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Measuring biodiversity and sustainable management in forests and agricultural landscapes

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Most of the world's biodiversity will continue to exist outside protected areas and there are also managed lands within many protected areas. In the assessment of millennium targets, there is therefore a need for indicators to measure biodiversity and suitability of habitats for biodiversity both across the whole landscape/seascape and in specific managed habitats. The two predominant land uses in many inhabited areas are forestry and agriculture and these are examined. Many national-level criteria and indicator systems already exist that attempt to assess biodiversity in forests and the impacts of forest management, but there is generally less experience in measuring these values in agricultural landscapes. Existing systems are reviewed, both for their usefulness in providing indicators and to assess the extent to which they have been applied. This preliminary gap analysis is used in the development of a set of indicators suitable for measuring progress towards the conservation of biodiversity in managed forests and agriculture. The paper concludes with a draft set of indicators for discussion, with suggestions including proportion of land under sustainable management, amount of produce from such land, area of natural or high quality semi-natural land within landscapes under sustainable management and key indicator species.

Keywords: criteria and indicators; forest management; agriculture; Convention on Biological Diversity

1. INTRODUCTION

The seventh meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD), in February 2004, identified a series of trial indicators to be developed and used to report on the previously agreed target for CBD member states: to 'achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on Earth.' Two indicators relating to sustainable use were identified as 'possible indicators for development', aimed for adoption at the next Conference of Parties in Brazil in early 2005, giving an 18-month period to develop realistic and agreed ways for their measurement. The two indicators provisionally identified are:

- area of forest, agricultural and aquaculture ecosystems under sustainable management;
- proportion of products derived from sustainable sources.

These two measures reflect efforts to measure and develop sustainable use, that is, a response to biodiversity loss rather than being a direct measure of biodiversity itself, although there is clearly some overlap between these two.

In line with the aims of the Royal Society meeting 'Beyond Extinction Rates', the current paper looks at options for monitoring the implementation of sustainable management and its impacts on biodiversity in forests and agricultural land. The current CBD proposals are taken as a starting point, but the paper is not limited to these.

(a) *Protected areas or sustainable use?*

It is sometimes suggested that the existence of scale of protected areas could serve as surrogate indicators for biodiversity conservation status and that, therefore, the survival of biodiversity in forests and farmland is relatively unimportant. We reject this, both because most of the world's biodiversity continues to exist outside protected areas and because many protected areas also contain managed land. Both these issues are examined below.

Protected areas are the cornerstones of most national and international conservation strategies, providing refuges for species that cannot survive and ecological processes that cannot be maintained in intensely managed landscapes or seascapes. Today, there are over 100 000 designated protected areas listed by the World Database on Protected Areas (WDPA covering over 12% of the Earth's land surface (Chape *et al.* 2005)). Most of these were identified and gazetted during the twentieth century, in what is

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probably the largest conscious land use change in history. However, this also means that almost 90% of the world's land surface still remains outside formal protected areas, themselves subject to varying degrees of biodiversity protection in practice. This would be less important in the context of biodiversity monitoring if the world's biodiversity was mainly concentrated in protected areas, but in fact the majority remains outside. Although a few species, such as the two African rhinoceros species, are now virtually confined to various categories of state-run protected areas or private land (including hunting areas), these are the exceptions rather than the rule. The giant panda (*Ailuropoda melanoleuca*) provides a good example of the tendency for wild nature to retain a foothold in the wider landscape. The Government of China has had the technical expertise and the political power to establish a series of protected areas that focus specifically on those places with healthy populations of pandas in areas where there is otherwise quite intense competition between people and wildlife. Yet, despite these ideal conditions for representing biodiversity within the protected areas network, surveys show that the majority of giant pandas continue to live outside protected areas (Louks *et al.* 2001). Similarly, in Hawaii the ranges of birds that are most rare exist outside the protected area network (Scott *et al.* 1987). A global analysis of vertebrates found at least 12% of species not represented in any protected area (Rodrigues *et al.* 2004). For more mobile species, this mismatch is often the rule.

Protected areas also only function effectively as tools for conservation if they are well managed and they retain their constituent species and habitats. Unfortunately, many protected areas are currently under threat or are experiencing degradation and loss. Research in 10 forest-rich countries found that local experts only rated 1% of protected areas as fully secure and almost a quarter were already suffering some form of serious degradation (Stolton & Dudley 1999). A global survey found widespread threats, particularly in the tropical countries (Carey *et al.* 2000). Surveys in 93 protected areas in 22 tropical countries (Brunner *et al.* 2001) and in 206 protected areas in temperate and tropical countries (Dudley *et al.* 2004) found several critical threats, in particular, illegal use related to logging and poaching. While these surveys suggest that the most protected areas continue to protect some biodiversity, no assessment system should assume that protected area status is equivalent to effective biodiversity conservation.

