European Union's CORINE programme.
- The services provided by the **Southern Africa Research and Documentation Centre** include a database and library on the region's environment, a fact sheet and briefing papers on key environmental issues, and bibliographies (Mavuso 1993).

Information about information

Where the required information is not already available, extensive searching may be required to identify what information exists, and where it may be found. This sort of study forms part of the 'institutional survey' identified in the previous section, but applies equally to individual sites. The key stages of such an exercise are to identify the relevant institutions and information, by questionnaire or interview.

Institutions which hold the relevant information

- Basic details (who, where and function)
- Available resources (human, technical and financial)
- Key linkages (who currently works with who, and how).

Relevant datasets

- Description of datasets (what, purpose, format and how managed)
- Coverage (geographic, thematic, timescale, completeness, limitations and gaps)
- Access (availability, cost, formats available and documentation).

A number of organisations maintain 'metadatabases' for particular purposes. Metadatabases are databases which contain information about information – they identify who has what information, where (largely in the form identified above). For example, the NASA *Global Change Master Directory* was established to maintain information for scientists on the location and content of datasets relevant to studies of global change, concentrating on the physical aspects in particular. WCMC is working with the

Box 4.

Availability of Biodiversity Information for East Africa

Launched at the 1992 conference "Conservation of Biodiversity in Africa", this project was an extensive survey of the sources and types of information held on the biodiversity of Kenya, Tanzania and Uganda by organisations both within and outside the region. The project was jointly implemented by the IUCN East Africa Regional Office, WCMC and key national institutions in each of the three countries.

Information was collected using a standard questionnaire. Within the region the questionnaire was completed at most institutions (about 1,000) during interview. Outside the region, the questionnaire was mailed to 1,000 institutions, and 'posted' on global electronic bulletin boards.

A total of 350 questionnaires were returned, allowing development of:

- A metadatabase on the sources and types of information available
- A printed report with summary information and a catalogue of sources (IUCN/WCMC. in press)
- A searchable electronic version of the published catalogue of sources.

This information is leading to increased use of the available information, and an increase in collaboration between various of the institutions.

Consortium for International Earth Sciences Information Network (CIESIN) to extend this into the fields of biodiversity and conservation.

Many simpler exercises have studied what information exists where. For example, the Council of Europe has, in the past, reviewed existing databases on nature conservation in Europe, and the European Environment Agency is now developing a Catalogue of Data Sources. A review has also been undertaken of the biodiversity information available for East Africa (see Box 4).

Internet sources

Computer information technology has developed rapidly over the last few years, potentially bringing to our desks information resources undreamt of until recently. While all the information required by protected area managers might not yet be available through this source, development is so rapid that managers need to be aware of the possibilities.

One of the most powerful computer communications advances is the development of the Internet, which is the most widely used network for science (recent estimates indicate millions of users). A number of programs and services are available through the Internet to enable organisations to manage their own information and to retrieve information from others. The most commonly used features include:

- *Email*

  Electronic mail or email does not require the use of the Internet by individual users, but the Internet is a major component in the email network. Email greatly facilitates contact between individuals, and also allows sending and receiving computer files. Email can be used to facilitate delivery of information services such as contents pages of journals.

- *List Servers*

  This a an extension of email, where users can decide to be on mailing lists for particular topics. Individuals subscribing to such lists receive all messages sent to the list by other subscribers. This facilitates email discussions on identified topics of interest to the participants. For example, all protected area managers within a country could have their own list server for discussing matters of mutual interest.

- *Anonymous File Transfer Protocol (FTP)*

  This is a network tool that enables users from different sites to access computer files and browse them or bring them onto their own computer. This makes it a powerful tool for data exchange. There are several tools which have been developed to assist FTP users in finding the desired data, for example *ARCHIE* is a tool for locating files at remote sites by filename search.

- *Gopher*

  Used to locate and retrieve available files from other linked computer systems through the use of a graphic interface. Its use is quite straightforward, and information is located independently of the site where it is residing.

- *World Wide Web (WWW)*

  This retrieves information resources via interfaces which use an 'intelligent text', technically called hypertext. Using these interfaces, called up from known addresses, the user 'clicks' on desired words, phrases or objects, and the WWW system displays the linked information (which may be on the same WWW server/ interface or another across the other side of the world). WWW handles data, images, text and sound.

The best way to describe how these tools can revolutionise the location and retrieval of information is to give some examples of WWW servers developed by a range of organisations. Much of the information available though these servers is also available through Gopher and Anonymous FTP.

- *ERIN* has developed a good example of a WWW server at the national level <URL: http://kaos.erin.gov.au/erin.html>. There is a wide range of information on the natural resources of Australia and on their management at state and federal levels. This information is compiled from a range of national and international sources, and in a number of cases links direct to the WWW servers of those sources.
- *Missouri Botanic Garden* maintains a WWW server describing their activities and including significant information on the plant species of certain parts of the Americas <URL: http://straylight.tamu.edu/MoBot/welcome.html>.
- The journal *Biodiversity and Conservation* produced by Chapman and Hall is now available at their WWW server, along with a number of other publications. The release of published work over the Internet by publishers is a very significant development.
- *WCMC* has developed a WWW server that both describes the work of the Centre and gives examples of many of the services and products that the Centre provides <URL: http://www.wcmc.org.uk>.
- The WWW server compiled by the Fletcher School of Law and Diplomacy, Massachusetts, USA, includes copies of the texts of a substantial number of international agreements relating to environmental issues <URL: http://www.tufts.edu/departments/fletcher/multilaterals.html>.

There are various 'search engines' for finding information available on WWW servers, the most familiar being the *Web Crawler* and the *World Wide Web Worm*. In addition, many of the better WWW servers already in existence provide lists of other servers with related information. In developing the project described in Box 5, WCMC has used all these sources to locate information on protected areas.

Box 5.

Protected Areas Virtual Library

A rapidly growing number of agencies are using the Internet and the World Wide Web to make information on protected areas more widely available. WCMC is developing a "Protected Areas Virtual Library" to facilitate access to these resources by providing one 'home page' or menu from which they can all be reached.

Firstly, WCMC staff have reviewed all of the WWW servers they are aware of which have relevant information. They have also 'visited' many of the other servers identified as being potentially useful by other Internet users. Finally, they have used the so-called 'search engines' to search WWW home pages using a range of relevant key words, such as national parks, reserve, protected area.

This service, which is being developed in collaboration with the IUCN Commission on National Parks and Protected Areas, will be launched during April 1995 and anyone with Internet access will be able to use it.

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Jeremy Harrison is Head of Information Services at the World Conservation Monitoring Centre, after working for 13 years as Head of its Protected Areas Programme. WCMC, 219 Huntingdon Road, Cambridge, CB3 0DL, UK. Email: <jerry.harrison@wcmc.org.uk>.

Geographical Information Systems: their use for environmental management and nature conservation

RICHARD J. ASPINALL

Geographic information is of importance in environmental management and for nature conservation. Geographical Information Systems (GIS) are described and discussed from two perspectives: 1) as a technology comprising geographically-referenced data, managed with computer hardware and software, and 2) as an approach to analysis based on application of a geographic perspective. Examples are given illustrating the use of GIS to develop geographic information for use in answering questions relevant to environmental management and nature conservation. Links between GIS and the related technologies of Global Positioning Systems (GPS) and remote sensing, and the use of GIS to link environmental data with socioeconomic data for development of multiple perspectives on issues, are briefly described.

GEOGRAPHIC INFORMATION is becoming increasingly important in nature conservation and environmental management as pressures grow on natural resources, and with greater concern for sustainable use of resources and conservation of biodiversity. Geographic information is also becoming more easily managed and used with the advent of Geographical Information Systems (GIS). Associated technologies such as Global Positioning Systems (GPS), and remote sensing platforms that provide large amounts of data about the earth's atmosphere and surface, are also more widely available and contribute to the application of GIS to environmental issues.

Geographic information

The nature and use of geographic information is central to this review and to understanding of the application of GIS, since much of the emerging importance of GIS is associated with three different roles for a geographical perspective on data and environmental issues. First, geographical data contain a powerful reference base (geographic location) which can be used for data collection and data storage. For example, maps are a familiar medium for storing a wide variety of data; soil, land cover, topography, climate, vegetation, geology, rivers and other data are routinely recorded and used in map form. Maps locate phenomena on the earth's surface and the inherent geographic reference provides a way in which these data can be captured and stored in a computer. In this sense GIS manages geographically referenced data in the same way that a word processor manages text. The use of a geographical reference system to locate features also allows diverse data to be combined and compared through a single database, as all data share the same reference system. Second, a geographical perspective provides a context for analysis of relationships in a dataset and for examining associations between different phenomena. For example, the climatic conditions with which a plant species is associated can be analysed using digital maps of the species distribution and climatic conditions. This type of analysis can offer insight into processes operating in the environment. Third, a geographic perspective is a powerful and effective way of communicating information. Pattern is readily seen in maps yet the same data presented in a table is obscure.

In this paper I briefly describe GIS as a technology comprising computer hardware, software, data and human resources. Related technologies of GPS and remote sensing will be included, since many of the technical possibilities of GIS arise from integrating these three technologies. Second, I extend the description of GIS to applications in environmental management and nature conservation. This is based on a different perspective: GIS is an approach to analysis of data that unlocks information through application of a geographic perspective. This makes GIS rather more than a technology; it is, however, where the real power of GIS lies. Some of the generic issues associated with GIS and geographic information will be apparent through the applications discussed, notably the importance of scale, and the accuracy (or reliability) of data and analysis. These issues are the focus of much current research effort in geographic information science (Goodchild 1992) and environmental scientists are providing an important lead (see, for example, Michener *et al.* 1994). Lastly I shall extend the discussion to consider the potential for integration of socioeconomic and cultural issues with environmental issues through the use of GIS.

GIS has been a valuable tool for assessing potential distribution and conservation requirements of the chequered skipper butterfly (Carterocephalus palaemon) *in the UK (see page 25).* Photo: Jim Asher.

GIS as a technology

The most widely used definition of GIS is technological: GIS is a computer-based system that captures, stores, manages, analyses and displays spatially-referenced data (i.e. data which refers to a particular location or point in space). All these functions have applications in environmental management and nature conservation. Some are alternative (and easier) ways of doing things that have traditionally been carried out manually using paper maps, tables of data and cartographic techniques. Others, especially analysis and display, replicate existing techniques and offer new opportunities. Some recent developments in analysis and modelling applied to environmental data are described below, notably predicting the distribution of wildlife species under present and changed environmental conditions, understanding the interaction of habitats and other aspects of ecological infrastructure within landscapes using methods based in landscape ecology, and interpreting biodiversity for use in land use planning and management.

Data

The data that are used in GIS include maps, satellite images, air photographs, tables of data collected on surveys, and, increasingly, photographs, video and sound (Cassettari and Parsons 1993). Examples of some of these data include topography, soils, geology and land cover as maps of various scales, Advanced Very High Resolution Radiometer (AVHRR) imagery with a 1 km spatial resolution, LANDSAT Thematic Mapper with a resolution of 30 m and SPOT with a 10 m resolution, tables listing species recorded on a nature reserve, and chemical and physical properties of soil types recorded on soil maps. The variety of data potentially able to be entered into GIS is large (Maguire *et al.* 1991).

For all data, the criterion for inclusion in GIS is that they be referenced to a geographic location (for example through latitude and longitude, or one of the national map referencing systems that operate in different countries). Location is one of the fundamental links that allows the GIS to be used to access and search its database, replicate map-related operations traditionally carried out manually using cartographic techniques, and that allows geographic inter-relationships to be processed and analysed. GIS recognises geographic location as both a property and context for data and data analysis. As with all computer systems, the data are fundamentally important since these limit the quality of output. In GIS, location is an additional property of data for which quality is important.

