CHAPTER 11

KNOWLEDGE GENERATION, ACQUISITION AND MANAGEMENT

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TITLE PAGE PHOTO

The collection of primary data is a critical part of knowledge generation, acquisition and management. Here, at Hang Moi Cave, Trang An World Heritage Property, Vietnam, archaeologists are shown briefing a World Heritage inspection group about an excavation; the layered sediments that the vertical archaeological dig exposed and the subsequent analysis of material from the different layers and their dating. The information obtained included evidence of human occupation of the cave between 10 000 BP and 5500 BP which forms part of the important cultural heritage values of this World Heritage property
Source: Graeme L. Worboys

Introduction

Decisions are made about protected area management every day. Decision-making can occur at different scales, including local, national or global, and by a range of different actors, such as site managers, planners or policymakers, politicians, business managers or funding bodies. In order to make good decisions, all these actors require access to quality data and information to understand and mitigate threats and pressures affecting protected areas and the implications of those threats for biodiversity, ecosystem services and the human communities they support. This chapter focuses on knowledge generation, acquisition and management, with particular reference to protected areas. Very often the terms 'data', 'information' and 'knowledge' are used interchangeably, but there are important distinctions between these terms that are critical to understand in the context of this chapter.

What is knowledge?

Data are raw numbers associated with measurements or observations, perhaps associated with an ecological process or species, and the nature of data, their collection, analysis, management and communication can be represented as a cycle.

Information is obtained when data have been organised or analysed for a particular context, and knowledge is based on an understanding of the meaning of that information. Cleveland (1982) viewed understanding as a continuum, taking data as a view of the past, knowledge as the present and going one step further to describe 'wisdom' as the future result (Figure 11.1). In the case of protected areas, the knowledge would relate to how information based on data is subsequently used to make decisions that inform policy or affect management activities.

Scarce resources mean that data gathering, information generation and knowledge management need to be as efficient as possible. Modern technologies allow for streamlined data flows, from field-based data collection to web-based data analysis producing information in a form that can be interpreted. Over the past years streamlining, interoperability (the ability for systems to link up and work seamlessly together) and internet-based data sharing have resulted in a paradigm shift in knowledge management. For example, where in the past, biodiversity data were collected at a site level, with the specimens curated in museums and published through the scientific literature, now global data-sharing initiatives, national-level data portals, online publishing and scientifically published data papers facilitate the wide distribution of data and information within a short time, and increasingly in near real-time—for example, the World Database on Protected

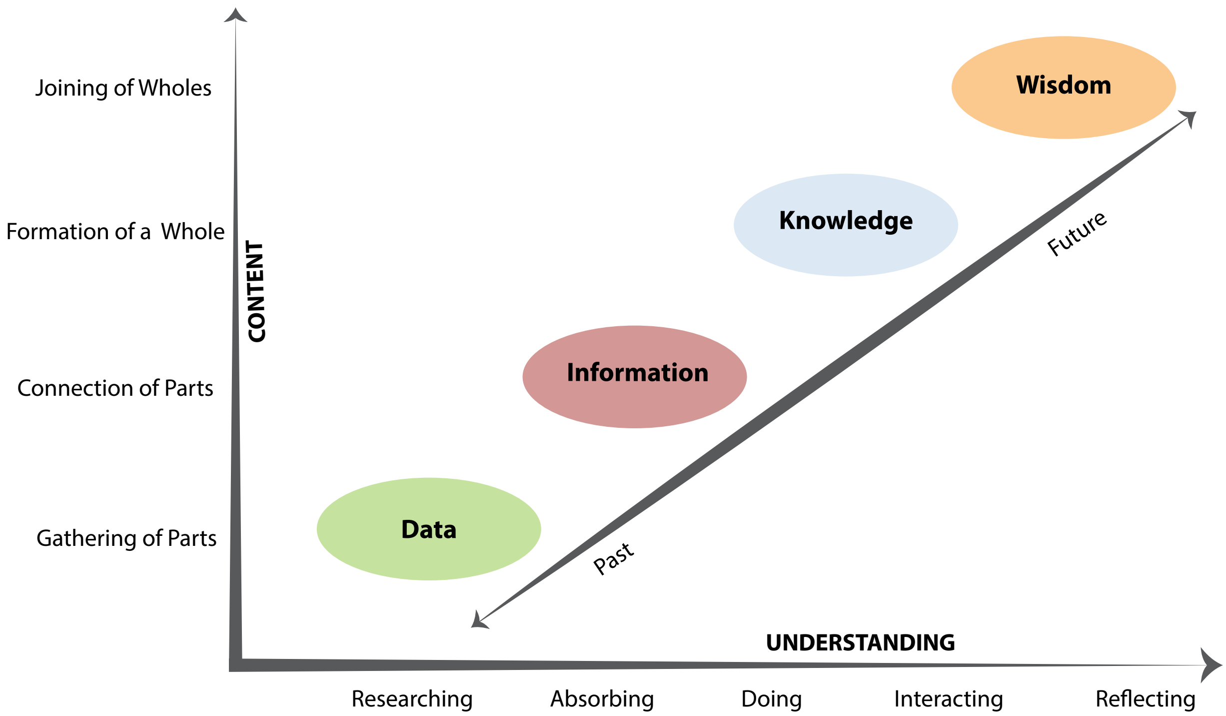


Figure 11.1 The continuum of understanding from the gathering of data, the presentation of information, generation of knowledge and ultimate wisdom

Source: Adapted from Cleveland (1982)

Ranger Mike Smithson and Fire Management Officer Paul Black, Parks and Wildlife Service, Tasmania, Australia, measuring fire fuel humidity levels as part of planning for fuel-reduction burns
Source: Graeme L. Worboys

Field data collection by community guards, Conservancy, Namibia
Source: Olga Jones

Areas (WDPA), the Global Biodiversity Information Facility (GBIF), NatureServe and the International Union for Conservation of Nature (IUCN).

In this chapter, we explore the drivers of the generation of knowledge on protected areas, the importance of standardisation and interoperability between systems, and the management, use and resourcing considerations for current and possible future systems. Knowledge management is a huge and diverse field, so rather than trying to present a comprehensive manual for protected area practitioners, we present generic issues, which we illustrate using examples representing best practice, and provide links to key resources from which more detail can be obtained.

Drivers of knowledge generation

Collecting data and information on protected areas is important for a number of core objectives. The knowledge and deeper understanding generated give us the ability to better locate new protected areas, manage those protected areas successfully for their conservation objectives, promote the value and importance of protected areas for biodiversity and society, make the protected areas more socially just and ensure they are resourced appropriately.

Data also allow us to work to identify where we know too little about sites (Pino-Del-Carpio et al. 2014), where the protected area networks are not representative (Bertzky et al. 2013) or whether they are insufficiently managed (Leverington et al. 2010).

Site management

A primary reason for data collection is to enhance the management of protected areas, which requires access to a wide range of information. Site management is multifaceted, and a large amount of data, information and knowledge is needed to achieve the conservation objectives of a site. This information may vary from spatial or attribute data on boundaries, land tenure, ecological trends, water sources, enforcement and permit records to contact lists for rangers, indigenous communities and landowners, counts of visitor numbers, financial records, habitat management regimes and social impacts. The information required and the scale of collection will depend on the uses for that information, and those responsible for information gathering must therefore consider this at the project design stage.

A number of tools are available to support an information-collection exercise; however, regardless of the tool used, it is critical that a strategic approach is taken, with a focus on gathering and collecting those data relevant to the goal at hand. Site management will often

be adaptive and informed by the information collected through monitoring programs. Where protected areas are open to the public, management authorities may decide to collect information on visitor numbers and their use of a site so they can manage visitor facilities and infrastructure, reduce impacts and threats to both visitors and biodiversity and target education and recreation activities.

Systematic conservation planning is a target-based approach for designing protected area networks and other conservation landscapes and seascapes. It seeks to provide transparent and scientifically defensible information that can be used to guide decision-makers and spatial planners (Margules and Pressey 2000). There are numerous tools available to assist with systematic conservation planning, requiring varying levels of complexity and input information (discussed in detail in Bowles-Newark et al. 2014).

The Conservation Measures Partnership (CMP) has developed Miradi software that applies the Open Standards for the Practice of Conservation—based on the experiences of several conservation organisations in

Box 11.1 Miradi: Software for conservation project planning

The Conservation Measures Partnership (CMP) has developed a user-friendly software called 'Miradi' (Swahili for 'project' or 'goal') that enables conservation practitioners such as park managers to design, manage, monitor and, above all, receive and perceive feedback from their projects and undertake adaptive management to increase the chances of achieving their goals. For protected areas, this is translated into better management effectiveness towards biodiversity conservation. Miradi can be used for the specific conservation project planning of a species or a set of species, for an entire landscape or ecosystem, or for elaborating management plans, among many other possibilities, by utilising the Open Standards adaptive management cycle shown in Figure 11.2 (see also Chapter 13).