Furthermore, protected areas surrounded entirely by radically altered habitat have limited usefulness in the long term for many species unless the areas are very large. Species trapped in protected area 'islands' risk genetic isolation and gradual decline. For example, in Java, Indonesia, the botanical gardens in Bogor were isolated in 1936 when surrounding forest was destroyed. Despite the garden's forests being maintained intact, bird populations have declined. Between 1932 and 1952, 62 species of birds were recorded in the gardens but, by the 1980s, 20 species had disappeared, four were close to extinction and five more had declined substantially (Diamond *et al.* 1987). The concept of protected areas as networks surrounded by buffer zones and interconnected by corridors and stepping stones of semi-natural habitat, suitable at the very least for the passage of species to allow genetic interchange (Bennett 1999), is now accepted throughout the conservation community and was a major theme of the Fifth World Parks Congress, held in Durban in September 2003. Increasingly, conservation organizations are looking at conservation on the scale of ecoregions (Olsen & Dinerstein 1998) and landscapes (Maginnis *et al.* 2004), which explicitly cover far more than just networks of protected areas.

In addition, protected areas are not necessarily made up entirely of untouched habitat. Protected landscapes and seascapes (IUCN Category V) and extractive reserves (IUCN Category VI) both may contain a considerable proportion of their area devoted to some kind of agricultural or forest management (IUCN and World Conservation Monitoring Centre 1994). These constitute a large area: 28.9% of the total protected areas that have been given an IUCN category, covering well over 5 million km^2 (Chape *et al.* 2003).

If biodiversity is to be conserved outside protected area networks, in economically productive landscapes, this implies that biodiversity use is sustainable in the overall landscape and in addition that management is compatible with the survival of some or all of the biodiversity originally present. Article 2 of the CBD defines sustainable use as: 'The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations'.

Sustainability must therefore be ensured from the environmental, social and economic viewpoints. Environmental sustainability implies that exploited populations should not be reduced to densities where they can no longer fulfil their ecological role—as pollinators, seed dispersers or predators, as part of the food chain, etc.—and conversely should be harvested when their densities rise above a level where their ecological role becomes distorted. Disrupting these functions potentially results in a gradual but profound shift in ecosystem functions and processes. Economic sustainability means that biodiversity should not be reduced to a point where it ceases to fulfil its economic roles in ensuring sustained livelihoods of dependent people. Lastly, social sustainability relates to the wide-ranging and diverse benefits of biodiversity for local communities that play an important role in addressing many social demands. Human-related disturbances (from global to local, from industries to communities) and policy decisions should be managed in a way that sustain or increase these benefits.

From a practical perspective, a sustainable use is one use that can be maintained in the long term. The statement that sustainable use is a form of conservation has therefore some merit and local interest in the resource is an important incentive for its maintenance. It should be clear also that all uses, consumptive or non-consumptive, will impact on the ecology in some way and will translate into more or less dramatic effects on the local environment, depending on the nature of this activity (Webb 1994).

It is essential to note that the optimal population density is likely to be different in each case outlined above (i.e. environmental, economic or social sustainability), and also to consider the time factor. As nobody can be sure that a particular use will be sustained indefinitely, there can only ever be a probability of a use being sustainable, based on current knowledge and commitments or on a qualification of the estimated sustainability by its expected duration and the necessary conditions (see review by Sutherland (2001)).

Accurate measurement of biodiversity status therefore needs to embrace the whole landscape mosaic, and to include consideration of biodiversity values in managed lands both inside and outside protected areas. Ideally, this should include the full range of different managed habitats but the current paper focuses on the two most significant terrestrial management systems: forests and agricultural land, the latter covering both cropland and grazing areas.

(b) *Critical challenges facing biodiversity measurement at a large scale*

While this broader scale of analysis is essential, it will certainly not be easy. Attempts at measuring progress in global biodiversity targets across a whole landscape, in a way that allows us to detect trends over a relatively short six-year timescale, will have to solve a number of serious methodological problems. At least three critical challenges remain to be addressed.