Maps are probably the most widely used form of data that are entered into GIS, although they are not without their problems since maps are a cartographic representation of real world phenomena rather than the data themselves. The cartographic process simplifies and modifies data and maps are often produced to illustrate trends and patterns without being an accurate record of either the data on which they are based or the location of the features being mapped. Nevertheless, maps are captured into GIS by digitising, a process of converting map features (points, lines and areas) into digital format using an electronic table, a cursor, and software that links the digitiser with the GIS database. Data also have to be edited and processed in the GIS during conversion to digital format to ensure that the appropriate database linkages are present. This process attaches a certain amount of intelligence to the data in the database and distinguishes GIS from Computer-Aided Design and Computer-Aided Mapping (CAD/CAM) Systems. The form of intelligence allows, for example, lines representing stretches of a river to 'know' that they connect to form the river and that water can flow in a particular direction, or areas representing a forest to 'know' that they are a coherent, identifiable block of land and that the neighbours are other land cover types (for example, grassland or water).

Recently, Global Positioning Systems (GPS) have revolutionised data capture for GIS. GPS fix position on the earth's surface using triangulation on a network of satellites that are in orbit above the earth. In differential mode, when a triangulation site on the earth's surface is used in conjunction with the satellite network, horizontal and vertical location can be fixed to within one or two metres; this is a much greater positional accuracy than is possible using a map and, given the importance of location in GIS databases, has an important contribution to use of GIS. GPS provide a cheap, accurate and accessible method for locating position on the earth's surface; GPS units are small and can easily be attached to a vehicle, placed in a backpack, or be carried during field survey work to locate position. Field data capture is eased as points, lines, and areas are digitised directly from the earth's surface without the need for a cartographic intermediate product. This use of GPS coupled with GIS should improve the locational accuracy of data in GIS databases and allow efficient and effective field surveys. An additional benefit is that data are incorporated into databases very rapidly since they are collected in digital format. As data capture is an expensive and time consuming process – it is likely to be four or five times more expensive than the computer hardware and software that are used for the GIS – GPS can help to make data capture more efficient and, relatively, much cheaper. That the locational information is of improved quality is an additional benefit. An example of combined use of GIS and GPS is found in the Laikipia Elephant Project that is mapping the movements of herds of African elephant on the Laikipia plateau in northern Kenya (Michelmore 1992). This project was established by the Kenya Wildlife Service in collaboration with the Zoological Society of London, World Wide Fund For Nature, and the Gallman Memorial Foundation with assistance from the United Nations Environment Programme/Global Environmental Monitoring System/Global Resource Information Grid and the Laikipia Research Project. GPS and radio telemetry are used to add data for elephants to a database containing data on hydrology, land use, land ownership and other themes to understand how elephants use the area and to help find ways of reducing conflict between humans and elephants.

Output

Output is an important part of the opportunity provided by GIS. Using GIS to produce map output provides great flexibility for cartographic communication as colour, design, and overall appearance of output can be rapidly and easily changed. Of course, the quality of the input data should be a prime consideration in deciding what is a valid output from GIS, but the software tools provided allow output to be tailored so that it communicates effectively. Computer screens further extend the variety of output and allow interaction between the users of geographic information and the database and output. Many GIS are at the heart of decision-support systems which support analysis of land use change, climate change and habitat change scenarios. The possible environmental and biological impacts of change in habitats within a region can be explored using the GIS database, analytical models that describe potential impacts of change, and the computer display. This provides rapid, interactive feedback on possible impacts and can lead to insights into ecological processes and environmental impacts. The speed with which new analyses can be carried out gives GIS an important educational role and can act to focus both analysis and discussion of an issue such as habitat change.

Human resources and GIS management

The final, and in many ways critical, aspect of GIS from a technological perspective is the human resource that maintains and operates the whole system. GIS software is seldom simple. The ability of a GIS to manage, search, and analyse its database by use of absolute or relative location as well as by theme or property is based on a complex data structure, incorporating multiple geographic layers and attributes. Many GIS also rely on powerful computer hardware and the software is specialised. Some GIS software provides over 1,000 functions (e.g. ARCINFO from ESRI based at Redlands in California) and is therefore technically complex to use and requires specialised training. As described above, capturing data into GIS is also costly and must be carried out efficiently with a view to its intended uses. In this context, GIS operators and users often need to be specially trained in aspects of database design and management, and in operation of the particular software and hardware to be used. This makes people an important resource as part of the operation, support, management and application of GIS in an organisation. Additionally, some of the GIS-based analyses described below from applications in environmental management and nature conservation require an analytical perspective that derives from geography rather than computer science. A geographic information perspective on GIS is discussed further in the next sections.

Although this technological description of GIS gives an idea of many of the associated management issues, GIS is primarily an applied technology whose purpose is providing 'useful' information. Environmental management and nature conservation provide an opportunity for application of GIS, and have begun to make exploration and analysis of ecological and environmental relationships possible at a range of geographic scales. This has practical applications in land and resource management, as well as in strategic and regional planning. The ability to produce geographic information at appropriate scales provides extra relevance to information obtained from databases, and the flexibility in presentation and communication of results that is inherent in computer-based displays increases the utility of a GIS-based approach. Some of the more innovative applications of GIS in environmental management use modelling coupled with the detail in the database. Examples are presented below.

GIS as an approach to data analysis

Many data relating to environmental and ecological systems have been collected and stored in forms suited to management and analysis using GIS. Sightings of plant and animal species have been recorded at biological records centres and mapped to indicate the geographic ranges or other limits on the different species. This of course, is not new – mapping and measurement have been carried out for many years. A GIS automates and thereby eases such processes, making them quicker and easier; the GIS also offers flexibility in generating output. The principle advantage of GIS is in the variety of other data that can be integrated with the biological record data – for example soils, land cover, geology, and climate – and used to investigate a wide range of questions. Over the last few years GIS has had better facilities for data management than data analysis, although this situation is changing and new facilities are being developed specifically for use in environmental applications. One reason for this change is the awareness of global issues and a need to understand questions that apply at this large scale. Environmental databases and remotely sensed data that continually add to the information base describing the earth's environment provide an opportunity to answer global questions. A benefit is the development of methods that can be applied in GIS to answer a wide range of environmental questions at many scales, depending on the availability of data. Local scales of analysis can use the techniques being developed at larger geographic scales.

Mapping and modelling geographic distribution

The simplest class of analysis with GIS is mapping and measurement within a single dataset. Records of a species or habitat can be stored in a database and mapped to show where they occur. This geographic information can be used to target surveys and monitoring schemes (Margules and Austin 1991). A map of a habitat type shows where the type occurs and GIS can also be used to measure the area of the type. Data on species or habitat distribution from different dates allows the locations of change (where) to be identified and their extent (how much) to be measured. Comparing geographic data in GIS also allows analysis of relationships. An example of this is bioclimatic analysis which has its basis in ecological theory describing relationships between species distribution and environmental characteristics, notably climate. This is of interest for predicting possible impacts of climate change on wildlife although the methods developed to compare distributions have a much wider application in analysis of environmental issues with GIS.

Bioclimatic analysis aims to characterise the climatic environment of a species to gain an understanding of possible causes of species distribution and predict the theoretical limits of its distribution. The climatic environment is identified through comparison of a dataset describing the geographic distribution of a species with a geographic dataset describing the variation in climatic variables (temperature, rainfall etc.). The two questions asked by bioclimatic analysis define the outputs required: quantified relationships between climatic variables and the response of the species being investigated (why is the species where it is?) and geographic information, possibly as maps, indicating the likely distribution of the species or the climatic regime in which it occurs (where might it occur?). A wide variety of techniques have been developed and incorporated into GIS to address these questions. Lindemayer *et al.* (1991) describe the use of BIOCLIM, a purpose-written analytical system that models the distribution of species from 24 bioclimatic variables derived from climatic data developed in a GIS database. BIOCLIM has been used to model the distribution of a variety of species and taxonomic groups in Australia, e.g. snakes (Nix 1986). Other methods include statistical and spatial analysis methods (Aspinall 1992).

Figure 1 shows an example of a bioclimatic analysis for the chequered skipper butterfly (Lepidoptera, Hesperiidae: *Carterocephalus palaemon*) in Scotland, UK. The output is based on a model that examines the way in which the climatic regime for chequered skipper changes on a month to month basis throughout the year, the map being the area in which the climate is suitable in all months of the year. The model suggests that the species is restricted to a relatively small area in the west of Scotland. This output successfully models the distribution of chequered skipper – all

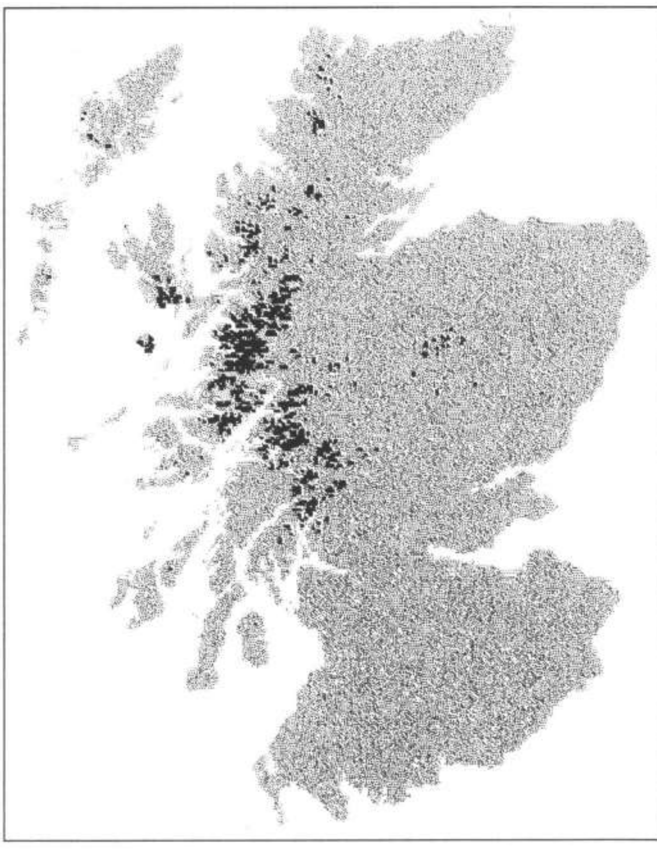

Figure 1. *Map output of the predicted distribution of chequered skipper butterfly in Scotland, UK. The map is based on the climatic regime of the species modelled by comparing the distribution of chequered skipper butterfly recorded by survey with climate data for each month of the year using GIS.*

records of the species in Scotland are from this area – and suggests that climate may be responsible for the restricted distribution of the species in Scotland. The analysis in this example is based on monthly mean climate data that have a geographic resolution of 1 km. The analysis of the distribution of chequered skipper is considered further below to illustrate another aspect of GIS-based analysis.

Bioclimatic analysis has applications in regional, national, continental and global scale analysis of environmental relationships and for modelling possible impacts of changes in climate. More generally, the use of GIS-based analytical modelling to investigate environmental relationships at larger geographic scales is leading to a significant understanding of the way in which different environmental factors influence the distribution and abundance of wildlife. This understanding would be difficult or impossible to gather using conventional field-based scientific experimentation. Many of the techniques used for bioclimatic analysis have a much broader application within environmental management if data that will support their use in answering questions about environmental relationships are contained in the GIS database.

The most common situations in which application of these modelling approaches is useful is when the distribution of a species or habitat is not fully known but when environmental data that are thought to influence the species or habitat distribution are recorded more comprehensively. Models of the distribution can be constructed and used in several ways. They can be used to predict where survey effort may be targeted, to provide insights into environmental relationships that are of use in developing inputs to management and strategic plans, to be used as substitutes for full surveys of the species in analysis of biodiversity at a regional scale, and to predict possible impacts of environmental changes. The ability to predict possible impacts of environmental changes within a computer environment is especially useful since it is neither possible nor acceptable to carry out real world experiments to measure these impacts. The exploration of possible outcomes from scenarios of environmental change within the model world of a computer can provide significant insight into important processes and give evidence that can be used in discussion of alternative environmental management options.