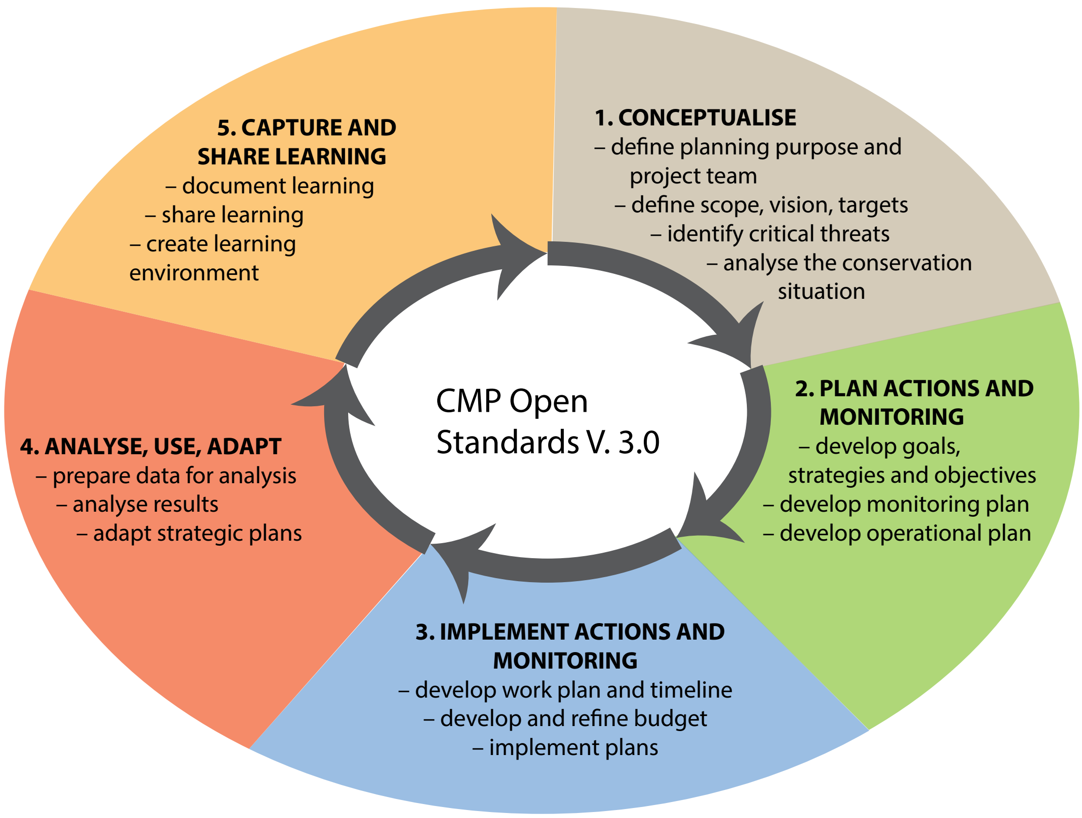


Figure 11.2 The Conservation Measures Partnership adaptive management project planning cycle

Source: Adapted from CMP (2013)

Box 11.2 SMART

The Spatial Monitoring and Reporting Tool (SMART) is designed to improve anti-poaching efforts and overall law-enforcement effectiveness in established conservation areas and management zones. SMART makes it possible to collect, store, communicate and evaluate data on patrol efforts (such as time spent on patrols, areas visited and distances covered), patrol results (for example, snares removed and arrests made) and threat levels. When effectively used to create and sustain information flows between ranger teams, analysts and conservation managers, the SMART approach can help to substantially improve the protection of wildlife and their habitats.

The SMART approach can be introduced to any conservation area that relies on patrol teams to protect wildlife and the natural ecosystems on which they depend. This approach has already demonstrated its effectiveness in improving law-enforcement effort, improving the morale of enforcement teams and reducing threats to wildlife and other natural resources in multiple sites across the world. At present, SMART is being implemented in more than 120 conservation areas in 27 countries worldwide and is fast becoming a global standard for law-enforcement monitoring and management. The advantage of using a system such as SMART is that it:

- uses the power of information and accountability to help direct resources to the places where they are needed the most
- empowers conservation managers with timely and accurate information on what threats are occurring, where they are occurring and how enforcement teams are responding
- guides conservation managers to use the information strategically to better plan and manage patrolling operations
- ensures accountability and good governance by providing clear and standardised measures of law-enforcement performance for staff, management, administration and reporting
- is affordable; SMART is free to download and use.

SMART was formally launched in early 2011 by the six founding members of the SMART Partnership: the Convention on International Trade in Endangered Species of Wild Fauna and Flora Monitoring the Illegal Killing of Elephants (CITES-MIKE), the Frankfurt Zoological Society, the North Carolina Zoo, the Wildlife Conservation Society, the World Wide Fund for Nature (WWF) and the Zoological Society of London.

— Olivia Needham, Zoological Society of London, on behalf of the SMART Partnership

Researcher Roger Good recording condition and change in condition data provided by ranger staff for the Alpine National Park in Victoria, Australia
Source: Graeme L. Worboys

conservation planning (Box 11.1). They rely on project cycles or adaptive management to achieve conservation goals.

In order to measure how well managed protected areas are and whether they are meeting their conservation objectives, a number of systems have been developed and are used around the world. In some cases these assessment mechanisms look at the management activities, and in others they look at monitoring trends in biodiversity responses. Protected area management effectiveness (PAME) assessments can use formats for data acquisition tailored towards the need of an organisation to be informed of the effective use of resources and to plan for further management. More than 40 PAME tools have been developed in recent years and the results of these assessments are summarised in Coad et al. (2013). A review of good evaluation methodologies for PAME can be found in Hockings et al. (2009) and Leverington et al. (2010) (see also Chapter 28).

Offences against wildlife, notably poaching, are some of the top threats to biodiversity requiring a particular approach to data gathering, monitoring and enforcement, and global initiatives such as the International Consortium on Combating Wildlife Crime (ICCWC) have come together to tackle this problem. The consortium has developed a wildlife and forest crime analysis toolkit, which provides guidance on data collection and analysis (ICCWC 2012). Data collection through dedicated

tools such as the Spatial Monitoring and Reporting Tool (SMART) (Box 11.2) ensures that information collected through day-to-day enforcement activities in sites is standardised and fit for purpose.

National reporting and tracking global change

Countries have signed up to a range of regional and international agreements relevant to protected areas—such as the Convention on Biological Diversity (CBD) National Reports, Aichi Targets and National Biodiversity Strategies and Action Plans (NBSAP); the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention); the World Heritage Convention; and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) National Reports and trade permit system. These agreements have varying levels of protected area reporting requirements for the countries (for an example of reporting to the European Nature Directives, see Box 11.3). In some cases, detailed site-level information is needed, while in others the information can be generalised at a national level. In all cases, they emphasise the need for reporting to be based on good-quality and relevant information. The reporting required of countries to multiple different agreements is complex and demanding. This has resulted in poor compliance among lower-capacity countries. As a result, efforts are now being made to streamline and harmonise the reporting requirements across all multilateral environmental agreements. The development of online reporting systems—still in its early stages for protected areas—is aimed at reducing the reporting and data access burden (for example, CITES; Box 11.4).

In 2010 the parties to the CBD agreed on a new strategic plan (CBD 2011) that includes a set of targets (the Aichi Targets). This plan provides an overarching framework for biodiversity, not only for the biodiversity-related conventions, but also for the entire UN system and all other partners engaged in biodiversity management and policy development. Protected areas underpin several of the targets, but are particularly relevant to Target 11, which states:

> By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape. (CBD 2011)

Box 11.3 National reporting obligations under the European Nature Directives

Within the European Union, two directives are focused on nature conservation: the Birds Directive (79/409/EEC; 2009/147/EEC) and the Habitats Directive (92/43/EEC), collectively known as the Nature Directives. These directives cover many issues relating to biodiversity but two are particularly relevant in terms of data collection. First, the directives require countries to designate and collect information on a series of protected areas to protect a prescribed set of habitat types and species. As of February 2014, there were 27 221 sites covering an area of more than 1 million square kilometres, which equates to approximately 18 per cent of the land area and 4 per cent of the marine area of the European Union. Second, the directives require countries to collect biodiversity datasets on prescribed habitats and species. Data are collected on the distribution, area, population, trend and overall conservation status of the species and habitat types listed under these directives. The data collected under this process form a central part of the overall biodiversity strategy for the European Union, and are publicly available through the European Environment Agency.

Box 11.4 Species+

Species+, developed by the CITES Secretariat and the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), is a website designed to assist parties with implementing CITES, the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and other multilateral environmental agreements. Species+ provides a centralised portal for accessing key information on species of global concern. In particular, Species+ contains information on all species that are listed in the appendices of CITES and CMS, as well as other CMS family listings and species included in the annexes to the EU Wildlife Trade Regulations.