2. VARIABLE DATA QUALITY

Unfortunately, there is often an inverse relation between the quality of data about biodiversity within a region or country and the conservation value of biodiversity itself; in general, the places with the best records are also those with the most impoverished wildlife. Thus, countries such as the UK and The Netherlands have unusually detailed information about wild nature, but an almost entirely cultural landscape where top predators are long extinct, little or no fully natural habitat remains and a largely unmeasured proportion of biodiversity has already disappeared. Countries such as those in the Congo Basin or the Amazon still contain huge areas of largely unmodified habitat but only the most superficial information even about the largest species and a significant proportion of smaller plants and animals have never been described. The risk from the perspective of the 2010 target is that the only reliable trend data will come from the least important areas.

Such a level of data poverty makes it almost impossible to set a realistic baseline against which to measure progress. Attempts to set up a monitoring system for a conservation project covering seven provinces of central Vietnam faced just such a problem: population levels of wild species remain virtually unknown, even for megafauna such as the tiger (Dudley *et al.* 2003). The differences are stark. In the UK, most groups are now mapped at a 10 km^2 level, with a very high degree of coverage for mammals, birds, butterflies and flowering plants (with some counties now mapping on a 2 km^2 level). On the other hand, when WWF International assembled 130 experts for an ecoregional assessment of the Congo Basin, they failed to identify the presence or absence of elephants over an area the size of France and Germany combined (Kamden-Toham *et al.* 2003).

3. INDICATORS OFTEN DO NOT INCLUDE INFORMATION ON BIODIVERSITY ITSELF

Many ‘biodiversity indicators’ actually give little information about overall biodiversity levels or status. Most monitoring, particularly in data poor countries, focuses on large species, usually mammals and birds or on land cover types. While these may give general information about the ‘existence’ of habitat, they often say comparatively little about its ‘quality’ (including its ability to support other species). Forest elephants in both Africa and Asia, for instance, can continue to live in quite degraded forests as long as sufficient food plants remain and the same is true for many of the great apes such as gorilla (*Gorilla beringei*) and orang utan (*Pongo pygmaeus*). Forests can appear intact or only slightly degraded using remote sensing tools when fauna has been virtually destroyed (the ‘empty forest’ syndrome; Redford 1992) or while undergoing cryptic deforestation (Nepstad *et al.* 1999).

A review of the impact of temperate forest management on bird populations found many different responses to changes in habitat, with populations of different species increasing or decreasing creating major problems in identifying useful trends (Dudley & Jeanrenaud 1996). Similarly, a recent review of the effectiveness of bioindicators in measuring the impacts of logging on biodiversity in tropical forests concluded that both intrinsic factors and methodological constraints limit their usefulness and suggested that broader indicators of environmental health might be more useful (Azevedo-Ramos *et al.* 2002).

Mistakes in the choice of indicator species can distort our understanding of overall biodiversity, either exaggerating or understating the magnitude of the impacts of management and use. For example, using a relatively adaptable species as an indicator can disguise changes to more sensitive species and thus serve to delay necessary management responses. In the middle decades of the twentieth century, the status of reindeer (*Rangifer tarandus*) and moose (*Alces alces*) were used as a major indicator of forest condition in managed forests in northern Scandinavia. Both these choices were justifiable: the reindeer has enormous cultural and economic importance to the Sami people and the moose is an important source of food to many families in Arctic Lapland. Yet these large mammals can thrive in secondary forest where many other species will decline or disappear. Continued loss of old growth forest, and in key forest components such as standing and lying dead timber, took place while reindeer and moose populations were maintained, resulting in threats to many species associated with natural forests so that today there are for instance several hundred saproxylic (dead wood living) species on the Red List for Sweden (Fridman & Walheim 2000).

In the absence of detailed information about wild species, those seeking practical indicators are often forced to rely on various forms of surrogates, such as *habitat condition* (Lindenmayer *et al.* 2000), *umbrella or keystone species* (Simberloff 1998) or particular *management interventions* as is already implicit in the suggested indicators from the CBD. These have limitations which should be noted (Caro & O'Doherty 1999; Dale & Beleyer 2001; Lindenmayer *et al.* 2000). Habitat condition tells us quite a lot about the likelihood that certain assemblages of species will be present but offers little direct evidence of their presence, and specific pressures such as poaching or air pollution can reduce or eliminate some elements of biodiversity even within a habitat that is apparently pristine. Lack of large mammals in some protected areas in the Congo Basin is a case in point: surveys of vegetation show a healthy forest but some keystone species are absent (Maisels *et al.* 2001). Measuring progress by management intervention takes measurement even further away from quantifiable reality by assuming that particular interventions invariably aid biodiversity. As explained below, in many cases the data are not yet strong enough to support these claims unequivocally. Changes in population densities of umbrella or keystone species can be recorded but we have no real basis to assess what percentage decline or increase is an acceptable level of change (see Ghazoul & Hellier 2000; Sheil *et al.* 2004).