Data showing species and habitat distribution, or sometimes models that predict these distributions as above, are also used to analyse the effectiveness of existing national park and other conservation designations. The Gap Analysis system being developed in the USA uses GIS to identify significant areas of habitat and parts of the geographic range of a species that are not protected by any form of conservation designation (Scott *et al.* 1993). Distributions for a range of species are modelled with GIS using maps of vegetation types and observations on the distribution of the species of interest. These distributions are combined within the GIS to identify areas of greatest diversity or core areas for the different species. This composite information is then compared with the distribution of protected areas to highlight significant areas for the species that are not within any form of protection. This approach begins to treat the ecological infrastructure as part of a networked system of areas that interact in geographic space; this principle is taken much further in GIS-based techniques that are based on landscape-scale ecological principles.

GIS and landscape ecology

GIS is increasingly being used for analysis of environmental and ecological relationships through development of techniques that couple the geographic information handling and analytical capabilities of GIS with the principles of landscape ecology (Haines-Young *et al.* 1993). These analyses have particular application in environmental management and planning for species and habitat conservation. GIS is used to describe and interpret geometric properties of landscapes, leading to understanding of the complex interactions between different landscape components. This use of GIS is based in the framework provided by landscape ecology (Forman and Godron 1986) which provides theoretical and analytical approaches to integration of environmental and biological features at a range of geographic scales. The main principles are directed towards structural, functional and dynamic elements of landscape, each of which can be analysed using GIS-based techniques. Structural elements of landscape include patches and corridors of habitat as well as the environmental matrix in which patches and corridors are located. Measures of these elements describe their size, shape, number, type and configuration (contiguity and connectivity). Contiguity describes the neighbours of a patch of habitat while connectivity describes the way in which different areas of habitat are connected in the landscape. Both of these are important since they describe the context for areas of habitat and provide an opportunity to analyse interaction of individuals, populations and habitats across larger geographic areas. They are fundamental to use of GIS to examine the geographical context of nature reserves at a range of geographical scales.

Functional aspects of landscape ecology focus on movement and use of the structural elements by organisms. Since the distribution of a species in a landscape is a product of both landscape structure and social behaviour, both environment and

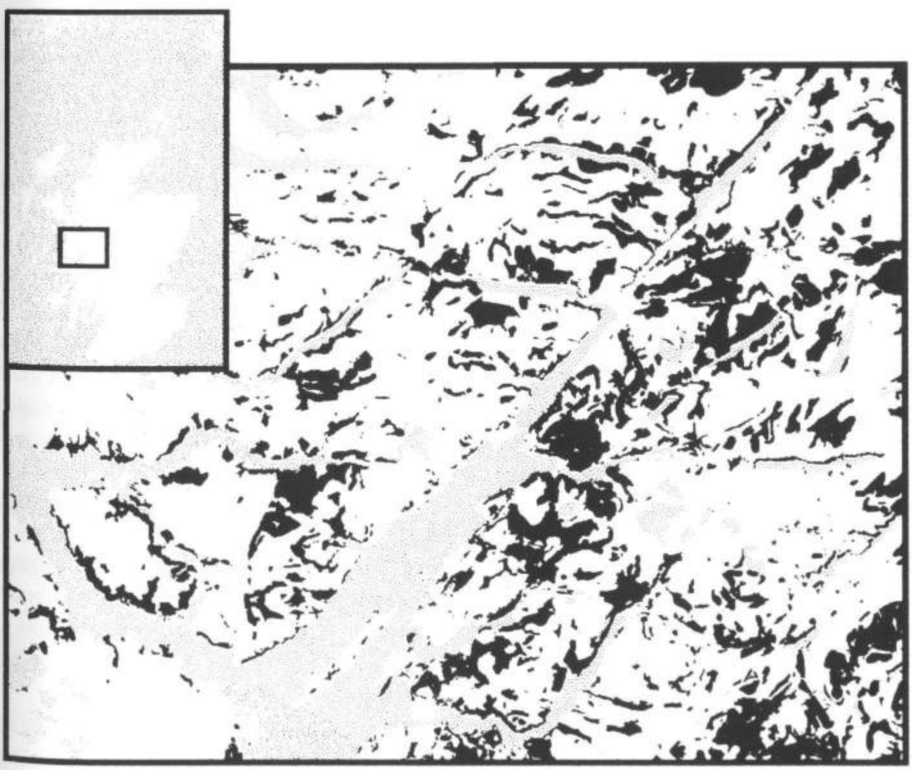

Figure 2. *Map of output of the predicted distribution of chequered skipper butterfly within its range on the west coast of Scotland, UK. Patches of habitat suitable for the species are shown in black (water is shown in grey). The distance between patches and their organisation in the landscape can be used to develop additional geographic information of use for planning habitat management to help conserve the species.*

species ecology can be considered under functional factors. The final element of landscape ecology is temporal. This includes the dynamics of landscape use by organisms and changes in landscape structure through time.

Figure 2 gives an illustration of the use of structural, functional and dynamic measures for analysis of the distribution of the chequered skipper butterfly at a landscape scale. The habitat patches mapped are based on analysis of the distribution of the chequered skipper butterfly compared with a detailed GIS dataset of land cover types mapped from 1:24,000 scale air photographs. The patches of habitat are within part of the area shown in Figure 1 which models the distribution of this species from 1 km geographic resolution climate data. The two analyses are complementary, Figure 2 showing the distribution at a different geographic scale to Figure 1. For this species, the two analyses suggest that although climatic factors are sufficient to restrict it to this general area on the west of Scotland, within this area it is further restricted to particular habitat types, particularly damp pastures combined with deciduous woodland (Thomson 1980). The geographic association of vegetation types is clearly important for the species. A further landscape ecological analysis can be carried out on Figure 2 from knowledge of the biology of this species. Although males do not move far, the females may move up to 2 km from the main site (Thomson 1980). Knowledge of these distances can be used within the GIS to identify patches that are separated by less than this distance. This technique identifies two types of patch and provides geographic information with relevance to landscape-scale habitat management for the species. Patches separated by less than the dispersion distance form groups that can be treated as functionally connected, while patches and patch groups that are more than this distance from other patches and patch groups are functionally isolated. These groups are different for males and females of chequered skipper. The significance of this GIS analysis showing the geographic context and interaction of patches is in three parts. First, it suggests areas in which biological populations may be isolated, with consequences for long-term survival. Second, it identifies specific patches that are most important in terms of inter-connection between individual patches. Removing these patches may fragment remaining populations. Third, it suggests habitat changes that may encourage greater inter-connection of populations, by habitat creation and management at strategic locations to increase connectivity.

Analytical descriptions of habitat at landscape scales using GIS provide geographic information that can be used to link with ecological studies of species population dynamics and provide an opportunity to develop detailed analyses of biological and spatial interaction at landscape and other scales (Turner 1990). The geographic and biological information this produces has direct application in environmental planning and management and in nature conservation. Designation and management of sites and areas can be based in understanding of wider geographic and ecological impacts and relationships based on the particular conditions found in individual geographic areas.

Biodiversity

An aspect of nature conservation that deserves special attention in the context of GIS is analysis, measurement and planning related to biodiversity. Maintenance of the maximum degree of biodiversity is an important objective for nature conservation (Bridgewater 1993). Geographic data can play a significant role in biodiversity assessment, species lists for sites, databases, and models of species distribution providing inputs to analyses whose outputs show the relative contribution of different sites to biodiversity at different geographic scales. A geographic context for analysis of biodiversity is particularly important in assessing the importance of sites within local, regional, national and international geographic and political contexts. In Australia, Walker and Faith (1993) have developed a GIS-based approach to analysis of biodiversity. This links species lists for different geographic locations with other geographic data describing the location of nature reserves and geographic variation in environmental conditions. The relative contribution of each nature reserve to biodiversity at different geographic scales is analysed by comparing the contribution of species present in each nature reserve to the diversity of species represented by the network of reserves. The importance of each reserve to the biodiversity represented by all the reserves makes a contribution to understanding the importance of each area in a larger geographic context. GIS-based models of species distribution such as those described in Figures 1 and 2 can provide input to this analysis of biodiversity and are useful in regional planning and exploring the strategic importance of different geographic areas. Linking analysis of biodiversity in nature reserves based on species lists with landscape ecological analyses of functional interaction between reserves (as in Figure 2) and the ecological context of reserves in terms of habitat in areas outside reserves provides a more comprehensive assessment of the importance of designated areas.

Linking environmental and socioeconomic data and analysis with GIS

In addition to giving a geographic context to environmental information, GIS are being used to link environmental data with socioeconomic data (Maguire *et al.* 1991). The power of geographic location as a reference base for data collection, storage and analysis of environmental data applies equally to socioeconomic data. For example, surveys and censuses of economic and social topics such as population, employment, industrial and urban development can be georeferenced and analysed in GIS. Other socioeconomic data can be measured by field survey or from maps and are directly analogous to soil, vegetation and altitude data for capture, storage and use in GIS. Examples include transport networks, industrial infrastructure, and historic monuments, as well as planning and other designations of land; the criterion is that the phenomenon be referenced to geographic location. GIS integrates these very different datasets within a single analytical system and allows environmental and socioeconomic data to be related and analysed together as easily as species distribution can be related to climatic data or vegetation to soils. A general example of the combined use of environmental and socioeconomic data within GIS is found in efforts to understand the impacts of ecotourism in particular geographic areas (Mathieson and Wall, 1982). Development of physical and socioeconomic infrastructure to support tourism must be integrated with careful management of environmental resources. Many of the data on which this integration is based are geographic and GIS can play an important role at both strategic and management scales.

A further class of examples considers what may happen in the future and comes from some of the research into possible impacts of global climate change. For example, predictions of impacts of change in climate are used to predict possible changes that may be forced in agricultural land uses. These changes will have consequences for human populations and for environmental issues and understanding these issues at global, regional and local scales is an area in which GIS is finding increasing application (Michener *et al.* 1994).

Relating environmental and socioeconomic data with GIS depends on clear definition of the question (or questions) to be answered and of the way in which geographic information contributes to developing answers. This guides both the use of GIS for analysis and the form of presentation of output. Output can feed back into questions and this iterative analysis of an issue helps develop clear understanding from a range of perspectives, easing communication and giving geographic information that helps in constructive discussion and resolution of issues. The use of a combined environmental/socioeconomic database for geographical analysis in environmental issues is increasing as sustainable development becomes a greater priority and as awareness grows of the inter-dependence of socioeconomic and environmental systems.

Conclusion

The use of GIS for analysis of environmental systems, either alone or integrated with socioeconomic systems in the ways described above, depends on establishing both the technology (with databases, hardware, software and human resources) and the use of geographic information for problem solving. The efficient fusion of these two perspectives on GIS is an important function of management of GIS within an organisation and also places an imperative on GIS design. This involves careful planning of the development of GIS based on the expected uses of the system within an organisation. Time and effort spent on this are rewarded with a powerful facility for information management, analysis and presentation that support many of the questions that are asked. As a technology GIS is relatively well developed. The use of geographic information in environmental management is progressing rapidly and will benefit from increased use by those who have a practical need to understand environmental issues and communicate their solutions.

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Dr Richard Aspinall is currently Head of the GIS and Remote Sensing Group at the Macaulay Land Use Research Institute (MLURI) in Aberdeen, Scotland. His research interests include developing and applying GIS and spatial analysis for resource assessment and wildlife ecology. MLURI, Craigiebuckler, Aberdeen, AB9 2QJ, UK.

HIVIEW and EQUITY: decision analysis for environmental management

AXEL J. KRAVATZKY

Multiple and conflicting objectives, uncertain or incomplete information, and multiple interest groups frequently characterise the decisions environmental managers must take. Difficulty in decision making arises when there are several feasible courses of action none of which is best overall. The range of decision problems which fall into this category includes: the choice between different courses of action to deal with a particular environmental problem, the development and implementation of a unified strategy for an organisation, the choice between several investment options, the allocation of resources and budgeting, or prioritisation modelling for projects.

The branch of decision analysis that uses multi-attribute (or criteria) value theory (MAVT) provides a set of formal techniques that are appropriate to deal with such situations. At the London School of Economics two computer programmes, called HIVIEW and EQUITY for Windows™, based on MAVT have been developed and used over the last 13 years. They have been employed most frequently in a decision conference environment, where a trained facilitator assists groups of decision makers and interest group representatives in tackling difficult and complex problems facing their organisation.