— Kelly Malsch and Alison Rosser (UNEP-WCMC 2014)

US National Park Service geologist briefing protected area experts on geothermal crustal expansion measurement, monitoring and mapping in the vicinity of Old Faithful Geyser, Yellowstone National Park, USA

Source: Graeme L. Worboys

Long-term ecological research plot established in Kosciuszko National Park in the 1960s post alpine stock grazing removal from the park, to track the recovery of the Australian alpine environments and to measure continued active stream erosion

Source: Dane Wimbush

In order to track progress on Target 11, countries supported by global initiatives need to mobilise and interpret a huge volume of baseline and monitoring data, on all aspects of protected area location, coverage, designation, management and governance. Indicators are used to track progress (Box 11.5). A further global initiative was launched in 2012, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), as an independent intergovernmental body focused on strengthening the science–policy interface, such that:

- scientific information is relevant to policy demands and is formulated in a way that is accessible to policy and decision-makers
- policy and decision-makers take into account available scientific information in their deliberations and they formulate their demands or questions in a way that is accessible for scientists to provide the relevant information.

Inputs for knowledge generation

In addition to there being a multitude of drivers and motivations for collecting data and information, there are also numerous tools and methods for collecting these data and information. These need to be considered and developed in the context of the project or purpose for which the data are collected. As such it is worth considering five main knowledge categories when discussing data types: 1) scientific knowledge collected as part of field-based surveys; 2) scientific knowledge gathered from remote sensing; 3) knowledge on 'values' such as economic values or human benefits; 4) knowledge gathered through citizen science; and 5) the huge body of traditional knowledge.

In all knowledge categories, given the significant resources required for data collection and analysis to generate information, it is important that the 'collect once, use often' principle is employed where possible. Responsible parties must consider the lifespan of the data they collect beyond the scope of the project they are undertaking at that time. The addition of one or two parameters can often increase the applicability of datasets and their value beyond a single project, and global data-sharing mechanisms and standards can ensure the data can be integrated and reused by another party or project at a later time.

'Collect once, use often' is a core principle of a number of online data-collection systems. In order to avoid duplication, the various national, regional and international collection systems need to be able to communicate with each other so countries can report once and the data can be used by other systems. Initiatives such as the Global Biodiversity Information Facility (GBIF) can accept data collected for multiple purposes and make it freely available to other researchers around the world (see Box 11.16). A key element in this 'collect once, use often' ideal is the need for data to come with associated metadata—often referred to as 'data about data'. Metadata allow future users of data and information to understand the background of how those data were collected, for what purpose, at what scale and level of accuracy, and any conditions on the use of the dataset. In addition, metadata can include information on sensible uses of a dataset or information product, and thus reduce inappropriate or misleading results being obtained for future analyses. Additional detail on some of the common data standards in use for both biodiversity and protected areas is presented later in this chapter.

Box 11.5 What is a successful indicator?

According to the Biodiversity Indicator Partnership (2011), a successful indicator should be:

- scientifically valid: a) there is an accepted theory of the relationship between the indicator and its purpose, with agreement that change in the indicator indicates change in the issue of concern; and b) the data used are reliable and verifiable
- based on available data: so that the indicator can be produced over time
- responsive to change in the issue of interest
- easily understandable: a) conceptually, how the measure relates to the purpose; b) in its presentation; and c) in the interpretation of the data
- relevant to a user's needs
- used: for measuring progress, early warning of problems, understanding an issue, reporting, awareness raising, and other needs.

Scientific field knowledge

Probably the largest body of information relevant to protected areas is collected as part of scientific surveys, surveillance and monitoring programs. These programs cover all facets of the biodiversity, environmental, management and socioeconomic processes. They rely on scientific methodology and experimental designs to make results more robust and comparable between sites and over time. Data collection can be done by field researchers or local people who are trained in sampling techniques and data management skills—for example, use of spreadsheets and simple analysis.

At the most basic level of data collection are surveys that generate lists or inventories, geological mapping and/or socioeconomic indicators that can serve as a baseline for further studies and monitoring. Often these data are used for proposals for new protected areas or management plans. Some scientific data, however, come from long-term projects like long-term ecological research sites and may not be readily available, although some long-term projects have policies that specifically promote sharing data from their sites and use a modified rapid assessment protocol to standardise methods to make them more comparable between the sites and also cheaper (for example, PPBio).

Monitoring is the term used to refer to this repeated observation or measurement to determine status and trend, assessed as change against a baseline measurement—often referred to as an indicator. Surveys, in comparison, are where measures are generally made at a single point in time (for example, to determine the distribution of a species). Gardner (2010) classifies biodiversity monitoring in three broad types according to their purposes.

- Implementation monitoring: Checks if management processes and recommendations are being implemented.
- Effectiveness monitoring: Used to gather information on the condition (status and trend) of a measured outcome. In other words, if a conservation management target has been achieved or not. Does not ask why it succeeded or failed.
- Validation monitoring: Gathers information towards validation of management interventions, analysing whether they were successful and why. This is a central component of adaptive management (see Box 11.1).

Biodiversity monitoring is required in many international agreements—for example, in the strategic plan of the CBD (2011), which outlines the Aichi biodiversity targets; the convention also asks countries in Paragraph 25 on support mechanisms to 'monitor the status and trends of biodiversity, maintain and share data'.

In order to focus the information-gathering exercise and collect the relevant information in a sufficiently large sample size to produce robust analyses and reliable

Box 11.6 PROBUC: Program for monitoring biodiversity and natural resource use in the Amazon State-protected areas

This program was set up by the Amazonas State Government in Brazil in 2006 to acquire information on the presence and use of biodiversity in State-level 'sustainable use' protected areas. These protected areas are defined in Brazil as natural areas that house traditional populations whose existence is dependent on systems based on the sustainable use of natural resources. These systems have been adapted throughout the ages to the local ecology, which has a strong role in the protection of nature and the maintenance of biodiversity, and the areas meet the criteria for IUCN protected area Category VI. The program aims at training and using local knowledge to acquire information on the subsistence use of fauna and flora (such as hunting and fishing, and brazil nut harvesting) and also of threats (such as illegal poaching, illegal deforestation and goldmining) to help monitor species trends and threats and plan the needed management actions.

Members of the local villages are trained to fill in questionnaires and to conduct fauna transect monitoring with emphasis on species hunted for food. They also acquire information on turtle populations (the annual release of baby turtles is promoted by local residents) and boat traffic inside the protected area. The acquired information is relayed to the State environmental agency to be analysed for relevant management information and stored in databases that can be accessed by researchers and other institutions. Feedback is given to the local communities, when results are presented and explained in a comprehensive manner during community meetings, including to the protected area community council meetings. Training has constant follow-ups to increase data accuracy and reliability.

Sources: Fonseca et al. (2011); de Lima et al. (2012)

results, indicators are often used in monitoring projects. Indicators are a useful way of reducing the number of complex parameters that need to be measured, which is particularly important when staff, time and financial resources are tight. Indicators are ideally quantitative (easily measureable, such as the population size of a species or nitrogen levels in soil), but can also be qualitative (such as the presence of an indicator species or the perceived condition of a habitat) and are often hierarchical, feeding up from site to national-level assessment (Box 11.5).

Knowledge from citizens

Traditionally, surveys and monitoring have been undertaken by qualified researchers, but increasingly 'citizen science' approaches are being used to engage and educate communities and the general public (Box 11.6). If done well, these projects have the added advantage of potentially speeding up the data-collection process, as well as increasing sample size and coverage. Recent research (Bird et al. 2014) highlights the value of citizen science data as long as constraints around data collection, management, analysis and bias are put in place. Similarly, research has shown the potential value and benefits of using local communities for natural resource monitoring of tropical forests (Danielsen et al. 2014a) and to monitor progress on biodiversity indicators (Danielsen et al. 2013). With careful protocol design, especially through data-entry templates, to minimise the amount of inaccurate data entering the system, citizen science projects can work to improve our knowledge and increase public engagement. Technologies such as smart phones and tablets with geolocation capabilities make citizen science an attractive approach; however, considerations such as data quality, quantity and complexity must be made at the project design stage, as well as whether citizen science is the most appropriate mechanism for engaging the community or collecting data on a particular problem. Projects such as Nature's Notebook (Rosemartin et al. 2014) and Instant Wild (Box 11.7) are excellent examples of citizen science in action.

Remotely sensed knowledge

In addition to field surveys, data also come from remotely sensed sources, ranging from those images acquired via satellite to images and laser scanning data derived from conventional airborne platforms and the emerging use of remotely operated unmanned aerial vehicles. Over the past decade there has been a rapid evolution of enhanced quality, reduced cost and simplified availability in remotely sensed data. These changes have greatly facilitated the use of remotely sensed data to analyse changes in habitat within protected areas over time, including sophisticated comparisons with comparable areas outside protected areas. As these datasets become increasingly detailed they also become much larger, which has increased the challenges of downloading, processing and analysing them.

The huge potential has been recently demonstrated by Hansen et al. (2013), who used 30-metre resolution satellite data from the freely available 'Landsat' archives to show the extent of global forest change. This example illustrates the potential value of remote sensing for

protected area monitoring, at scales and levels of precision that could not possibly be measured by means of field-based survey or reviews of national indicators. As an example, deforestation in Virunga National Park in Central Africa is shown from 2000 to 2012 from data analysed by Hansen et al. (2013; Figure 11.3).