In practice, until now, the choice of indicators has often been influenced mainly by the particular interests of the specialists involved or the availability of data, rather than being an attempt to provide an overall assessment. Exceptions are some work on identifying useful assemblages (Kremen 1992) and drawing up hierarchies of indicators (Noss 1990) and identifying indicators for larger areas such as has been attempted for Alaska (Sidle & Suring 1986). Yet a broader understanding of biodiversity implies selecting a suite of indicators that will give as broad a picture as possible of the state of ecology and wild nature.

4. THE NEED TO CHOOSE INDICATORS THAT RESONATE WITH THE PUBLIC AND DECISION-MAKERS

Although indicators of biodiversity condition should clearly be driven by good science, they also have an important political aspect, which needs to be acknowledged and addressed if they are to be successful in influencing management. Biodiversity indicators are not only important in providing scientists with a means of measuring the state of nature, but they also have to resonate with the policy-makers who respond to the information that they contain, to politicians, industry representatives, land managers, non-governmental organizations and perhaps most important of all, with the wider public (to whom governments are responsible). Indicators in a politically driven process such as the CBD, therefore also have a role in telling a wider story about biodiversity and in setting and driving responses to the pressures that they illuminate. Indicators not only have to be technically coherent and defensible, but to provide information in a way that many people outside the fields of the biological sciences will be able to understand and to sympathize with. To be of political value, an indicator or suite of indicators may need to embody some kind of 'vision' for how the problems it is illuminating could be addressed. This implies a level of negotiation and trade-offs may be needed in reaching a final indicator list.

Agreement on specific indicators within an international agreement implies a certain level of commitment to it being applied and therefore to the message that they contain. As such, good biodiversity indicators in this context need to have more attributes than would be needed from a strictly scientific point of view, and in an ideal world would:

- be easy to identify and locate in the field without heavy reliance on specialists and often encountered when the management or uses are at an acceptable level;
- provide reliability but also a broad range of information within a single indicator;
- give good value for the resources invested (i.e. avoiding data that is more complex or expensive to collect than necessary);
- be usable by many people and if possible not relying on a small number of specialists to identify or collect;
- resonate with public and policy makers and telling a clear and understandable story about what is happening within an ecosystem (Dudley & Jeanrenaud 1996).

This also implies that all indicators will need accompanying explanation, with their limitations clearly articulated. Once indicators leave the confines of the scientific world and are used in wider policy-making and by many more stakeholders, they will also be shaped and sometimes constrained as a result of these wider interests and varying applications.

Indicators can 'foster better management. However, there are confusions and tensions to reconcile between general and local applications, between the ideal and the pragmatic, and between the scientific and the democratic. To overcome this requires a sober appraisal of what can realistically be achieved in each location and how this can best be promoted. Good judgement remains the foundation of competent management. Data can inform this judgement, but an over-reliance on data collection and top-down bureaucratic interventions can add to problems rather than solving them' (Sheil *et al.* 2004; about ecological indicators in forest management).

5. CURRENT STATUS AND APPLICATION OF SUSTAINABLE USE INDICATORS FOR TERRESTRIAL SYSTEMS

Before attempting to identify possible indicators, a rapid review of their current status was undertaken. Because of the short timescale involved in developing and applying indicators for the 2010 target and the scarcity of resources, use of existing indicators and information will be important if not essential. Yet there is currently no single source of information that will tell us everything we want to know about sustainable use. To date, considerably more effort has been made to develop global indicators of sustainable forest management than those relating to agriculture, and forest management is therefore considered first here below.

(a) *Indicators of sustainable forest management*

The 1992 Earth Summit in Rio de Janeiro first set international targets for forest conservation through its *Forest Principles* (Anon. 1993*a*). Although much derided at the time for being too weak, in retrospect the *Principles* played an important role because they set a precedent of international *targets* for forest management. In the years since, other more quantifiable targets have been developed by institutions such as the International Tropical Timber Organisation (ITTO). More are in the process of development by the CBD and the United Nations Forum on Forests, and there are a handful of influential targets advocated by non-governmental organizations. Having agreed to the principle of measurable targets, governments have had to make some effort to find ways of recording these criteria and indicators of good forest management assumed much higher political importance than in the past. A summary of some of this activity is given in table 1; all the processes described have a general target of measuring ‘sustainable forest management’ or something similar, but use a variety of different indicators.