HIVIEW or EQUITY assisted decision processes provide a balanced view over a wide range of criteria, where hard data is integrated in a rigorous manner with subjective data. They also provide an audit trail of the way decisions were reached which can be revisited as values change over time. Furthermore, a shared understanding of the issues, a sense of common purpose, and commitment to action among participants is created.

This review uses the development of a licensing scheme for the fishery in the Danube Delta, Romania, to outline the techniques employed and to provide an example of the use of HIVIEW. EQUITY is illustrated through a hypothetical resource allocation problem.

DECISIONS MADE in environmental management often have to integrate and satisfy a variety of objectives, such as nature conservation, economic interests, local community interests, and financial considerations. Seldom does any one course of action satisfy all the objectives completely, and difficulty in choice between options arises when no one option performs best overall. These difficulties in comparing options stem from the fact that some of the criteria used for comparisons do not have precise measurement units (e.g. conservation value, political acceptability) or accurate values are not available. In addition various interest groups usually have differing opinions as to which factors are most important and what their values should be. Multi-attribute (or criteria) value theory (MAVT) and decision analysis provide a set of formal techniques that help in such situations. The basic (iterative) procedure is as follows: (1) define the options and the criteria representing the objectives pursued; (2) evaluate each option separately on each criterion; (3) assess the relative importance of the criteria; (4) combine the weighted scores of the single-criterion evaluations of the options to obtain an overall evaluation of the options; (5) perform sensitivity analyses and make recommendations (von Winterfeldt and Edwards 1986).

At the LSE, two computer programmes based on MAVT, namely HIVIEW and EQUITY[1], have been used in decision conferences over the past 13 years. Such conferences consist of one to three day meetings in which decision makers and interest group representatives are assisted by an outside trained facilitator in addressing difficult decisions or strategy issues affecting their organisation (see Phillips 1990).

The main benefits of HIVIEW or EQUITY assisted decision processes are that they lead to a balanced view over a wide range of criteria, where hard (e.g. financial) data is integrated in a rigorous manner with subjective data. The method also provides an audit trail of the way a decision was reached which can be revisited as values change over time. Furthermore, a shared understanding of the issues, a sense of common purpose, and commitment to action among the participants is created. HIVIEW is the more suitable of the two when the problem is one of choosing between different management options. It helps in the definition, analysis, evaluation and justification of complex decisions. EQUITY, on the other hand, is designed to help in resource allocation, budgeting, and prioritisation modelling. In this review I will use the development of a licensing scheme for the fishery in the Danube Delta as an example of the use of HIVIEW, and a hypothetical resource allocation problem to illustrate the use of EQUITY.

HIVIEW: the Danube Delta fishing licences case study

The Danube Delta is the largest and least damaged wetland in Europe. In 1990 it was declared a Biosphere Reserve under UNESCO's Man and Biosphere Programme. In 1993 a technical assistance and investment programme[2] started for the newly created reserve authority (DDBRA). The focus of the programme is the promotion of sustainable development for the inhabitants of the delta.

Fishing in the Delta has always been very important as a source of income and for subsistence. However, as a result of pollution and habitat destruction the fish population in the delta has declined significantly. Equally worrying is a dramatic change in the fish species composition over the last 25–30 years: it has shifted from a perch (*Perca fluviatilis*) type community to one dominated by bream (*Abramis* spp.), pike (*Esox lucius*), and perch. In the Delta, as in the rest of Romania, the transition from a highly centralised, state run, economic system to one of private enterprise and competition brought with it uncertainty and confusion. As new companies emerge and others are being restructured, ample scope and incentives have developed to circumvent regulations. As a result data on real fish catch and effort used have become very unreliable, making management of the fishery sector near impossible.

[1] HIVIEW and EQUITY for Microsoft Windows™ are distributed through Enterprise LSE, London School of Economics, Houghton Street, London WC2A 2AE, United Kingdom. Tel: +44 171 955 7128. Fax: +44 171 955 7427. They are available as DOS versions but not for the Apple Macintosh. It is possible to purchase the applications as one-offs, multiple copies, site or global licences. Training courses (software as well as decision analysis concepts and techniques) and consultancy services are also offered.

[2] This programme is financed in the framework of technical cooperation agreed between the Commission of the European Communities and the European Bank for Reconstruction and Development. It is implemented by Euroconsult and IUCN.

In 1993 the law governing the Biosphere Reserve, which asserted that the DDBRA was responsible for governing all activity in the Delta, was passed by parliament. However, while the legal position of the DDBRA was clarified, opinions remained very divided on the causes of the difficulties in the fishery sector and their implications for management. Disagreement was not confined to specialists: for example, after the DDBRA tried to implement a licensing system based on auctioned fishing zones, they were met with a wave of protest from companies, fishermen, and local government. Various objectives were pursued by the different groups involved. The Biosphere Reserve governor wanted clear and simple policies based on scientifically established facts which took account of political and economic interests; managers were concerned with the integration of the other Biosphere Reserve management plan elements; technocrats wanted simplicity; local government wanted to keep political and economic influence; fishermen wanted to maintain the current system where they obtained all gear and salary from the monopoly companies and which tolerated black market trade; companies wanted to consolidate their position; and researchers wanted to do objective and independent research.

In order to develop better alternative licensing schemes in line with the overall objectives of the Biosphere Reserve the executive director of the DDBRA (who had received some training in decision analysis during a study tour in London) decided to call a decision analysis workshop where specialists and interest group representatives were brought together. The work method adopted was a series of three-day preparatory workshops, coordinated by the author, and a two-day decision conference in which the author assisted a decision facilitator from the London School of Economics as a decision analyst, with on-the-spot computer modelling using HIVIEW.

The decision conference

The participants in the decision conference were the staff of the DDBRA, the Danube Delta Research Institute (DDI), a Dutch fishery consultant, a company director, and the DDBRA's legal advisor. The conference opened with a discussion on the fundamental objective of the DDBRA and the group eventually agreed on the following formulation: "Nature conservation and restoration of nature (maximisation of conservation value)". They then went on to identify more immediate objectives, or means objectives, through which they were going to achieve the fundamental one (see Figure 1).

Table 1. *Possible licensing schemes agreed at the decision conference.*

1. **Current**	Maintain status quo.
2. **Proposal**	License areas to fishing companies, licence fee on obtained catch; companies are monopoly distributors.
3. **Direct**	License quotas to fishermen, licence fee on quota, inheritable and transferable; distribution through auctions.
4. **Distribution**	Increase revenue to companies by improving distribution so that they can pay fishermen more.
5. **Association**	As 2 but allow associations to be licensed.
6. **Margin**	Extend contract length to 20 years (investment security) and promote smaller companies and individual gear ownership, also auctioning (competition).
7. **2 Improved**	As 2 but fee on quota licensed.

Licence scheme development

On four adjoining posters the present regulation system, the original controversial proposal worked out by DDBRA and DDI, and four additional options were displayed in table format, using as column headings the areas where the DDBRA had a choice between different courses of action[3]. All of the participants were able to formulate their own proposals, explain the rationale to the other participants, and modify them easily. Seven licensing schemes were eventually agreed as possibilities (Table 1).

The model

The facilitator used the discussion about the advantages and disadvantages of these licensing schemes to construct the value tree in Figure 1 that expressed the value-relevant objectives and criteria for comparing alternative licensing schemes.

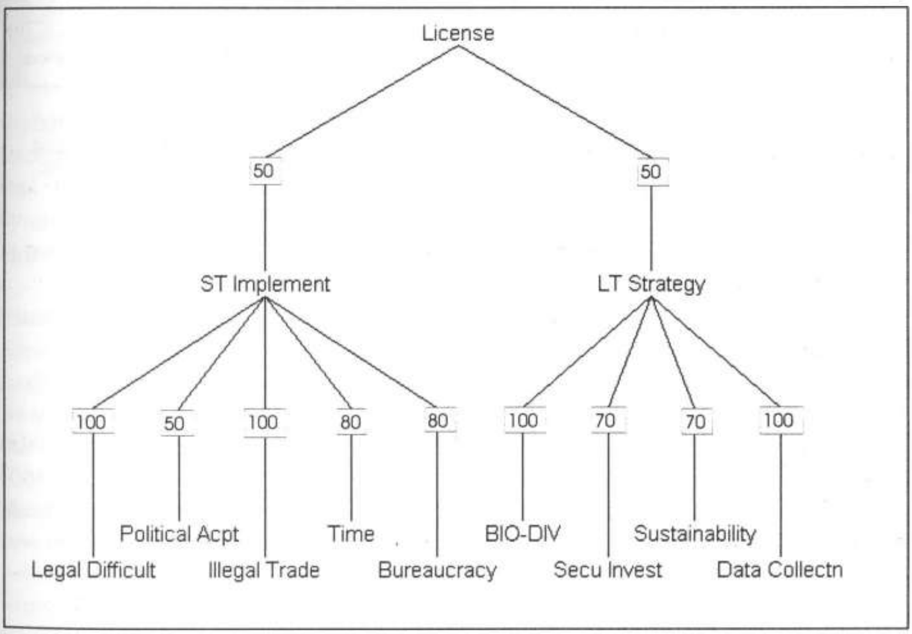


Figure 1. *Value tree and weights of final model.*
The bottom level criteria capture the main differences between the licensing schemes (political acceptability, bureaucracy, and security of investment were added during the last stages of the conference). The two upper level nodes express the main concerns of the DDBRA, i.e. to be able to implement and improve the situation in the fishery sector in the short term (ST) and to fulfil the longer term (LT) strategy objectives. The figures in the boxes show the relative importance or weights given to the criteria.

Evaluating the licensing schemes

When modelling with HIVIEW, a liquid-crystal-display screen was used with an overhead projector so that the analysts' work on the computer could be followed by all participants. After the value-tree was agreed participants began to score the licensing schemes on each of the criteria in turn. For example, Figure 2 shows that auctioning licences for quotas, i.e. **Direct,** was judged to be the most effective system for reducing illegal trade because it provided fewest economic incentives to

[3] The method used to elicit these 'areas of opportunity of choice' was based on Friend and Hickling (1987), who call them "Decision Areas".

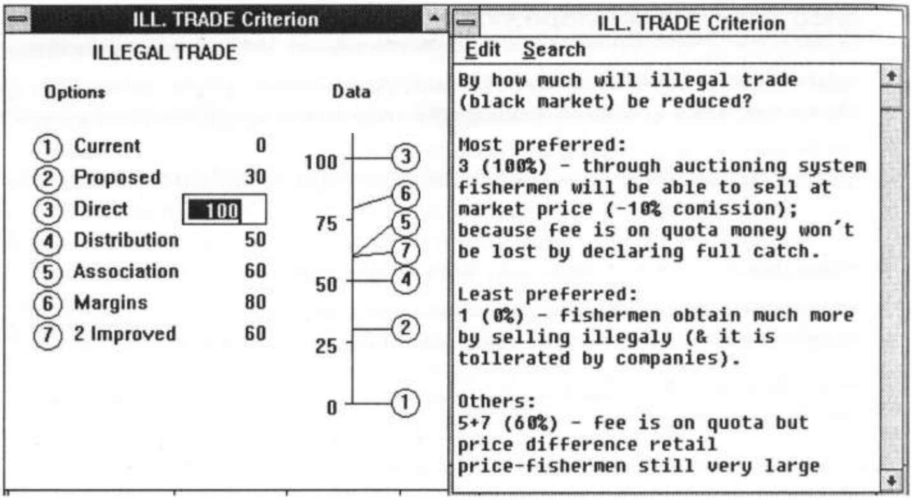


Figure 2. *Illegal trade thermometer.*
Relative preference scales, where 100 represented the most preferred option, and 0 the least preferred one, were used to evaluate the performance of all options on each criterion. Notes, capturing the rationale for the scores allocated, were entered in the adjoining window.

sell on the black market, while the **Current** system was least preferred on this criterion.