Change detection for other habitat types or ecosystems can be much more challenging as the variations of the pixel 'signature' can be harder to detect and it is therefore easy to confuse habitats—for example, a natural grassland would look similar to a cropped area (Mello et al. 2012).

Knowledge on 'value'

Increasingly, the scientific and economic cases for biodiversity conservation are being made through the promotion of the value of 'ecosystem services' and 'natural capital' to human wellbeing and the global economy. In order to develop scientifically rigorous approaches to this valuation and subsequent decision-making, data on ecosystem services are being gathered and incorporated into planning processes and used to develop new policy frameworks and finance mechanisms. Initiatives such as The Economics of Ecosystems and Biodiversity (Kumar 2010) have expanded, refined and improved the methodologies used in these assessments.

Box 11.7 Instant Wild

The Zoological Society of London's Instant Wild iPhone Application (app) is a unique citizen science tool that enables members of the public to identify and discuss images that have been instantly transmitted from motion-triggered camera traps set up across the globe. In the first 24 months after its launch, it had more than 100 000 downloads and participants initiated more than one million image identifications, with an identification success rate of more than 90 per cent. The app empowers the general public to get involved in field conservation work and improves awareness and knowledge of the species in camera locations. It also means that the society has the ability to instantly know if a rare and threatened species has been spotted—for example, the critically endangered Javan leopard (*Panthera pardus melas*) was seen on the society's Indonesian camera in 2013 and the incredibly rare mountain mouse-deer (*Moschiola meminna*) was sighted on the society's Sri Lankan camera. There are cameras transmitting from Kenya, Namibia and the United States. As more cameras go online, the app has the potential to save conservationists thousands of hours of work, as members of the public help sort the images by species group, enabling faster data analysis.

— The Zoological Society of London, Conservation Technology Unit, London, 2014

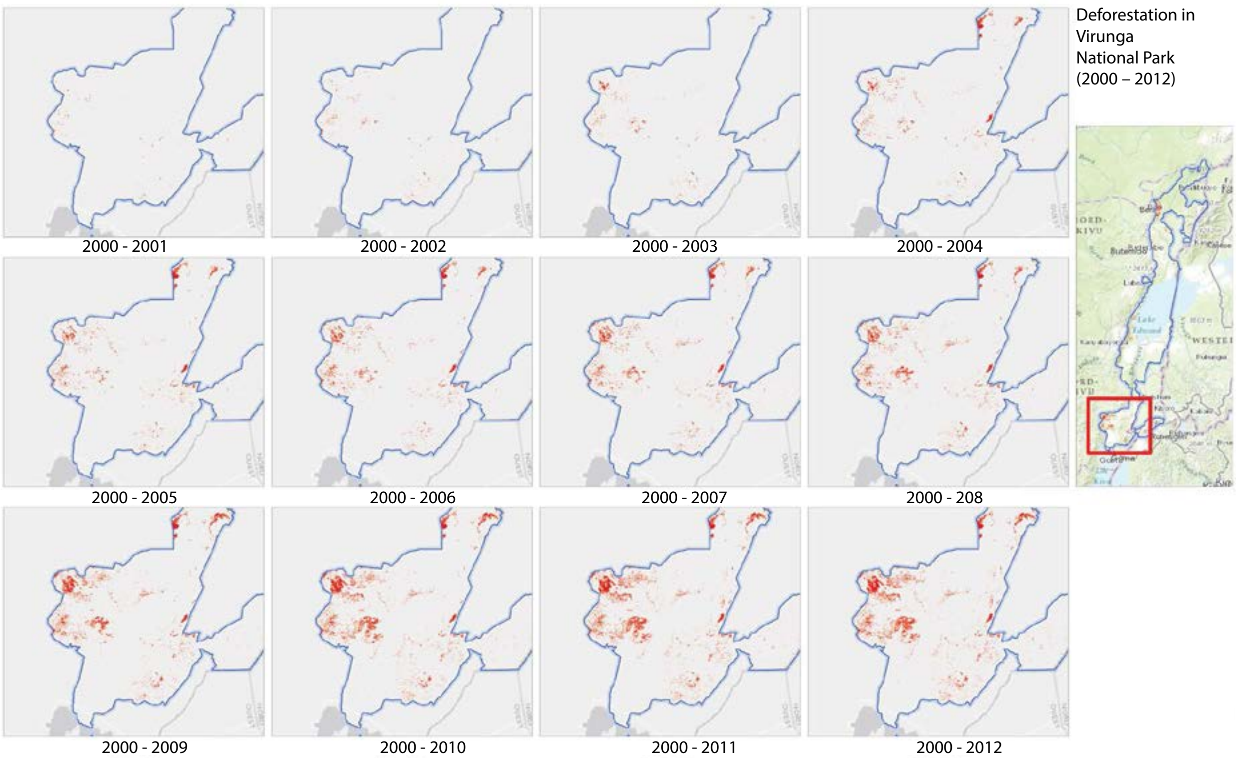


Figure 11.3 Deforestation (red areas) in Virunga National Park (outlined in blue), Democratic Republic of Congo, measured from 2000 to 2012

Source: Adapted from Hansen et al. (2013)

Box 11.8 Toolkit for Ecosystem Service Site-based Assessment

The Toolkit for Ecosystem Service Site-based Assessment (TESSA) guides local non-specialists through a selection of relatively accessible methods for identifying which ecosystem services may be important at a site, and for evaluating the magnitude of benefits that people obtain from them currently, compared with those expected under alternative land uses. The toolkit recommends the use of existing data where appropriate and places emphasis on enabling users to collect new field data at relatively low cost and effort. By using TESSA, the users could also gain valuable information about alternative land uses, and data collected in the field could be incorporated into regular monitoring programs.

Source: Peh et al. (2013)

Box 11.9 Traditional knowledge of the Kogi communities, Colombia

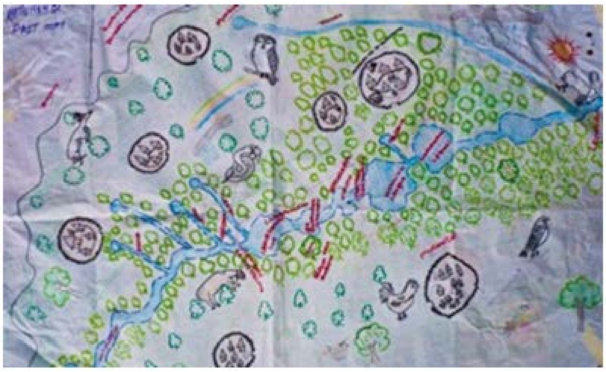
Indigenous peoples and local communities who have occupied and used territories of land and sea have adapted over long periods to ecological complexity and the nonlinear, unpredictable nature of ecosystems. For instance, the traditional Kogi communities of the Sierra Nevada de Santa Marta in Colombia live in close contact with the natural environment (Rodriguez-Navarro forthcoming). Over generations of constant travel throughout their territory with all its sacred sites, they have gained exceptional insights into how to protect and sustainably use its biological resources, even in unpredictable situations. Their cultural systems are complex and depend on the *Mamas'* (or priests) decisions and community way of life, of which the 'Law of the Mother' is an integral part. The law of the mother is a complex code of rules that regulates human behaviour in harmony with plant and animal cycles, astral movements, climatic phenomena and transhumance in the sacred geography of the territory. Culture denotes customs, traditions and codes; it has to do with the way these indigenous communities live collectively. Humanity and its cultural diversity interact with, and depend on, both the living and the non-living components of the planet—and this is something the *Mamas* always consider in their efforts to maintain balance. Ritual enactment related to these sacred rites is an innovative mechanism of monitoring.

— Ashish Kothari

A detailed guide to the assessment, including information requirements, of the social and economic benefits of protected areas is available in Kettunen and ten Brink (2013). Several tools have also been developed to allow non-specialists to assess the ecosystem services important at a site, such as the Toolkit for Ecosystem Service Site-based Assessment (TESSA) (Box 11.8).

Traditional knowledge

Information and knowledge, including techniques and best practices, accumulated over time by communities and passed from generation to generation—often referred to as traditional knowledge or indigenous knowledge—can be difficult to measure and understand, but are no less important aspects of the protected area knowledge base. This information is often ignored in protected area planning and management, which can have problematic consequences. Data on seasonality, resilience, medicinal properties, traditional management practices and their conservation or restorative values can all be collected from communities, as can information such as on land tenure, property rights and protected area impacts. Traditional knowledge can also help with monitoring the abundance of and changes in key species and habitats within the protected area, and the trends generated by these methods can be as reliable as ground-based surveys by scientists (Danielsen et al. 2014a). Another value of traditional knowledge comes in raising hypotheses for further scientific investigation.