At a global level, a range of criteria and indicators have been developed for tropical forests by the ITTO and for forest biodiversity by the CBD. ITTO indicators are often quite detailed, covering specific management approaches (plantations, natural forests) and there are guidelines relating to biodiversity. However, use of any of the ITTO guidelines has been voluntary and highly erratic and there is no obligation to collect data; although this may change because ITTO is trying to require a reporting system based on indicators in its member countries.

Issues of forest management, including specifically biodiversity, were addressed by the temperate and boreal forest component of the Forest Resource Assessment 2000, organized jointly by the FAO and the UN Economic Commission for Europe. The Temperate and Boreal Forest Resource Assessment 2000 (Anon. 2000*a*) addressed data collection through the use of national correspondents and included considerable details about biodiversity, including information on protected areas, naturalness, species under threat, invasive species and area and type of regeneration. The survey was the first attempt to collect data on area of natural forest as compared with total forest cover. While incomplete and of variable accuracy, TBFRA2000 represents the best attempt to date to identify biodiversity information for the entire forest estate (Dudley & Stolton 2004). However, the tropical section of the global report (Anon. 2002*c*) carries far less information about biodiversity, in part because of the way that data are assembled in the tropics, but also, to a large extent, because of genuine difficulties in finding the necessary information. The mismatch between temperate and tropical systems is continued through many other attempts to gather data about forests.

In a parallel process, six regional criteria and indicator processes for sustainable forest management have been developed, drawing on the Forest Principles from the Earth Summit and focusing in greater detail on particular issues relevant to different parts of the world. The first two, the Ministerial Conference on the Protection of Forests in Europe (MCPFE) and the Montreal Process, were initiatives of groups of governments; later developments were coordinated by the Food and Agricultural Organization of the United Nations (FAO) and in one case by the African Timber Organization and the ITTO. Some of these continue to be influential while others have since lost funding and appear to have been abandoned. By far the strongest systems are the Montreal Process and the MCPFE, while most of the tropical criteria and indicator initiatives have either been only weakly applied or not at all, reinforcing the split in data quality between temperate and tropical regions. The work at international and regional level has been complemented by the development of national systems in many temperate countries, in part to implement regional C&I processes.

The latest report from the MCPFE (MCPFE 2003) requests that governments report on many issues relating directly to the biodiversity of managed forests, including, for instance, level of threat to forest-dwelling species, regeneration, protection and even the amount of deadwood. While many countries admit to having poor information to respond to some of these questions, efforts are currently underway to improve monitoring schemes and to build a comprehensive European data set on forest condition. Unfortunately, this level of information is not mirrored in any way in most tropical countries.

Lastly, there has been a wide range of non-governmental initiatives. Many are based around stand-level assessments for the purpose of assessing performance of forest management to achieve certification under the auspices of bodies such as the Forest Stewardship Council, the Programme for Endorsement of Forest Certification Schemes (formerly the Pan-European Certification Scheme) or the International Organization for Standardization. These are interesting in that they are established with the specific aim of improving management for social and environmental reasons, including forest biodiversity, and they function through third-party inspection and verification against agreed principles and standards, embarked upon on a voluntary basis by forest managers. This means that there are regular site visits to certified forests and at least some data collection (Elliott 2000). Certification is also unusual in that it can be a joint effort between forest owners (either state or private) and forest products companies, creating a rare and direct link between industry and biodiversity monitoring.

However, the extent to which various certification schemes focus on forest biodiversity values differs markedly (and also differs between national standards even within a particular umbrella scheme such as the Forest Stewardship Council (FSC) or the Programme

Table 1. Existing indicator systems for sustainable forest management.