The remaining licensing schemes were scaled between these two extremes (**Direct** and **Current**) such that differences in the numbers reflected the importance of the differences in short-term illegal trade reductions. For example, **Association** was scaled at 60 because its difference from **Current** (0) was judged to be one and a half times as important as its difference from **Direct** (100). Similarly, the importance of the difference in illegal trade reduction between **Association** (60) and **Proposed** and between **Proposed** and **Current** (0) was judged to be equal. Therefore **Proposed** was scaled at 30. To ensure consistency and an equal-interval scale other differences were compared. Revisions were made so that the scales reflected the group's views accurately. If the group could not agree or was unsure of a particular score, this was noted for further exploration in the sensitivity analysis phase.

Assigning weights to the criteria

Once all the licensing schemes were evaluated on all criteria, the relative importance of each criterion had to be determined. The weights given to the individual criteria represent the importance of the differences between the top and the bottom of the scales. For example, Figure 3 shows that the difference between **Direct** and **Current** in improving data collection was judged to be 80% as important as the difference between their effect on biodiversity. One can also say that the weights express the trade-offs between the scales: moving from 0 to 80 on the data collection scale is equivalent to moving from 0 to 100 on the biodiversity scale. This simple paired comparison technique, known as the swing weight method, is often used to help groups assess weights.

Weights were then normalised, by dividing each by their sum so that the numbers add up to 1.0. A weighted average of the scales derived from these normalised

LT STRATEGY Node

Add

BRANCH	WGHT	Current	Proposed	Direct	Distribution	Association	Margins	2 Improve	CUM
* BIO-DIV	100	0	60	100	60	100	80	80	20.8
* SUSTAINABL	60	0	60	100	50	70	80	60	12.5
* DATA COLLEC	80	0	40	100	50	80	80	60	16.7
TOTAL		0	53	100	54	86	80	68	50.0

Figure 3. *LT strategy scores and weights.*
Relative importance weights are entered in the WGHT column. The performance of the different options on the three criteria are listed here in the rows and serve as consistency checks.

weights was then shown in the TOTAL row of Figure 3. The last column, CUMWT, showed the calculated overall weight each criterion had in the complete model. In this way, the weighted averages of all long-term strategy (LT) criteria provided a single LT scale, and similarly a single short-term implementation (ST) scale was constructed.

First analysis

As a result of the weighting process each licensing scheme is characterised by a single LT and ST number. Using these numbers the group created a scatter plot of ST implementation versus LT strategy and compared all licensing schemes for their abilities to satisfy the ST and LT objectives (Figure 4).

Figure 4 shows that scheme **Direct** was most attractive in terms of LT goals while **Margins** scored highest on ST criteria. Only these two would have been chosen, depending on the trade-offs between ST and LT; however, **Association** and **2 Improved** (which was better than schemes 1, 4, and 2, on both ST and LT) were close enough to the upper right-hand corner that they could still be considered.

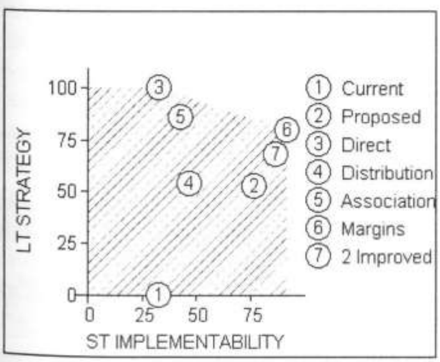
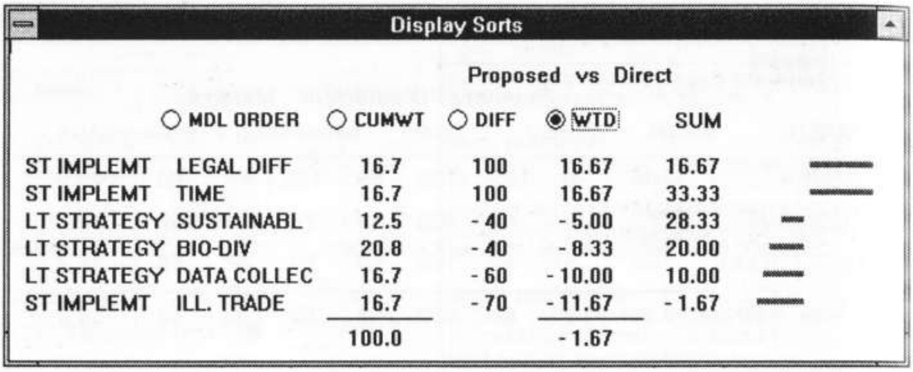


Figure 4. *Scatter plot of ST implementation versus LT strategy.*
Each option is characterised by a weighted-average number for ST implementation and LT strategy performance. The edge of the shaded area is known as 'the frontier'. Options 3 and 6 are both potentially best, depending on the weight one places on ST and LT (the optimal strategy would be in the top right-hand corner).

In order to get a better understanding of the differences between the licence schemes the group then examined from which criteria the options drew their comparative advantages and disadvantages. For example, in the table of Figure 5 the criteria are sorted with respect to the degree that they favoured **Proposal** over **Direct**.

This analysis tool permitted the group to compare all the licensing schemes with each other according to the


Display Sorts

Proposed vs Direct

		MDL ORDER	CUMWT	DIFF	WTD	SUM
ST IMPLEMT	LEGAL DIFF		16.7	100	16.67	16.67
ST IMPLEMT	TIME		16.7	100	16.67	33.33
LT STRATEGY	SUSTAINABL		12.5	-40	-5.00	28.33
LT STRATEGY	BIO-DIV		20.8	-40	-8.33	20.00
LT STRATEGY	DATA COLLEC		16.7	-60	-10.00	10.00
ST IMPLEMT	ILL. TRADE		16.7	-70	-11.67	-1.67
			100.0		-1.67	

Figure 5. *Sorted criteria of* ***Proposed*** *versus* ***Direct****.*
Proposed *trails* ***Direct*** *by 1.67 points. The weighted difference scores (WTD) of the criteria are displayed numerically and graphically.*

cumulative weight scores (CUMWT) of the criteria, the unweighted differences of the scores within the criteria (DIFF), or the weighted differences (WTD) as in Figure 5. **Direct** had advantages over **Proposed** in four of the six criteria, the biggest being on the ST criterion 'illegal trade'. This was because fees were based on the quota auctioned and fishermen sold their fish through auctions, where they would be expected to receive a much higher price than under the current company monopoly system. However, one of the big disadvantages of **Direct** was that changes in law would be required before its implementation. In order to overcome this drawback the group came up with the idea of starting a pilot project which would be used to fine tune the system and muster public support while the necessary changes to the law were pursued.

Developing better schemes

From the insights gained during the decision process the group was then able to construct two further schemes (Table 2). The first (8) contained all the advantages of the previous schemes, even if it meant that because of the law immediate introduction was not possible. The second (9) contained as many of the features of 8 as were possible while remaining immediately applicable.

Table 2. *Further licensing schemes developed through the decision process.*

8	**Best Strategic**	Area and/or quota licensing, auction catch, fee on quota, co-management of stock.
9	**Phased Strategic**	Area licensing (including smaller complexes for small companies) + fixed fee (in instalments, indexed) + introduction of 8 as pilot.

From discussion it emerged that the schemes differed in several other important ways, so the first value tree was enlarged with three new bottom-level criteria (political acceptability and bureaucracy for ST implementation, and security of investment for the LT strategy) (see Figure 1).

With two further licensing schemes and new criteria in the model, all the options were re-evaluated, noting always the doubts and uncertainties of the group. In ST versus LT space (Figure 6), one could then see, as expected, that scheme 9 was in the top right hand corner. It was just as good as 8 on LT, and while a little bit worse than 6 on ST, it was much better on LT than the latter.

Depending how much weight one placed on ST and LT one would then adopt either **Margin (6)** or **Phased (9)**. **Best (8)** was not a possibility because of the current legal position. HIVIEW's sensitivity analysis tool then made it quite easy to determine the distribution of weight at which either of the two licensing schemes would be chosen (see Figure 7).

While there was some discussion over what the appropriate ratio of weights between ST and LT should be, nobody thought that more than 75% of the model weight should be placed on ST Implementation. Therefore scheme 9 was proposed for adoption.

Finally, the robustness of the model was tested through a series of further sensitivity analyses exploring all the areas where the group had expressed uncertainty. HIVIEW makes use of the Windows™ environment possibility of keeping several views open at the same time so that the effects of changes in one area (scores or weights) could be seen immediately in the rest of the model. In this way it was easy to determine whether the new proposal (9) was sensitive to small changes in scores and weights. This was not the case so that at the end of the second day the group was confident that they had developed a licensing scheme that met the objectives of the Biosphere Reserve. Even though they were not able to resolve all their differences in opinion in the course of the two days, they did agree on a common solution. The decision conference then came to a close with an eight-point action plan.

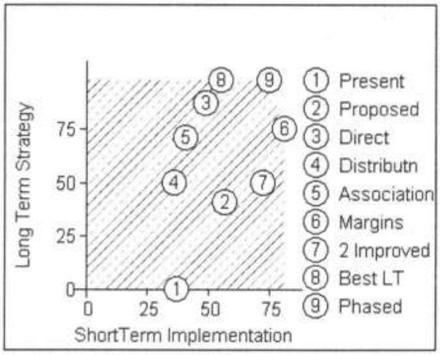


***Figure 6.** Scatter plot ST implementation versus LT strategy, final model. Because the final option (9) built on the advantages of the other options it is in the top right-hand corner of this graph.*

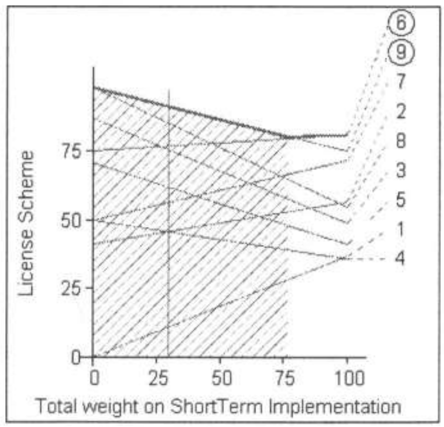


***Figure 7.** Sensitivity analysis on total weight given to ST implementation. The vertical line at 30% indicates the proportion of total weight of the model placed on ST implementation. In this case option 9 would be chosen. Only if this weight would be increased to over 75% (implying less then 25% for LT strategy) would option 6 be chosen.*

The most important outcome of the decision conference was that the executive director, who had called the meeting, was now confident that he could present a better proposal to the governor, at the final integrated management planning seminar of the technical assistance programme, and to the public. If in the course of these consultations, he should find that particular points are disputed he could make the changes in the model and see what effect they would have.

The value tree used in this model was very simple. In another decision workshop held in the Delta (on management options for a lagoon which contains endangered

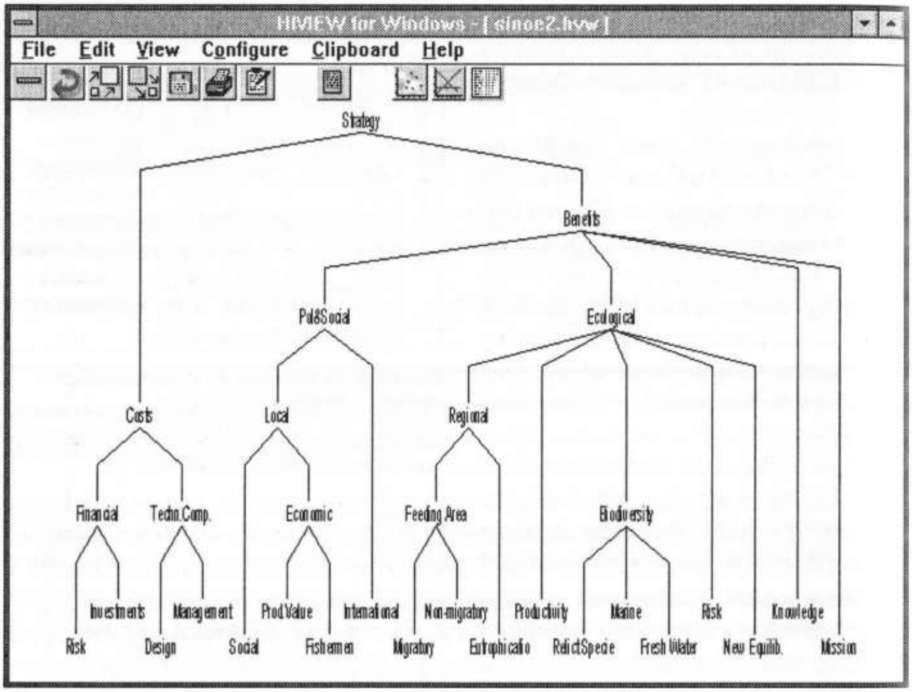


Figure 8. *Value tree developed in decision conference on an endangered lagoon. An example of a more elaborate value tree.*

species) 19 bottom level criteria were used with 11 nodes at various levels (see Figure 8). There is, however, no inherent advantage in constructing a complex model. The aim in this type of facilitated group work is to help all individuals, and the group as a whole, model their view of the problem in such a way that new insights are gained and progress is made on a difficult problem. In this case study, for example, the top level split between ST implementation and LT strategy provided an important pivot point for the discussion.