Ancestral map of the past, showing the ecological order of the territory in Venda, South Africa

Source: Dzomo la Mupo, Mupo Foundation, Gaia Foundation

As many ecological systems and landscapes have been modified over time by the human communities they support, an understanding of the traditional management practices and community-based resource management systems can be key to building a good understanding of the management of protected areas (Box 11.9). This is especially important for those protected areas that permit

Elephants crossing, Samburu National Reserve, Kenya, an IUCN Category II protected area

Source: Geoffroy Mauvais

human populations to be residents or to explore for and exploit natural resources. One of the challenges here is to translate this traditional knowledge—often based on metaphors—into information that can be used for conservation planning and monitoring trends in key species or habitats. Oba et al. (2008), for example, describe how the traditional knowledge of herders in central Uganda can help identify best practices for the conservation of landscapes and associated fauna and flora. In another study, Constantino et al. (2008) show how the traditional hunting knowledge of the Kaxinawá ethnic group in Brazil can help biodiversity monitoring by enhancing fauna species lists. Danielsen et al. (2014b), working in Nicaragua, found that supplementing research findings with indigenous and local knowledge could increase the amount and geographical scope of information available for assessments. An example of a database that sets out to record information on traditional knowledge is the global Indigenous Peoples' and Community Conserved Territories and Areas (ICCA) Registry (Box 11.10), but several national-level databases are also maintained or in preparation (Kothari et al. 2012).

Importance of standards

A critical component of any data collection, management or analysis process, not just related to protected area information, is the need to have data standards—documented profiles for the uniform representation and formatting of data. At their most fundamental, data

Box 11.10 Indigenous Peoples' and Community Conserved Territories and Areas Registry

The ICCA Registry has been set up to build a knowledge base that increases information about these special areas, documents their values, enhances understanding and recognition of their purposes and impacts, and increases the engagement of local and traditional communities in biodiversity conservation and policy arenas. The two main types of information stored include: 1) descriptive information, such as the main habitats within the ICCA and the names of the community or communities living within or near the ICCA; and 2) spatial information, such as the size, location and boundaries of the area. Additional details are included where available, such as information about the history, governance, customary laws and management of an area, details on community decision-making processes and socioeconomic factors. Multimedia data, such as photos and videos, are incorporated within case studies to broaden the visual features of communities and the richness of their knowledge and conservation efforts. The ICCA Registry adheres to the principle of 'free prior informed consent' (FPIC), so any communities registering their permission for the information to be included in the ICCA database can additionally specify whether this information should be kept confidential and not released. The ICCA Registry is maintained by the ICCA Consortium and the UNEP-WCMC.

Box 11.11 The World Database on Protected Areas data standard for protected area information

The World Database on Protected Areas (WDPA) is a joint project between the UN Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN) that is managed by the UNEP World Conservation Monitoring Centre (UNEP-WCMC), based in Cambridge, United Kingdom. The WDPA started as the UN List of Protected Areas, produced under mandate from the UN General Assembly since 1962, and has developed into a spatial geographical information systems (GIS) mapping database on protected areas throughout the world. It includes information on protected areas of all IUCN categories and governance types. In collaboration with governments, non-governmental organisations (NGOs), academia and industry, the WDPA is the most comprehensive global database of marine and terrestrial protected areas, comprising both spatial data (that is, boundaries) with associated attribute data (that is, tabular information). The WDPA is made available online through the Protected Planet website (<www.protectedplanet.net>), where the data are both viewable and downloadable.

The WDPA Data Standard was developed in 2009 as a mechanism to make the requirements for inclusion of data in the WDPA clear for all data providers, and to ensure interoperability of the dataset. This standard was expanded in 2014 in order to streamline the WDPA with the requirements of Aichi Target 11, which stresses the importance of 'other effective area-based conservation measures'.

Under the new data standard, the WDPA will continue to incorporate sites that fit the IUCN and CBD definitions of a protected area, alongside sites that do not fit these definitions but nevertheless have conservation value. This distinction will be clearly made within the attribute data, providing data users with the option to easily differentiate between those sites that fit the definition and those that do not.

Data submissions must meet the following five requirements to be included in the WDPA.

1. The site must either fit the IUCN/CBD definition of a protected area or have clear conservation value and a long-term commitment in place.

Sečovlje Salina Nature Park, Slovenia, a Category IV and Category V protected area that includes an important bird wetland area and an active and sustainable salt production industry based on methods used at the site for hundreds of years

Source: Andrej Sovinj

2. The spatial boundaries of protected areas should be provided as shapefiles in multi-part polygon format, where possible. Where boundary data are unavailable, the central geographical point location (latitude and longitude) must be given as a reference point for the protected area instead. Therefore, each protected area in the WDPA is represented as either a polygon boundary or, if unavailable, a point location. Spatial data must be provided, preferably in shapefile format. A maximum of two shapefiles should be submitted—one containing all the polygon data and the other all the point data for any protected areas without boundary data. The WDPA is based on the geographic coordinate World Geodetic System (WGS), therefore all data should ideally be submitted in this reference system. It is preferred that GIS data are in shapefile format, but other formats such as .gdb and .kml files are also accepted.
3. Recording accurate source information in the WDPA is important to ensure that ownership of the data is maintained and traceable. The WDPA Source Table conforms to the minimum geographical information and service standards as outlined in the ISO guidance report on geographic information (SIO/TC 211). A data submission will only be accepted if the minimum source information is provided. Under the new WDPA Data Standard, data will be stored in both the data source and by the party responsible for verifying the data, where applicable.
4. Attributes represent essential pieces of information about the spatial data that aid in the analysis, reporting and tracking of trends in the growth and coverage of the world's protected areas. There are 25 attributes associated with every protected area in the WDPA, with these categorised as 'minimum', 'core' or 'enhanced' attributes. The minimum basic requirement for data to be accepted into the WDPA is that the minimum attribute information is provided.
5. The data must be either provided or verified by a national government or other authoritative source. Data contributors that provide data for inclusion in the WDPA are requested to sign the WDPA Data Contributor Agreement. This ensures that there is a written record of the data provider agreeing for their data to be in the WPDA. The agreement specifically states how the data provided will be used and that they will be subject to the WDPA Terms and Conditions. A data submission will only be accepted if the WDPA Data Contributor Agreement is signed.

Source: UNEP-WCMC (2014)

standards allow for the collection of data in a quality-controlled manner, leading to improved quality and an associated confidence in the use of the data collected. The more datasets that exist within a system, the more important it is that there are clear data standards for each dataset. All of this highlights the importance of ensuring that at the onset of a data-collection process, there are clear data standards outlined that allow for the collection of the relevant scientific information as well as ensuring the data can be managed effectively.

As geographical information or geospatial data become more available and more web-based, the need for such standards is crucial. Both the International Organisation for Standardisation (ISO) and the Open Geospatial Consortium have developed a set of standards for geographical information. The ISO has created an entire series of standards covering geographical information (ISO 19100 series).

Biodiversity Information Standards, also known as the Taxonomic Databases Working Group, has developed a set of standards for the exchange of biodiversity data. These are exemplified by the 'Darwin Core', which includes a set of terms relating to taxa and their occurrence in nature, and a set of practices regarding the use of these terms in the publication of biodiversity data and information (GBIF 2010). The Darwin Core is used by the GBIF and many national biodiversity data nodes. For protected areas, the WDPA acts as the global standard (Box 11.11), with a set of core attributes any site must have in order to be listed. Standards also ensure the mobilisation of biodiversity information. The Biodiversity Heritage Library is one such collaborative resource enabling open access to major natural history literature collections put together by a group of organisations from around the world.

A basic requirement for data systems is the need for each object or measurement (for example, protected areas) to have a unique identifier. Unique identifiers should as a minimum satisfy two basic criteria: they should be:

1. unique—that is, the identifier should be unique across the organisation
2. persistent—the identifier should remain unchanged for the life of that object.

With the advent of increasingly user-friendly global positioning system (GPS) surveying and the availability of digital datasets, there are increasing possibilities for the collection of highly accurate spatial biodiversity data. As an example, in the case of protected area boundary digitisation, the exact scale used is a function of the resources available. Detailed surveying of sites will produce highly accurate boundaries but at a high cost, while digitising the boundaries from digital cadastral maps at an appropriate scale can provide relatively accurate boundaries in a cost-effective manner.

Knowledge sharing

Data sharing means the disclosure of data—in this case, biodiversity data—from one party to a third party either within an organisation or to external organisations. The sharing of data can be influenced by a number of factors, both positive and negative, including: the presence or lack of organisational best-practice documents relating to data sharing; ownership of the data; copyright of the data or indeed the base maps from which data are created; technical challenges; national laws relating to data use and downloading of data; and restrictions on disseminating data to third parties. The ownership of data can be tied up in institutional rules, copyright issues and commercial sensitivities, and the dissemination by digital means may not be covered by national laws or the laws may not cover the use of digital data in online systems and the subsequent downloading of data. There can be restrictions on allowing third parties to disseminate the data. On the positive side, there are a number of national and regional agreements on the use and dissemination of public data, such as the Conservation Commons (2006), which encourages the release of biodiversity data in order to facilitate biodiversity conservation.

The inability to share data is a critical problem in the assessment of global biodiversity: with incomplete data, an incomplete picture emerges. Where there are issues surrounding data sharing, solutions should be found, either in adopting best practice from other countries or organisations or in having clear data-sharing agreements. In the case of ICCAs and many other aspects of traditional and indigenous knowledge, data-sharing restrictions can relate to national laws, cultural sensitivities or ownership information. All sites submitted to the ICCA Registry (Box 11.10) undergo an agreed FPIC process. This allows the communities involved to choose whether or not their data are made publicly available.