Relevant convention or process	Indicators
Global level processes seeking to measure sustainable forest management on a country scale	
Millennium Development Goals	Under goal 7: 'Ensure environmental sustainability' there is an indicator: 'proportion of land area covered by forest' but no reference to forest quality or sustainability of management
Convention on Biological Diversity	The CBD secretariat is developing indicators for its 2010 target including, 'Area of forest…ecosystems under sustainable management'. It seeks to develop outcome oriented targets to assess the programme of work on forest biological diversity with some indicators relevant to SFM
International Tropical Timber Organization	ITTO has drawn up various C&I including for biodiversity conservation (Anon. 1996*a*), natural forest management (Anon. 1992), plantations (Anon. 1993*b*) and restoration (Anon. 2002*a*)
UN Forest Resources Assessment	The Forest Resource Assessment 2000 included aspects of biodiversity, naturalness and non-timber forest products (Nyyssönen & Ahti 1996) particularly in the temperate and boreal component
Regional level criteria and indicator processes seeking to measure forest quality on a country scale	
Ministerial Conference for the Protection of Forests in Europe	MCPFE has drawn up indicators of good forest management at a national level (Anon. 2002*b*), and used them to report on European forest status (MCPFE 2003)
Montreal Process	Has drawn up C&I with 10 non-European temperate and boreal countries including a definition of sustainable forest management (Canadian Council of Forest Ministers 1995)
Tarapoto Process	Indicators were developed by the Amazon Cooperation Treaty (Anon. 1995*a*; but this process has not yet been reported in detail
Dry-Zone Africa Process	A series of C&I were agreed (Anon. 1996*b*), but have not been measured
Central American Process	Draft C&I were developed in 1997, but have yet to be fully applied
North Africa and the Middle East	FAO process—draft C&I were produced in 1997
African Timber Organization	C&I developed with the International Tropical Timber Organisation (Anon. 2003) with plans for implementation (Anon. 2003)
National level criteria and indicator schemes seeking to measure forest quality on a country scale	
France	Detailed indicators for French forests were developed in the 1990s and are still used for reporting to the MCPFE process (Anon. 1994)
Finland	Criteria and indicators were developed in 1997 (Eeronheimo *et al.* 1997)
Stand and landscape-level attempts to set criteria of forest quality and biodiversity	
Forest Stewardship Council	An accreditation body for independent assessment of sustainable forest management. The *Principles and Criteria* guide certification bodies, which draw up their own standards
Programme for Endorsement of Forest Certification Schemes	Formerly the Pan European Forest Certification scheme, previously operating just in Europe but now seeking a global programme
ISO 14000	The International Organization of Standardization has developed a certification scheme for timber, although this does not use independent assessment at stand level
Center for International Forestry Research (CIFOR)	CIFOR conducted a series of field-test to develop a generic set of C&I for SFM as well as toolkits for developing, choosing and testing C&I for stand-level forest management, along with specific criteria and indicators for plantations (Poulsen *et al.* 2001)
Non-governmental attempts to define good forest management	
WWF/IUCN/École Polytehnique Fédérale de Lausanne	A landscape-scale system for measuring forest quality was developed and tested, based on indicators of authenticity, environmental benefits and social and economic benefits (Dudley & Rae 1998)
IUCN The World Conservation Union	IUCN developed a computer software approach to measuring forest well-being using variable indicators (Moiseev *et al.* 2002)
WWF European forest scorecards	The WWF European programme developed detailed scorecards for forest condition on a national scale (Sollander 2000)
ProForest	Indicators of High Conservation Value Forest have been developed at stand and landscape level (Jennings *et al.* 2003)

for the Endorsement of Forest Certification schemes (PEFC). Indeed, one of the problems in using data from certification schemes in biodiversity monitoring is that there has been a protracted and sometimes bitter dispute about the worth of different schemes. All have attracted criticism from at least some environmental NGOs for not being stringent enough (Liimatainen & Harkki 2001; Counsell & Terje 2002) and although some institutions, such as the United Nations Economic Commission for Europe (UNECE), tend to count them all as one in forestry statistics (Hansen & Juslin 1999), this would certainly not be supported by all stakeholders. Certification under all schemes still covers less then 5% of the world's forests and less than 10% of certifications are in the tropics (Rametsteiner & Simula 2003). Furthermore, to date, the biodiversity values of such schemes are still largely 'inferred' from the changes in management needed rather than 'measured' through long-term studies in changes in forest biodiversity following certification and some NGOs remain sceptical that sustainable forest management offers a good option for conserving forest biodiversity (e.g. Rice *et al.* 2001).

There are also some NGO attempts to measure forest quality criteria at a regional level, such as the WWF European forest scorecards (Sollander 2000) and a system of assessment of forest quality developed by WWF, IUCN The World Conservation Union and the École Polytechnique Fédérale de Lausanne (Dudley & Rae 1998). These all include methodologies for the collection of data on biodiversity, but again have only been applied on a limited scale or in certain parts of the world. More recently, WWF and the World Bank have started to collaborate on a simple scorecard for measuring progress in sustainable forest management in forest stands, building on an existing scorecard used to track progress in protected areas (Stolton *et al.* 2003). When complete this will include a rapid process of collecting information on forest management based on around 30 multiple-choice questions.