EQUITY: a resource allocation example

The sister programme of HIVIEW is EQUITY for Windows™. It too is based on MAVT but is designed to help management teams build a shared understanding of the issues facing their organisation when there are many different competing uses for resources but relatively few benefit criteria. The programme facilitates the efficient and systematic integration of a number of discrete workable plans, which have defined costs and benefits, in a way that maximises the benefit for the whole organisation. Particularly in large organisations, where for some time budgeting may have been done on an incremental basis, inequalities of opportunity in terms of possible benefits and associated costs or risks usually develop, so that although individual departments may do the best with the limited resources available to them, gains to the organisation as a whole remain below optimum (this is a form of the well known 'dilemma of the commons': "unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational self-interested individuals will not act to achieve their common or group interests" –

Olsen 1965). To overcome this dilemma the inequalities of opportunity must be identified and capitalised upon. This involves the evaluation of alternative uses of the resources against the organisations' objectives, judging trade-offs between the different budget categories and objectives, and the selection of options to create a portfolio which collectively makes the best use of the available resources.

EQUITY allows the construction of a model (containing objective and subjective measures) which displays all possible combinations of resource expenditures in the form of a cost–benefit graph. From this it is then possible to examine the various combinations which produce the greatest benefit for a given amount of costs. The following is a hypothetical example given to illustrate the use of EQUITY.

A Research Institute had standard annual contract for environmental research work and was due to receive a substantial grant from a multilateral agency. The overall goal of these funds was to widen and improve the research that the DDI does. The difficulty was knowing and agreeing on which areas the money would be best spent. In addition, the director of the Institute believed that, if convincingly argued, he could obtain a larger share of the total amount of money available in this aid project for his Institute. He therefore called a one-day decision workshop with the institute's department heads which coincided with a visit of the expert mission in charge of the aid project.

As a first step the director asked the heads of the computing, biology, socioeconomics, and fishery departments to prepare descriptions of the strategies they would employ assuming that they all received an equal share of the total currently allocated. They were also asked to consider alternatives that would require significantly different amounts of finance. Figure 9 indicates the various plans developed by each department. Fisheries, for example, planned to widen their research if they received an equal share of the total grant allocated. If they had less, they would have to restrict themselves to more sampling, but if they received more than an equal share they could do some more basic fish research. With even more money they could carry out a pilot project on sustainable fishing. The computing department also developed four plans, while biology and socioeconomics worked out three. Therefore 4×3×3×4 = 144 combinations (or packages) of plans (or strategies) were possible.

	Level of Investment			
	1	2	3	4
Computing	Current Better	**EQL:+ Add**	+Sophistica D.Base	+Custom Software
Biology	Current Better	**EQL:+Mor Equipmnt**	+More Analysis	
Socio-Econ	More Field Work	**EQL:+ Wider**	+Wider+De	
Fishery	More Sampling	**EQL:+ Wider**	+More Basic Res.	+Pilot Project Wk

Figure 9. *The model structure.*
Each department developed plans, or strategies, for what they would do with various amounts, or levels, of resource. They indicate what they would do if they receive an equal share of the aid funds (EQL), and what they would do if they received greater or smaller amounts than that.

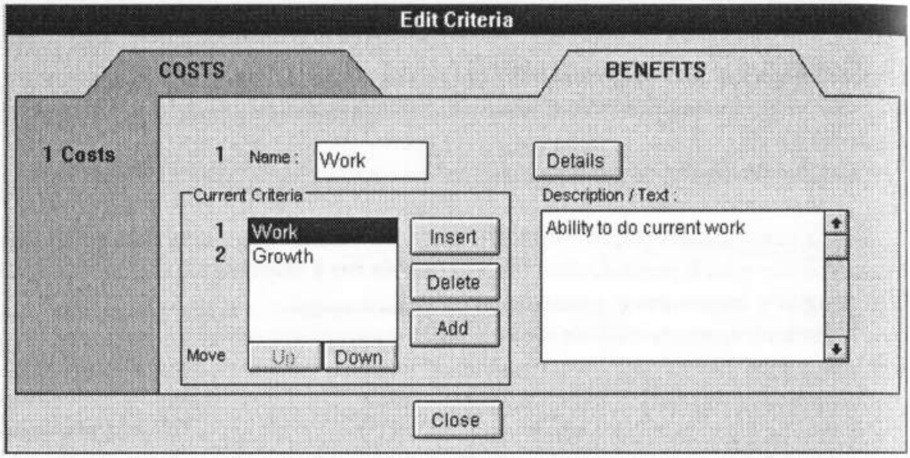


Figure 10. *Entering the criteria.*
Three common criteria to evaluate the strategies of all departments were chosen: the overall financial costs; the ability to do current contract work; and the degree to which balanced growth of the institute is promoted. There is no predefined limit as to how many criteria may be considered. However, having too many sub-criteria under costs and benefits may make the evaluation task very extensive.

Next, the group had to choose the criteria on which they were going to judge the various plans. Since its establishment in the mid-1980s, the Institute had undergone radical changes and through various international collaborations some departments, especially the computer department, had progressed tremendously and were among the most advanced in the country. Others, however, such as the socioeconomic and biology departments had not been able to develop at the same

	Costs	Work	Growth
Computing	-	60	50
Biology	-	100	100
Socio-Econ	-	100	100
Fishery	-	80	100
Across wts	100	100	80

Figure 11. *Editing the weights.*
The weights in the 'Work' column, 60-100-100-80, are the WITHIN CRITERION WEIGHTS and they show that the group considered the differences between the top and bottom of the 'Work' scales for the biology and socio-economics departments to be equally important, while moving from 0 to 100 on the 'Work' scale in Computing is only 60% as important. The ACROSS CRITERIA WEIGHTS, 100-100-80, indicate that the group thought the importance of the differences of the strategies is greatest in terms of 'Costs' and 'Work' (because the Institute must fulfil its current contract work), while 'Growth' is only 80% as important.

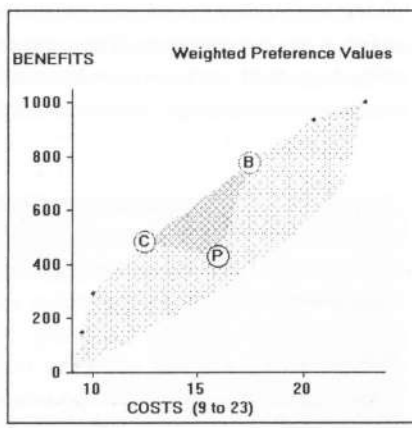


Figure 12. *Envelope and proposed package. Inside the shaded area only one particular package, the one of the equal allocation of resources across departments, is shown as point P. Point B indicates a better package, where for slightly higher costs much greater benefits are achieved. Point C indicates a package where slightly higher levels of benefits can be achieved at much lower costs.*

pace. As much of the Institute's work was multi-disciplinary this disparity reduced their overall effectiveness. The group eventually decided that two objectives were most important for the Institute as a whole: (1) their ability to do current contract work and (2) to achieve a balanced growth. These objectives were entered in the window of Figure 10.

The group then turned to assessing the development options using preference scales (the method used here is the same as that of HIVIEW, see Figure 3). In the course of the discussion several of the departments refined their plans, and a new one was added to the socioeconomic set. This also provided an ideal opportunity for all of the participants to present their concerns and hopes.

Next, two sets of weights had to be assessed: one, the WITHIN CRITERION WEIGHTS expressing the trade-offs between the four departments, the other, the ACROSS CRITERIA WEIGHTS, the trade-offs among the three criteria (one cost and two benefit) (Figure 11).

Using EQUITY a doubly-weighted average of the two benefit scales was taken for each department such that each plan was characterised by a single cost number and benefit number. From this, the total costs and total benefits of all 192 packages (combinations of plans) was calculated. The six packages which produced the greatest benefit for a given cost level were indicated as points on the upper edge of the 'envelope' graph of Figure 12; all other packages lie somewhere in the shaded area. The make-up of all six packages could then be viewed in the model structure, shown in Figure 13.

	1	2	3	4
Computing	C B	P		
Biology	C	P	B	
Socio-Econ		P	C B	
Fishery		P	C B	

Figure 13. *Proposed, Cheaper and Better packages.*
The package at equal resource allocation across departments is indicated by the letter ***P***. ***C*** *indicates the make-up of the cheaper package: if computing and biology were to receive less than an equal share (enabling them to do their current work better) while socioeconomics and fishery received more, then with less total resources a greater level of benefits for the Institute as a whole could be achieved.*

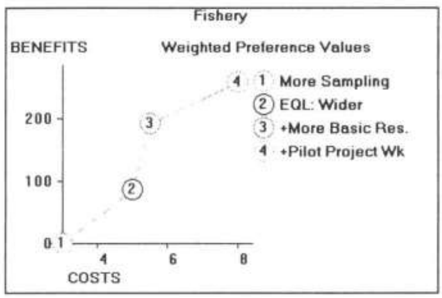


Figure 14. *Cost–benefit graph for fishery department.*
The graph shows that to gain more benefits increased resources would have to be used. The convex shape of the curve indicates decreasing returns on investment. It also shows that with only slightly more than 'equal' resources (strategy 3 instead of strategy 2) the fishery department would achieve much greater benefits.

The group then analysed the cost effectiveness of the various strategies proposed by each department by examining the graphical display of the cost–benefit relationships (Figure 14). From this they could see how increases of costs and benefits were seldom proportional within a department and less so across the departments. EQUITY allowed them to capitalise on these inequalities and choose the package that produced the greatest benefits for the Institute as a whole.

Having agreed on a package that maximised the benefits for the amount of resources already allocated to them the group used EQUITY's 'order of buy' analysis tool to examine the implications of changes in the overall resource allocation to the Institute. Figure 15 shows the order in which the alternative strategies would be

Order of Buy					COSTS		BENEFITS	
	Departmt		LEVEL		INC	CUM	INC	CUM
#0	1	Computing	1	Current Better	3	3	0	0
#0	2	Biology	1	Current Better	1	4	0	0
#0	3	Socio-Econ	1	More Field Work	3	6	0	0
#0	4	Fishery	1	More Sampling	3	9	0	0
#1	3	Socio-Econ	2	EQL:+ Wider	1	10	126	126
#2	3	Socio-Econ	3	+Wider+Detailed	1	10	116	242
C	4	Fishery	3	+More Basic Res.	3	13	192	434
B	2	Biology	3	+More Analysis	5	18	290	724
#5	1	Computing	4	+Custom Software	3	20	161	885
#6	3	Socio-Econ	4	+Envir. Econ	1	22	48	934
#7	4	Fishery	4	+Pilot Project Wk	3	24	66	1000

Figure 15. *Order of buy.*
The items above the line are the components of the lowest cost packages. As more money becomes available the socioeconomics department would be first to get more money. Then the fishery department would get money so that it could implement the '+More Basic Research' strategy option. With this list the director of the Institute could show the aid team that if they received $5,000 more than they needed for the cheapest package, the rise in benefits would be of 290 units (taking the total from 434 to 724).

chosen and their associated costs and benefits as the resources available to the Institute are increased.