Knowledge management

In recent years, and as the importance of knowledge management has been recognised, national governments and research organisations in many countries have been putting in place biodiversity information facilities or data centres. These facilities use a range of approaches and models very much dependent on the data and information being gathered, the user base of the system, how accessible the information needs to be and the resources available.

Community-level knowledge management can, however, take a very different approach. Corrigan and Hay-Edie (2013) provide insights into sharing knowledge in ICCAs and other community-led conservation areas, including documenting and mapping, local management planning, monitoring, adaptive learning, communication and sustainable financing. Regional structures also play a role here, particularly in developing regions, as they ensure best practices in information management and access for decision-making, often in some of the world's most biodiverse places, while reducing the management burden and resources required for a state-of-the-area data centre. Examples include the Association of South-East Asian Nations (ASEAN) Centre for Biodiversity (Box 11.12) and the Shared Environmental Information System (SEIS) (Box 11.13).

The CBD calls on parties to the convention to implement and expand national-level clearing-house mechanisms (Article 18.3). A clearing-house mechanism sets out to provide a web-based information portal and discovery services to facilitate the implementation of national biodiversity strategies and action plans. Such mechanisms have also been implemented at regional and global levels.

Global initiatives play an important role in data management and mobilisation. The IUCN knowledge products make conservation-related knowledge available (Box 11.14). In other cases, global information initiatives allow tracking of global biodiversity targets—such as the Biodiversity Indicators Partnership and the WDPA, both managed by the UNEP-WCMC (Box 11.15).

Thematic networks, such as BirdLife International, the Ocean Biogeographic Information System or the Global Invasive Species Database (GISD), play an important role in focusing on the information requirements of specific issues, biomes or taxonomic groups. The use of global data management standards, however, ensures that the thematic data can be interchanged seamlessly with regional systems or other networks. In some cases, they allow for the repatriation of data between regions—for example, from museums in the developed world to protected area managers in developing countries where the specimens were collected through the GBIF (Box 11.16).

Knowledge use

Access to the best available data on biodiversity is an essential requirement for successful conservation outcomes (Box 11.17). In making available the various biodiversity-related datasets that are held by different bodies, conservation practitioners from researchers to policymakers are able to make decisions based on the best data available. In addition, by making datasets available, new and novel analysis and products are created similar to the proliferation of 'mashups' available

Box 11.12 ASEAN Centre for Biodiversity

The ASEAN Centre for Biodiversity is an intergovernmental regional centre that facilitates cooperation and coordination among the 10 ASEAN member states on the conservation and sustainable use of biological diversity, and the fair and equitable sharing of benefits arising from the use of such natural treasures. To assist the organisation of the biodiversity information that forms the basis of assessments, decisions and policies, the Centre for Biodiversity adopted the Darwin Core Archive and WDPA as a standard data structure for sharing and publishing data on biological diversity. With this standard, the centre hoped the member states would be equipped to populate their clearing-house mechanisms for biodiversity and therefore be able to provide and process the necessary information for biodiversity conservation.

Both online and offline encoding facilities were developed based on the standardised format to improve interoperability and aid the digitisation of species and protected area information in the ASEAN region. The primary purpose of the Darwin Core Archive and the WDPA was to create a common structure for sharing biological diversity data that are harmonised and reuse metadata standards from other dataset domains. All clearing-house mechanism focal points were informed of these developments and were encouraged to engage in a cost-sharing training arrangement to improve the capacity of their staff and partners in data management. The Biodiversity Information Management Unit developed a regional clearing-house mechanism to organise biodiversity information at the regional level and present interactive trends and maps where useful for analysis. Both online and offline encoding tools were made accessible on the regional clearing-house mechanism website to assist member states in digitising their biodiversity data.

— Christian Elloran, ASEAN Centre for Biodiversity

Box 11.13 Shared Environmental Information System

The Shared Environmental Information System (SEIS) aims to create an improved environmental information system for Europe. The goal is to base it on a network of public information providers that share their environmental data and information. Their existing systems and processes would be simplified, streamlined and modernised, including being web-enabled. The overall system would be decentralised but integrated. Quality, availability, accessibility and understanding will be improved as a result. The SEIS is also about a shift in approach, from individual countries or regions reporting data to specific international organisations, to their creating online systems with services that make information available for multiple users—people and machines.

The SEIS is based on seven 'principles'. Information should be:

- managed as close as possible to its source
- collected once, and shared with others for many purposes
- readily available to easily fulfil reporting obligations
- easily accessible to all users
- accessible to enable comparisons at the appropriate geographical scale, and to enable citizen participation
- fully available to the general public and at the national level in the relevant national language(s)
- supported through common, free open software standards.

Cutting across the principles above, a key goal of the SEIS is to maximise and expand use.

Source: European Commission (2008:111–12)

on the Internet. These 'mashups' have at their heart the principle of using data from multiple sources to present the data in a new manner or to create new products (such as IBAT; Box 11.18). This also serves to highlight the key requirements, and the challenges, necessary to expand and enhance the use of the existing datasets. In addition, they remind us of the importance of sustained investment in data collection, collation, management and dissemination; without investment the quality and currency of the data cannot be maintained, and the relevance and accuracy of the 'mashup' decrease.

The key challenges faced have been discussed in previous sections, but it is worth reiterating them as it this issue which acts to link them together (Boxes 11.19 and 11.20). Biodiversity data are often very heterogeneous and not centralised, as they are often located in several organisations, both nationally and internationally. As highlighted in the section on the 'Importance of standards', there is a lack of global standards and procedures relating to quality control of the data, and even data collection can vary dramatically depending on the aims of a project and the organisation involved. It is

Box 11.14 Knowledge products delivered through the IUCN

As a science-based organisation, the IUCN provides a wide range of knowledge to inform society's decisions on how to value and conserve nature equitably. It is through this union, under the mandate of the IUCN 2013–16 program, that knowledge products are developed, maintained, updated and disseminated.

The IUCN has six knowledge products in different phases of development (Figure 11.4). Knowledge products are combinations of standards, data, processes, tools and products developed and maintained by the IUCN as global public goods put towards the conservation and sustainable use of the world's biodiversity.

The following characteristics are common to all datasets.

- They are scientifically driven, transparent and repeatable. All engage scientists (from the IUCN's six commissions, membership, the Secretariat and beyond) in their development and maintenance.
- They are structured to ensure independent governance and avoid political manipulation. In particular, processes to maintain their standards and respond to petitions are accountable to the relevant chairs of the IUCN commissions.
- They are inclusive; their standards and data are developed through international, participatory processes (for example, 'framing workshops') with all relevant and interested stakeholders. Gaining consensus amongst such stakeholders is fundamental to success and makes the resulting product much more robust than it would otherwise be.
- They are supported through engagement with the IUCN Secretariat, often in collaboration with many other partner institutions.
- They require expert review prior to acceptance and publication.
- They are not targeted to specific, narrow applications, but rather are applicable, often in combination with other information, to increase awareness of biodiversity and to inform decision-making in policy and practice—not only in the conservation sector but also in society at large.
- They are (or will be) maintained over time, and through such time series inform indicators for monitoring.
- They are delivered by the IUCN (commissions, members and the Secretariat) and partners as freely available for non-commercial applications in scientific research, biodiversity conservation and sustainable use.
- Commercial applications may, through agreed policies and where appropriate, contribute resources towards maintaining the quality and currency of the underlying data.

The IUCN maintains many other databases and information systems, such as the Global Invasive Species Database (GISD) and four library catalogues, including ECOLEX, which serves the world's most comprehensive and authoritative catalogue of environmental law. Each of the knowledge products is fundamental in its own right. There is, however, potential for them to deliver even more than is possible through each of the parts individually.