Most of the systems focus on sustainable forest management, although all those listed in table 1 have at least some reference to biodiversity values. There are marked similarities between the regional systems, to the extent that there was an unsuccessful attempt to combine them into one system, associated with an intergovernmental meeting in Helsinki in 1996 (Anttila 1996). There have also been a number of attempts to evaluate and compare the various schemes, most notably by the Center for International Forestry Research (CIFOR; Prabu *et al.* 1996) and on a more theoretical basis by the Dutch-based Tropenbos Foundation (van Buren *et al.* 1997). CIFOR has also developed a methodology for users to select a portfolio of indicators suitable to their particular situation and has tested this in many parts of the world (Prabu *et al.* 1999).

(b) *Indicators of sustainable agriculture*

Agriculture has generally received less attention than forests with respect to measuring biodiversity value or conservation success, especially at the international level. Many indicators are still partially developed, have never been put into operation or are apparently abandoned. Two exceptions to this are the Organisation for Economic Co-operation and Development (OECD) and the European Union, where a number of initiatives, by the European Commission, EUROSTAT, the European Environment Agency and various EU research programmes, are currently attempting to develop agricultural sustainability indicators, including some for on-farm biodiversity, with the aim of implementation in due course. Indicators have been reviewed by Baldock (1999).

The OECD has had a substantial programme of work on agri-environment indicators in recent years, including a number of workshops, working documents and published reports. The aim has been a manageable number of indicators covering the full range of sustainability, including biodiversity, which has proved one of the more technically challenging and politically sensitive. Within the EU, the emphasis has also been on a broad suite of indicators, a small proportion of which are founded on biodiversity. The European Environment Agency is one of the organizations taking forward this work and has also initiated studies exploring the scope for developing indicators of 'high natural value' agriculture in Europe.

Compared with forestry, there is generally less agreement about how the links between biodiversity and agriculture might be measured, with much of the emphasis (where it occurs at all) put towards measuring detrimental impacts of agriculture on surrounding habitats (for instance through soil erosion or pollution run-off) rather than looking at biodiversity within agricultural systems (Gascon *et al.* 2004). This is an important shortcoming because, while the most intensive farming systems support little biodiversity, as shown through serious declines in species previously associated with farmland, many traditional agricultural systems, rangelands and various forms of ecologically based agriculture can support a proportion of wild species. Residual natural and semi-natural vegetation and structures on farmland, if not overly affected by inappropriate management, can provide important reservoirs of biodiversity and corridors and stepping-stones between natural habitat including protected areas. Low-intensity farming systems can mimic some of the attributes of more natural systems and can be associated with greater species diversity than other land uses competing with them.

Some indicator systems are now trying to address these wider issues, often based around life-cycle approaches to sustainable agriculture (Aistars 1999), but there are currently few global or regional data sets available comparable to those associated with sustainable forest management. Certain species, e.g. farmland birds in Europe (Gregory *et al.* 2005), have become an indicator for progress informally while a broader international consensus is being sought. There are also data on levels of some key aspects of agricultural management, such as the intensity of nitrogen or agrochemical use or stocking density in different regions and countries. These can be adapted to provide some information about likely levels of contamination or pressures on biodiversity. A brief overview of some current or recent assessment systems is given in table 2 below: all these have the target of measuring sustainable agriculture.

One exception to the general rule about lack of application and data is the system of certified organic agriculture, operated in many countries and generally meeting principles agreed upon at an international level. The certified management has the advantage of regular inspections and data collection as an intrinsic part of its requirements. Some forms of organic agriculture have also, unlike certified forests, been

Table 2. Criteria and indicator systems for sustainable agriculture and range management.