Concluding remarks

The two examples described in this review have illustrated only a very small range of the uses of the programmes, HIVIEW and EQUITY. There are many more situations where multi-criteria value theory provides the appropriate framework for analysis. Both HIVIEW and EQUITY are intuitively easy to understand, and present no difficulty in use, particularly for those experienced with other Windows™ applications. Their simplicity allows users to concentrate on content and the programme thereby becomes a tool that can be applied to a large variety of environmental management problems.

In the case of the DDBRA fishing licensing decision conference all the participants expressed enthusiasm for the method and said that they had learned much from each other. Just as important as having a 'good solution' was the fact that the persons who have to justify, implement and live with the recommendations were active

Fishing in the Danube Delta Biosphere Reserve continues to be an important source of income and food. Photo: Paul Goriup/ Pisces Nature Photos.

participants in the decision process. Their thoughts and concerns were therefore part of the solution. This is precisely why decision conferences using tools such as HIVIEW and EQUITY have such a good track record for creating 'commitment for change'.

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Axel Kravatzky is a PhD student working on the application of decision analysis theory and techniques for environmental management and environmental economics. Development Studies Institute, London School of Economics, London WC2A 2AE, UK. Tel:+44 171 955 7425. Fax: + 44 171 955 6844. Email: <A.J.Kravatzky@lse.ac.uk>

Legal brief

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

AMIE BRÄUTIGAM

The ninth biennial meeting of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was held from 7 to 18 November 1994 in Fort Lauderdale, USA. Although the meeting laboured over a number of recurrent issues, major advances were made that hold promise for strengthening the treaty and improving its effectiveness in species conservation.

CITES is well-known and generally enjoys a favourable reputation as a treaty that has contributed significantly to the conservation of wild plants and animals. However, for many – scientists and government officials, as well as those involved in both the conservation and commercial aspects of wildlife – the difference between what CITES intends to be and what it actually is has been a source of frustration. For the past several years, CITES has been dogged by a philosophical schism – stimulated by the elephant debate – surrounding the consumptive use of wildlife, with those who prefer CITES as a paradigm of the protectionist approach to conservation at odds with those who support a more pragmatic, flexible approach to meeting the treaty's objectives. While these philosophical tensions continue to temper CITES debates, a different nature of disagreement – more political than philosophical – is taking prominence. This centres around whether CITES should extend beyond the 'traditional' wildlife sector to regulate commercial fisheries and the timber trade and, secondly, whether national sovereignty should take precedence over global responsibility. However, CITES is resilient, and these negative trends are being offset by the Parties' tendency towards discussing problematic issues through inter-sessional consultative mechanisms.

119 of CITES' 124 (currently 128) Parties convened in Fort Lauderdale, Florida to discuss a wide range of species and treaty implementation issues. Amongst the species issues were 135 proposals to amend the treaty's Appendices and a number of resolutions, including two addressing, respectively, the trade in rhinoceros and tiger specimens. The technical issues that the meeting addressed included guidelines for disposition of confiscated live animals, and legislation implementing CITES in treaty member States. By far the most momentous decisions, however, were the adoption of new criteria for listing species on the CITES Appendices, establishment of an inter-sessional mechanism to review the implementation of CITES for timber tree species, and, finally, the decision to review the effectiveness of the treaty.

Species issues

The Parties discussed a wide variety of proposals for listing species on the Appendices. Some proposals related to species such as North American box turtles

Terrapene spp. and tarantula spiders *Brachypelma* spp. featuring in the live animal trade, as well as a number of species of Madagascan succulent plants, representatives of *Aloe* spp., *Euphorbia* spp., and *Pachypodium* spp., valued in the horticultural trade. Several other proposals involved different types of trade than those CITES traditionally addresses, including that in traditional medicinal products and that oriented towards the pharmaceutical industry. The Parties accepted the listing of saiga antelope *Saiga tatarica*, used in traditional Chinese medicine, and that of several plant species, including African stinkwood *Prunus africana* (the bark of which is used in the manufacture of a drug to treat prostate cancer) and the Himalayan yew *Taxus wallichiana* (used to synthesise taxol, used to treat breast and ovarian cancer). In adopting these last proposals, the Parties have extended CITES' purview and increased the number and type of implementation problems the treaty will face in regulating international trade in these types of commodities.

One proposal that was not accepted by the Parties involved yet another type of trade – that in a food commodity, Asian swiftlet *Collocalia* spp. nests, used in birds'-nest soup. Although the Asian edible birds'-nest industry was firmly opposed to CITES' regulation of this lucrative trade, the exporting countries did agree a resolution, which the Parties accepted, establishing a schedule for reviews of national management regimes and calling for an international meeting in early 1995 to discuss conservation measures that may be required for this genus.

Rhinos and tigers

Despite the Appendix I (international commercial trade prohibition) that most of these species have benefited from since the entry into force of CITES in 1975, populations of all but one species of rhino (the white rhino *Ceratotherium simum* listed on Appendix I in 1979) and the tiger have continued to decline alarmingly. Although habitat loss has, until recently, been considered the primary concern for the tiger and may be more important for the Asian rhinos than the African rhinos, the major causal factor in this decline is undoubtedly the persistent demand for products of these species for use in traditional Chinese medicine and for cultural purposes, such as the manufacture of dagger handles in Yemen. The Parties adopted a resolution initially formulated by the IUCN Species Survival Commission's African and Asian Rhino Specialist Groups that recommends an evaluation of the effectiveness of actions to reduce illegal trade in rhino products, the development of standardised indicators of success to measure any changes in illegal hunting, and, finally, the widening of options available for rhino conservation.

The Parties also approved a proposal submitted by South Africa to transfer

Black rhinos (Diceros bicornis) in Kenya. Photo: Paul Goriup/Pisces Nature Photos.

that country's population of the white rhino *Ceratotherium simum simum* from Appendix I to Appendix II, to allow trade in live animals and hunting trophies only. This decision will be reviewed at the tenth meeting of the Parties; in the meantime, South Africa has undertaken to monitor and amend the list of traders to whom export permits will be granted, in order to ensure that exports are limited to "appropriate and acceptable destinations".

The resolution on tigers was particularly noteworthy in having been jointly presented by the ten main tiger range countries and tiger-product consuming countries. This resolution calls for cooperative bilateral and multilateral agreements for the protection and management of shared wildlife and habitats and recommends a number of other measures relating to the consolidation of government-held stocks of tiger derivatives, improvement of national legislation to stem illegal killing of tigers and trade in tiger parts, and promotion of substitutes amongst the traditional medicine communities.

The CITES Animals Committee is reviewing the status and trade of shark species, none of which are currently listed on CITES. Some fisheries catch large numbers of sharks for the international trade in shark fins, and there is concern over the effect this may be having on shark populations. Photo: John Stevens/IUCN Shark Specialist Group.

Vicuña

The Parties approved the transfer from Appendix I to Appendix II of those populations of Vicuña in Peru that had not been downlisted in 1987 (those of the higher Andes, outside of protected areas) and also agreed to allow the export from both Peru and Chile of wool from live-sheared animals in addition to any cloth that may be manufactured in either of these countries from such wool, which had previously been the only permitted commodity under the 1987 decision. This will expand the options available to local communities in both countries who are increasingly taking on responsibility for the protection and management of Vicuña populations and represents, at least in the case of Peru, a shift from traditional law enforcement to more innovative approaches for enhancing the conservation prospects for such valuable species while improving opportunities for the isolated Andean communities that live closest to them.

Sharks

The Parties established a precedent whereby species not listed on the Appendices may be formally reviewed by CITES structures, with input of information from the Parties. They approved a proposal submitted by the United States in a discussion document (i.e. neither a formal CITES Appendix amendment proposal nor a resolution) calling for the CITES Animals Committee to review the status and trade of shark species, none of which are currently listed on CITES, and report on their findings to the next biennial CITES meeting. Although there was some opposition to discussion of a commercial fishery issue – with some Parties arguing that other international bodies were better placed to manage shark fisheries and regulate trade in sharks – there was broad recognition of the concerns in scientific and fisheries circles regarding the impact on shark populations of the very high rates of exploitation of these species. This decision may prove useful for other species or groups of species that are being over-exploited for international trade but may be difficult to list owing to lack of information or the complexity of the problem.

Timber

As was the case with commercial fisheries, there was opposition to any attempt to further extend – or consider further extending – CITES to tree, particularly timber tree, species. Proposals to list two genera of African mahoganies *Khaya* spp. and *Entandrophragma* spp., and African blackwood *Dalbergia melanoxylon* were defeated after several interventions by African states. A proposal to list American mahogany *Swietenia macrophylla* was narrowly defeated after extensive debate in committee and a working group. A positive step forward, however, was the decision to convene an inter-sessional meeting on African Blackwood or Mpingo *Dalbergia melanoxylon*, which is to be organised by the government of Mozambique.

An additional positive step, particularly after the at-times acrimonious debate on timber and CITES, was the adoption – after protracted negotiations – of a resolution submitted by the United Kingdom recommending the establishment of an *ad hoc* CITES working group to review technical and practical problems associated with the listing of timber on CITES. This working group, to be chaired by the chairman of the CITES Plants Committee, will address temperate, boreal and tropical timber species, and involve a broad range of interested parties, including exporting countries, the International Tropical Timber Organisation (ITTO), the UN Food and Agriculture Organisation (FAO), and the Forest Stewardship Council. One of the first tasks of this working group will be to define, in consultation with the Standing Committee, the group's relationship with international organisations involved in the utilisation of forest resources.

Technical issues

Revision of the CITES Listing Criteria

One of the reasons for the apparently haphazard decisions on listing species on the CITES Appendices has been the lack of clear criteria for what constitutes threatened under the terms of the treaty. Although Article II of the treaty clearly states that Appendix I shall include all species that are threatened with extinction and are or may be affected by trade, and that Appendix II shall include *inter alia* all species that though not necessarily threatened now might become so if trade were not strictly controlled so as to prevent exploitation incompatible with survival, the treaty does not actually define the term *threatened*. The Berne criteria adopted in 1976 as the basis for evaluating listings of species on the Appendices did not go much further, establishing informational requirements rather than any clear statement about what degree of risk of extinction qualifies a species for inclusion in either of these two Appendices. In agreeing revised criteria, the Parties have effectively rectified this shortcoming.

IUCN, through the Species Survival Commission, had done the initial technical work to draw up criteria for defining threatened under CITES, drawing extensively on the revision of the IUCN Threatened Species Categories (these have now been adopted by IUCN Council in November 1994). The technical work was then revised through extensive consultation with the Parties and a joint meeting of the CITES Animals and Plants Committees and the CITES Standing Committee. Although the proposed new criteria were the target of severe criticism, particularly as they were viewed to be insufficiently precautionary, the Parties were able to agree a text that had been revised after extensive consultation in a working group.

The new CITES listing criteria will provide a much more explicit scientific basis for listing species on the Appendices, through quantitative guidelines regarding population and distribution and the significance of various risk factors. At the same time, they clearly establish that a species may be listed on Appendix II where there is no potential threat of extinction, only if harvesting for international trade is detrimental, i.e. it may be exceeding the level that can be continued in perpetuity. The precautionary principle has been firmly enshrined in the criteria for removing species from these appendices: no species may be removed from Appendix I without first being transferred to Appendix II to enable an evaluation of the potential levels of international trade.

Having established these guidelines, the Parties are now in a position to debate in a much more deliberate fashion whether certain species should or should not be listed on the Appendices. Any problems with the application of the criteria or other measures provided for by the new resolution will be addressed when the resolution, including the criteria's scientific validity and their applicability to different groups of organisms, is reviewed at the twelfth CITES meeting.