— Jane Smart, Thomas Brooks and Diego Juffe-Bignoli*, IUCN (*now with UNEP-WCMC)

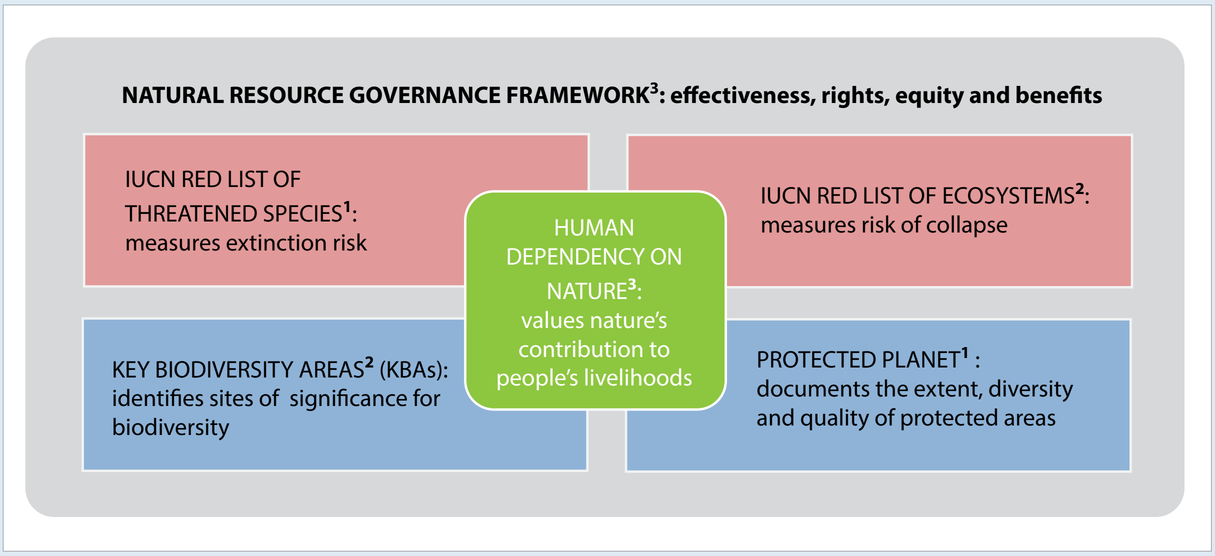


Figure 11.4 The six knowledge products delivered through the IUCN

1) Advanced, widely published and agreed and global datasets available
2) Undergoing active consolidation and revision. Global datasets for key biodiversity areas available
3) At inception phase or early stages of development

Box 11.15 UNEP World Conservation Monitoring Centre

Working with partners worldwide, the UNEP-WCMC is the specialist biodiversity assessment arm of the UNEP, based in Cambridge, in the United Kingdom. The WCMC provides objective, scientifically rigorous products and services to help decision-makers learn about the value of biodiversity and apply this knowledge. The centre not only collates and verifies data on biodiversity and ecosystem services but also undertakes analysis and interpretation, making the results available in accessible forms.

The vision of the WCMC is a world in which decision-makers in all sectors and at all levels recognise and take full account of the values of biodiversity as the bedrock of a global green economy and human wellbeing. The mission is to provide authoritative information about biodiversity and ecosystem services in a way that is useful to decision-makers who are driving change in environment and development policy. In partnership with the UNEP and IUCN, the UNEP-WCMC manages the World Database on Protected Areas (WDPA) (see Box 11.11).

Box 11.16 Global Biodiversity Information Facility

The GBIF is an international open data infrastructure, funded by governments, which ensures that anyone, anywhere can access data about all types of life on Earth, shared across national boundaries via the Internet. By encouraging and helping institutions to publish data according to common standards, the GBIF enables research not possible before, and informs better decisions to conserve and sustainably use the biological resources of the planet.

The GBIF operates through a network of nodes, coordinating the biodiversity information facilities of participant countries and organisations, collaborating with each other and the secretariat to share skills, experiences and technical capacity. It provides a single point of access (through this portal and its web services) to more than 400 million records, shared freely by hundreds of institutions worldwide, making it the biggest biodiversity database on the Internet.

The data accessible through the GBIF relate to evidence about more than one million species, collected during three centuries of natural history exploration and including current observations from citizen scientists, researchers and automated monitoring programs. More than 900 peer-reviewed research publications have cited the GBIF as a source of data, in studies spanning the impacts of climate change, the spread of pests and diseases, priority areas for conservation and food security. About 20 such papers are published each month. Many GBIF participant countries have set up national portals using tools, codes and data freely available through GBIF to better inform their citizens and policymakers about their own biodiversity.

Source: GBIF (2012)

often not possible for the datasets to communicate with each other, therefore they are not interoperable. There is a need for the skills of information management, technology and biology to overlap to ensure the data that are collected are scientifically robust and stored, managed and disseminated in a manner that will allow them to be used by the wider community.

Using data to generate improved knowledge necessitates that the data are open to be shared and made accessible, are based upon international standards so that the different datasets can be understood, and the data need to be credible (quality checked, scientifically robust). If these conditions can be fulfilled, the potential for meaningful analysis and interpretation of biodiversity datasets will be greatly enhanced. There are, however, issues of sensitivity and risk to be considered, and users should always familiarise themselves with the terms and conditions for the use of data, and review metadata to ensure use cases are appropriate and not liable to misinterpretation. In addition, where there is a likelihood that communities or specific groups (such as women, landowners or pastoralists) may be impacted by the use of the data or the resulting decisions, consideration should be taken of the potential outcomes.

Resourcing considerations

The collection of data, information and knowledge is often seen as an end in itself, without consideration of the longer-term value of managing knowledge as a resource. Too often projects and their associated websites or data management processes end once the project ends and funding dries up. This means that a large amount of potentially valuable information is lost to local managers, communities, scientific and policy communities and on-ground decision-makers. From the outset, projects

Box 11.17 The use of comparative analyses for the assessment of World Heritage nominations under biodiversity criteria

Under the UN Educational, Scientific and Cultural Organisation (UNESCO) World Heritage Convention, state parties submit nomination proposals to the World Heritage Committee, which determines, based on the recommendations of its advisory bodies, whether the nomination meets at least one of the necessary criteria to be inscribed on the World Heritage List. One of the IUCN's roles under the World Heritage Convention is to provide technical advice to the World Heritage Committee on the nominations of natural sites. For sites nominated under biodiversity criteria, Criteria (ix) and (x), the UNEP-WCMC provides comparative analyses to help inform the IUCN's recommendations to UNESCO.

The spatial analyses use global datasets in order to answer a number of questions to inform the assessment of the outstanding universal value of the site.

For Criterion (ix):

- *Does the nominated property represent ecosystems/communities that are currently underrepresented or not represented on the World Heritage List?*

  Spatial analyses are carried out to find the number of existing World Heritage sites and Tentative List sites found in the same biogeographical units as the nominated property: Udvardy province; terrestrial realm, biome or ecoregion; and marine province or ecoregion, if applicable.

- *Are these ecosystems/communities globally significant, and is the nominated property the best example, or one of the best examples, of these ecosystems/communities?*

  Spatial analyses are completed to determine whether the nominated site belongs to one of the following broad-scale conservation priorities using the following global datasets: Terrestrial Biodiversity Hotspot, High Biodiversity Wilderness Area, Terrestrial/Freshwater/Marine Global 200 Priority Ecoregion, Endemic Bird Area and Centre of Plant Diversity.

For Criterion (x):

- *Is the nominated property the most diverse and/or representative, or one of the most diverse and/or representative, of its kind?*
- *Has the nominated property been identified as a global conservation priority—for example, for globally threatened or restricted-range species?*

  If the nomination file provides a list of threatened species, it is checked against global data on the IUCN Red List of Threatened Species. The IUCN also looks at the indicative number of threatened species that may be found on the property based on their geographic ranges using globally assessed species on the Red List. Spatial analyses are undertaken to assess whether the nominated site belongs to one of the following site-scale global conservation priorities: Alliance for Zero Extinction (AZE) sites and key biodiversity areas other than AZE sites (for example, important bird areas). The results of these global spatial analyses are used to inform the evaluations of the IUCN World Heritage Panel, which considers all nominations of natural and mixed properties to the World Heritage List. The meeting of the IUCN World Heritage Panel then leads to recommendations to UNESCO on the IUCN's position in relation to each new natural nomination.

Box 11.18 Integrated Biodiversity Assessment Tool

The Integrated Biodiversity Assessment Tool (IBAT) is an innovative online system designed to facilitate access to accurate and up-to-date biodiversity information to support critical decision-making. The tool is the result of a groundbreaking conservation partnership between BirdLife International, Conservation International, the IUCN and the UNEP-WCMC. Through a state-of-the-art online mapping system, users can view, overlay and interrogate global biodiversity datasets including the WDPA, Key Biodiversity Areas, AZE sites, the IUCN Red List of Threatened Species, Biodiversity Hotspots, Endemic Bird Areas and High Biodiversity Wilderness Areas.

and initiatives should plan for the full life cycle of the information collection and long-term management. This includes sufficient resource and funding allocation to the preparation of data for long-term maintenance, including submission to global repositories, scientific publications and proper organisation and filing.

Increasingly, national governments are taking note of the value of managing knowledge, and are building policy frameworks and technical infrastructure that mobilise knowledge for public use and ensure it is available for tracking trends in the longer term. Funding is necessary for all activities in the cycle and should be incorporated in the government's budget to guarantee its continuation through long-term financial sustainability alongside proper legislation on data collecting, sharing and storage—as this can be not only time-consuming but also expensive if not done properly. Costello et al. (2014)

Chishui National Nature Reserve, Guizhou Province, China, a World Heritage property protecting outstanding Danxia landscapes
Source: Graeme L. Worboys

recommend that for long-term sustainability databases should become integrated into larger collaborative projects and curated by an organisation or institution with a suitable mandate. In the case of protected area information, this would include organisations such as the IUCN, UNEP-WCMC and the GBIF.

For data acquisition, agencies should consider the costs of field expeditions, continuous training and capacity building of data collectors and analysts. At the field level, data can be collected by researchers or local communities. In both cases the most cost-effective method is to implement permanent plots and transects that can be surveyed by different thematic teams over several years. Such sampling areas need to be maintained as well and protocols should be standardised. To avoid bias and misinterpretation of data and to fine tune data entry (for example, species name, sighting positions along transects) teams need to have frequent training sessions and discussions—all of which have financial implications.

For data analysis and storage, ideally agencies should maintain a permanent team to work on the data as part of the general management of protected areas. If this is not possible, data analysis standards, protocols and metadata should be in place to allow new personnel to continue with work of the same quality. Important initiatives on protected area management have failed due to the higher turnover of trained staff because of variable funding sources and the lack of standard protocols for data collection, analysis and storage.

Box 11.19 Knowledge use in Mexico

The Mexican Commission for the Knowledge and Use of Biodiversity (CONABIO) is an inter-ministerial commission dedicated, among other activities, to the development, maintenance and updating of the National Biodiversity Information System; to the support of projects and studies focused on the knowledge and use of biodiversity; to advising governmental institutions and other sectors; to undertaking special projects and programs and sharing knowledge on biological diversity; to following up on international agreements on topics related to biological diversity; and providing services to the public. Its mission is to promote, coordinate, support and carry out activities aimed at improving our understanding of biological diversity, as well as its conservation and sustainable use for the benefit of Mexican society.

The CONABIO advises policy and decision-makers to conserve and use biodiversity in a sustainable way by providing data, information and knowledge. It is a leader and innovator in biodiversity informatics and efficient processes, and maintains high-quality products and services. Some activities and achievements of the CONABIO are:

- creation of the World Information Network on Biodiversity (REMIB) and of an automated system of early warning of wildfire detection for Mexico and Central America
- the Mexican priority regions program for biodiversity conservation
- development of BIOTICA curatorial information manager
- publication of more than 350 titles and research papers.

Furthermore, the CONABIO acts as the scientific authority of CITES and as the focal point of the clearing-house mechanism, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), The Global Taxonomy Initiative and the Global Strategy for Plant Conservation of the CBD. At the national level, the CONABIO also coordinates the implementation of the Mesoamerican Biological Corridor in Mexico, and the elaboration of the Second Biodiversity Country Study, the National Biodiversity Strategy and similar processes for every State/Province in Mexico, among others. CONABIO provides data, information and advice to various users and implements the national and global biodiversity information networks, complying with international commitments on biodiversity entered into by Mexico, and carries out actions directed towards the conservation and sustainable use of biodiversity in Mexico.

Source: CBD (2014)

Box 11.20 Protected Areas Resilient to Climate Change in West Africa

The Protected Areas Resilient to Climate Change (PARCC) project, implemented by the UNEP-WCMC, aims to assess the vulnerability of protected area networks in West Africa to the impacts of climate change, enhance their resilience by improving the effectiveness of their management, and build capacity in the region to ensure that the new tools and strategies can be used effectively after the project's completion.

To achieve these aims, the project relies on effective data sharing between all the project partners, including the IUCN Central and West Africa Protected Areas Programme, the governments of the five project countries (Chad, Gambia, Mali, Sierra Leone and Togo), and several world-class scientific partner institutions involved in the development of new science-based methodologies (Figure 11.5). Effective production and sharing of global and regional data are in place.

- National liaison officers and consultants, and national governments are involved in data collection at the national level (for example, on climate, species distribution and policies).
- The Meteorological Office Hadley Centre provides high-resolution climate data and future regional climate change scenarios to feed into the vulnerability assessments.
- BirdLife International contributes data on the avifauna of West Africa, which are incorporated into species vulnerability assessments.
- Durham University develops species distribution models focused on West Africa and applies them to future climate scenarios over the protected area network.
- The IUCN Global Species Programme provides data on species extinction risk and vulnerability to climate change based on their specific biological characteristics.
- Durrell Institute of Conservation and Ecology, University of Kent, develops—based on all the data provided by other partners on climate change and species vulnerability—systematic conservation planning systems for the West African region.

These planning systems are then used to inform the development of climate change strategies and policy recommendations for West African countries. In order for the scientific information provided to be accurate and hence the methodology sound and the project successful, all the data exchanged between the various partners have to be interoperable, follow data standards and go through a rigorous quality check.

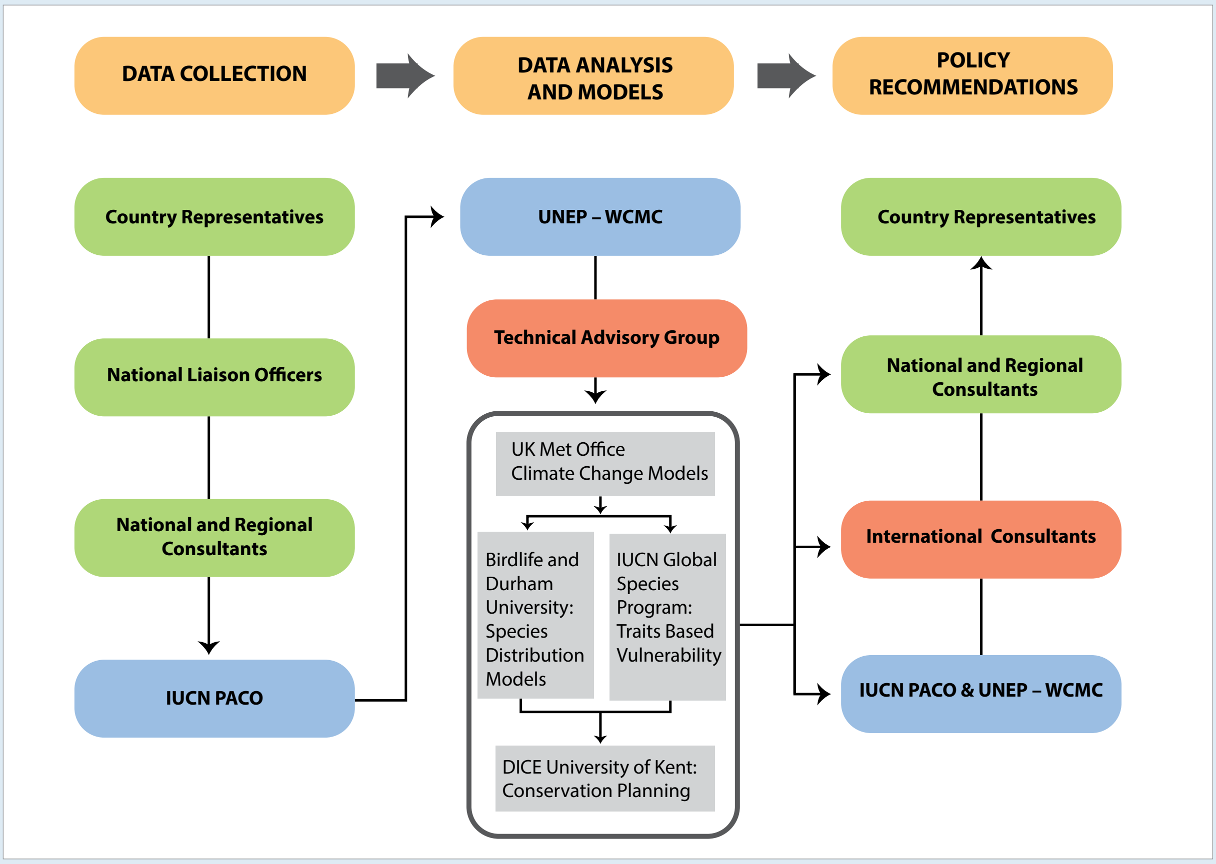


Figure 11.5 PARCC project process for production and sharing of global, regional and national data

Conclusion

There are a number of basic principles for consideration when working at the various points in the cycle of the acquisition and generation of data, their analysis and interrogation to provide meaningful information, and the understanding and communication of the resulting knowledge.

- There are many reasons for collecting data, and the data required and the scale of collection will depend on the uses for that information, so those responsible for information gathering must consider whether the data they are collecting are appropriate for the question being asked at the project design stage.
- Consider the lifespan of the data being collected beyond the scope of the project, and potentially modify the data-collection protocol to increase the applicability of datasets and their value beyond a single project.
- The use of global data standards and sharing mechanisms will ensure that the data can be integrated and reused by another party or project at a later time, and will be interoperable with other similar datasets.
- Maintenance of metadata ensures that future users understand how and why the data were collected, and what an appropriate and sensible use or interpretation of the information would be.
- Organisations, individuals or projects generating data should endeavour to ensure that they are made available through one of the global facilities, but at the very least make it available through an online and open-access resource where possible.
- Publication of data through official channels should be encouraged to ensure the above.
- The terms of conditions and appropriate use of data and information must be respected, particularly where there might be an impact on sensitive species, habitats, community groups or sites.
- The long-term resourcing to ensure proper maintenance and accessibility of data needs to be built into project design and close-off.

River dwellers receiving training towards satellite imagery interpretation for biodiversity resource monitoring in the Unini river, central Amazonia. Taken during a capacity building course for monitors of biodiversity resources of the River Unini, Central Amazonia run by the Fundação Vitória Amazônica, a Brazilian NGO.

Source: Fundação Vitória Amazônica

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