Review of the effectiveness of CITES

Another far-reaching decision taken by the Parties was the agreement of terms of reference for an external evaluation of the effectiveness of the treaty. This review will include *inter alia*: an analysis of the stated and implied objectives of the treaty and their continued relevance to species conservation; the effect that CITES listing has had on the status of a selection of listed species; the role of the various participants in CITES – non-governmental and inter-governmental organisations; and CITES' relationship with other regional and global conservation instruments. Although these and other relevant questions that merit analysis in such an evaluation are complex and will be difficult to flesh out in the six-month time-frame envisaged for Phase I of this study, the review could be instructive not only for CITES but for institutions such as IUCN, which are making substantial contributions to the treaty's operations as part of its species conservation activities, and other international instruments that, like CITES, are still struggling to meet their full potential.

National legislation

The inadequacy of legislation implementing CITES in member countries has been a persistent problem compromising the effectiveness of the treaty. In an effort to make progress on this issue, the Parties requested, at the eighth meeting, that the CITES Secretariat prepare a report on the Parties' CITES legislation for the ninth meeting. The Secretariat commissioned the IUCN Environmental Law Centre and the TRAFFIC Network (the joint WWF-IUCN trade monitoring programme) to analyse the CITES legislation of 81 Parties with high levels of trade in CITES species. The resulting report concluded that only 15 of these Parties have national legislation adequate to meet all the requirements to implement the treaty, while 27 Parties and a territory of an additional Party had insufficient national legislation to meet any of CITES requirements. An initial draft resolution calling for possible trade sanctions against Parties not having enacted adequate legislation by the tenth CITES meeting was amended to require that *draft* legislation be *introduced* by that time. It is hoped that with a realistic target, concrete steps will be made in addressing what is a fundamental problem for the treaty.

Disposition of confiscated live animals

An increase in the number of confiscations of shipments of live animals has placed mounting pressure on wildlife authorities to identify suitable options for placing these specimens. This task has invariably posed considerable dilemmas, as confiscating authorities have had to balance humane with conservation considerations while also minimising not only the financial costs but also the risks of a recurrence of the type of illegal or irregular trade that initially gave rise to the confiscation. The assumption that return to the wild is automatically the best option and euthanasia the worst has further complicated efforts to identify viable solutions to this problem. Since the eighth meeting of CITES in 1992, the CITES Animals Committee and IUCN's Species Survival Commission have worked together to develop CITES guidelines for disposition of confiscated animals, drawing on the findings of IUCN/SSC's consultation process, which is on-going. The results of these deliberations were adopted by the Parties in the form of a resolution on Disposition of Confiscated Animals.

The 18-page Annex of the resolution explores the advantages and risks associated with three options for disposition – maintenance in captivity (through placement in zoos or other types of life-time care facilities), return to the wild, and euthanasia – and presents a decision-tree to facilitate the decision-making process. It advises that the conservation status of the species be the major consideration in initiating the review of options and that any releases to the wild follow the Reintroductions Guidelines recently developed by the IUCN/SSC Reintroduction Specialist Group. As CITES initiates a process to develop guidelines for disposition of confiscated plants, IUCN/SSC is continuing its consultation on this issue.

Conclusion

The decisions the Parties have taken at their ninth meeting will account for a great deal of work in the intervening years leading to the tenth CITES meeting, to be held in Zimbabwe. That so much of the treaty's deliberations will be conducted through inter-sessional mechanisms holds much promise for enhancing collaboration on complex and divisive issues, which can only contribute positively to CITES and species conservation.

Amie Bräutigam, Wildlife Trade Programme Officer, IUCN Species Survival Programme, 219 Huntingdon Road, Cambridge, CB3 0DL, UK.

Résumés

Planification de l'aménagement des aires protégées

MIKE ALEXANDER

Il est communément admis que la planification de l'aménagement représente une condition préalable essentielle à la sauvegarde et à la gestion efficaces des aires protégées. L'application à l'ensemble des aires protégées d'une approche normalisée et d'un système de planification uniforme représenterait un avantage considérable. Cependant, l'importance d'un plan et, peut-être plus encore, les ressources disponibles pour sa réalisation, devraient correspondre à la superficie et à la complexité de l'aire, ainsi qu'à l'ensemble des ressources disponibles pour en assurer la protection et/ou la gestion. Les plans d'aménagement doivent satisfaire à plusieurs fonctions essentielles. Ces dernières comprennent: l'identification des objectifs ou des buts de l'aménagement, la description des systèmes de surveillance et de gestion nécessaires à la réalisation de ces objectifs et l'identification/justification des ressources nécessaires. Finalement, un plan peut être utilisé pour démontrer la productivité et l'efficacité de la politique d'aménagement.

A la recherche de l'information

JEREMY HARRISON

On a assisté, au cours des dernières années, à une révolution dans le domaine de la disponibilité de l'information et du développement et de l'application des outils permettant son traitement. Un nombre grandissant d'organisations et de pays sont attirés vers le soit-disant *information superhighway*. Mais, dans le même temps, d'autres se trouvent toujours dans l'incapacité d'obtenir les information nécessaires à leur travail. Cet article s'intéresse au processus de recherche de l'information et résume les principales méthodes permettant de la rechercher et de la trouver.

Les Systèmes d'Information Géographique: leur utilisation dans la gestion de l'environnement et la protection de la nature

RICHARD J. ASPINALL

L'information géographique est importante dans le domaine de la gestion de l'environnement et de la protection de la nature. Les Systèmes d'Information Géographique (GIS) sont décrits et examinés sous deux angles: 1) comme une technologie à base de données géographiques, traitées avec matériel informatique et logiciels et 2) comme une approche analytique basée sur l'application d'une perspective géographique. Des exemples sont donnés qui illustrent l'utilisation des GIS dans le développement d'une information géographique permettant d'aider à répondre aux problèmes de la gestion de l'environnement et de la protection de la nature. L'article décrit brièvement les liens existant entre les GIS et les technologies voisines des GPS et de la télédétection, ainsi que l'utilisation des GIS pour combiner donnés environnementales et données socioéconomiques afin de développer des perspectives variées sur les divers problèmes.

HIVIEW et EQUITY: analyse des décisions pour la gestion de l'environnement

AXEL J. KRAVATZKY

Les décisions que les gestionnaires de l'environnement doivent prendre sont fréquemment caractérisées par des objectifs variés et opposés, une information incertaine ou incomplète et l'influence de groupes aux intérêts variés. Le choix entre plusieurs lignes de conduites – dont aucune n'est la meilleure – rend la prise de décision difficile. Les problèmes qui se posent dans ce cas comprennent: le choix entre différentes lignes de conduite pour traiter un problème environnemental particulier, le développement et la mise en œuvre d'une stratégie uniformisée pour une organisation particulière, le choix entre plusieurs possibilités d'investissement, la répartition des ressources et du budget, ou l'ordre de priorité à accorder aux modèles de projets.

La branche de l'analyse de prise de décision utilisant la théorie des valeurs (ou critères) à attributs multiples (MAVT) offre un ensemble de techniques permettant de traiter de tels problèmes. Deux programmes informatiques basés sur la MAVT, HIVIEW et EQUITY for Windows™, ont été développés à l'institut d'études économiques de l'université de Londres et utilisés durant les treize dernières années. Ils ont été utilisés le plus souvent dans le cadre de réunions au cours desquelles un animateur qualifié aide des groupes de décideurs et des représentants de groupes d'intérêts à s'attaquer aux problèmes difficiles et complexes auxquels leur organisation doit faire face.

Pour le processus de décision les systèmes HIVIEW ou EQUITY offrent une vue objective sur un ensemble de critères très divers, où données factuelles et données subjectives sont combinées de manière rigoureuse. Ils constituent également un système de référence, indiquant la manière dont des décisions antérieures ont été prises, et qui peut être vérifié lorsque les données changent avec le temps. En outre, il se développe chez les participants une compréhension commune des problèmes, le sens d'un but commun et un engagement à l'action.

Cette étude utilise le développement d'un projet de pêcherie commerciale dans le Delta du Danube, en Roumanie, pour résumer les techniques employées et illustre l'utilité des systèmes HIVIEW et EQUITY avec un problème hypothétique d'affectation de ressources.

Resumenes

Paneación de manejo en relación a áreas protegidas

MIKE ALEXANDER

La planeación de manejo ha sido ampliamente aceptada como un prerequisito esencial para proteger y manejar efectivamente a las áreas protegidas. Habría muchas ventajas considerables en aplicar un enfoque standard y una estructura de planeación uniforme a todas las áreas. Sin embargo, el tamaño de un plan y mas importantemente, los recursos disponibles para su producción deben estar en proporción al tamaño y a la complejidad del área y también a los recursos totales disponibles para salvaguardar y/o manejar el área. Los planes de manejo cumplen varias funciones esenciales. Estas incluyen: la identificación de los objetivos o propósitos de manejo, la descripción de monitoreo y el manejo requerido para lograr los objectivos y la identificación/justificación de los requerimientos de recursos. Finalmente, un plan puede ser usado para demonstrar que el manejo es efectivo y eficiente.

Encontrar la información

JEREMY HARRISON

En los últimos años ha habido una revolución en la disponibilidad de información y en el desarrollo y aplicación de herramientas para manejar la información. Un creciente numero de organizaciones y países han sido atraídos a lo que se llama la *supercarretera de información*. Sin embargo, al mismo tiempo, a otros les ha sido imposible encontrar la información que necesitan para desempeñar sus trabajos. Este reporte se enfoca en los procesos para localizar información, resume algunos de los métodos claves para encontrar donde está dicha información y como obtenerla.

Sistemas de Información Geográfica

RICHARD J. ASPINALL

La información geográfica es de importancia para el manejo ambiental y para la conservación de la naturaleza. Se describen y discuten los sistemas de información geográfica (SIG) desde dos perspectivas: 1) como una tecnología comprendiendo datos con referencias geográficas, manejados con equipo y programas computacionales, y 2) como un enfoque para análisis basado en la aplicación de una perspectiva geográfica. Se presentan ejemplos ilustrando el uso del SIG para desarrollar información geográfica para uso en las resolución de preguntas relevantes al manejo ambiental y la conservación de la naturaleza. Se describen los enlaces entre el SIG y las tecnologías relacionadas del SPG y sensores remotos. Asimismo, se describe el uso del SIG para enlazar datos ambientales con datos socioeconómicos para el desarrollo de perspectivas múltiples sobre problemas.

HIVIEW y EQUITY: Análisis de decisión para manejo ambiental

AXEL J. KRAVATZKY

Objetivos y conflictos múltiples, información incierta o incompleta e intereses de grupos múltiples frecuentemente caracterizan a las decisiones que los administradores ambientales deben tomar. La dificultad en la toma de decisiones surge cuando existen varias rutas de acción factibles y de las cuales ninguna es la mejor en general. El rango de problemas de decisión que cae en esta categoría incluye: el elegir entre diferentes cursos de acción para tratar con un problema ambiental en particular, el desarrollo e implementación de una estrategia unificada para una organización, la asignación de recursos y presupuesto, o el priorizar el modelado para proyectos.

La rama de análisis de decisión que usa la teoría de valores de atributos múltiples (o criterios) proporciona un juego de técnicas formales que son apropiadas para tratar con dichas situaciones. En la Escuela de Economía de Londres, se han desarrollado y usado a lo largo de 13 años, dos programas computacionales llamados HIVIEW y EQUITY para Windows™ basados en MAVT. Estos programas han sido usados más frecuentemente en un ambiente de conferencias de decisiones, donde un facilitador entrenado asiste a grupos de tomadores de decisiones y a representantes de grupos interesados en tratar con problemas difíciles y complejos a los que se enfrentan sus organizaciones.

Los procesos de toma de decisiones asistidos por HIVIEW o EQUITY proporcionan una balanceada vista sobre un amplio rango de criterios, donde se integran datos de manera rigurosa con datos subjetivos. Estos también proporcionan un registro de la manera en que se llegó a las decisiones las cuales pueden ser estudiadas nuevamente conforme también los valores con el tiempo. Más aún, se crea un entendimiento compartido de estos problemas, un sentido común de propósito, y un compromiso de acción entre los participantes.

Esta revisión usa el desarrollo de un esquema de licencias para la pesquería en el Delta del Danubio, Rumania, para enmarcar las técnicas empleadas y para proveer un ejemplo del uso de HIVIEW. EQUITY se ilustra a través de un problema hipotético de asignación de recursos.

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