Relevant convention process or government	Indicators
Global level processes seeking to measure sustainable agriculture on a country scale	
Millennium Development Goals	There are no specific references to agricultural sustainability or agricultural biodiversity in the Millennium Development Goals
Convention on Biological Diversity	'Area of…agricultural…ecosystems under sustainable management' is identified as a possible indicator by the CBD
International attempts to define indicators of sustainable agriculture	
Food and Agricultural Organisation of the UN	The Sustainable Agriculture and Rural Development initiative has developed C&I including Improved Management of Natural resources and Sound Use of Agricultural Inputs (Tschirley 1996)
World Bank	Initial work has been carried out into C&I of sustainable agriculture, but not yet applied (Dumanski 1997; Dumanski *et al*. 1998)
Organisation for Economic Cooperation and Development	There is a programme of work on indicators for sustainable agriculture. This has included national studies from 15 countries (OECD 2001)
Regional attempts to define indicators of sustainable agriculture	
European Union	The European Commission has published some proposed indicators on agriculture and the environment. The project on Indicators for Sustainable Agriculture is developing C&I to be measured using existing EU data in three fields: landscape, agricultural practice and rural development (Anon. undated)
Indicator Reporting on the Integration of Environmental Concerns into Agriculture Policy	The IRENA project of the European Commission is integrating and measuring environmental concerns in the Common Agricultural Policy. Thirty-five indicators have been identified, including landscape-scale factors
Environmental Indicators for Sustainable Agriculture	The ELISA research project identified a set of 22 state and 12 pressure indicators for sustainable agriculture to help to implement EU policies, especially for landscape indicators
Examples of national processes to define towards sustainable agriculture	
Belgium	The SAFE: Framework for assessing sustainability levels in Belgian agriculture includes the development of indicators measured at three scales: field, farm and ecosystem/landscape
Canada	The Environment Bureau has developed C&I including farm resources management, soil degradation risk; water contamination risk; and agro-ecosystem biodiversity change (McRae *et al*. 2000)
The Netherlands	The Centre for Agricultural Environment has developed environmental performance indicators and yardsticks for agriculture, focusing mainly on potential environmental problems (Horlings & Buys 1997)
UK	The Department of Farming and Rural Affairs has developed indicators of sustainable farm management including coverage of a range of biodiversity-related indicators (Anon. 2002*b*)
Examples of farm-level assessment systems developed by or for food companies	
Organic standards	There are now almost 200 organic standards around the world, meeting the principles of the International Federation of Organic Agriculture Movements and in Europe meeting EC regulations. Most include standards relating to biodiversity
University of Michigan	An on-farm assessment tool for sustainable agriculture developed for Ben and Jerry's Homemade Inc., included genetic diversity; management of natural areas, riparian strips, pasture, crop fields and surrounding lands; and GMOs (Bylin *et al*. 2004)
Unilever's criteria for sustainable agriculture	Unilever identified 10 indicators, including one for biodiversity with some 'typical parameters': level of biodiversity on site, habitat for natural predator systems, cross boundary effects (Kees Vis & Standish 2000)

proven to support more biodiversity than surrounding farms, even if these are managed extensively (Feber *et al*. 1998). Thus, as an indicator, it could act as a fairly strong surrogate for biodiversity conservation. However, the global proportion of land under organic agriculture remains proportionately very small, albeit expanding. The total area under organic management is more than 24 million hectares (ha) worldwide. In addition, the area of certified 'wild harvested plants' is at least a further 10.7 million ha, according to various certification bodies (Willer & Yussefi 2004).

In summary, developments in criteria and indicators for sustainable forest management have led to many potential indicators and to a reasonable assemblage of data for many of the temperate and boreal regions, but far less for the tropics. The situation is generally less well-developed for agriculture and, although there is now an array of indicators, again particularly in the richer temperate countries, collection of data is far less advanced.

6. A POSSIBLE FRAMEWORK FOR MONITORING, WITH INITIAL INDICATORS

Given the timescale and likely budget, global indicators need to be based as much as possible on existing information. However, consensus on indicators will be hampered by the major discrepancies in data quality among different regions of the world. Developing a system that every country or even that most countries can meet in the short term would mean setting aside much of the relatively good information available in those countries where assessments have been undertaken for some time. On the other hand, basing data requirements entirely on these northern-based datasets would effectively prevent the participation of most of the countries with the richest biodiversity. The need is thus for a system that makes the best use of available data (and encourages data collectors) without excluding countries with less monitoring infrastructure. In some countries, fairly reliable data based on measurement, will already be available, in others there will be some data but also a measure of value judgements, while in a third group, information may have to draw largely on expert opinion. All these can provide useful information, but they become potentially misleading if they are not distinguished; this is a problem with some official data sources at present, where there is no indication of how far the data draws from systematic surveys or is little better than guesswork.

It is therefore proposed that data for the sustainable use indicators be distinguished according to quality of information that they use, by distinguishing between the accuracy of measurement of particular indicators. This can be done by dividing them into a number of categories: for instance quantitative, semi-quantitative or qualitative; or perhaps some measure of accuracy such as frequency of surveys or use of primary data. (This approach might well be appropriate for other indicators within the CBD targets.)

Each participating country would therefore report on the same indicators but would list the data used in the appropriate column, adding notes if further explanation were required, so that the likely accuracy of this data is made reasonably transparent. This would allow virtually all countries to report on specific indicators but would not set an impossibly ambitious task over the next six years for those nations where data collection has not even begun. Governments could in these cases also work with the CBD and other partners to improve the quality of data (a target which might be attractive to some donor agencies), thus moving to a 'higher' column as time goes on. For data users, it would provide a far more realistic picture and also give an indication of the strength of particular data sources. While governments would be responsible for assigning the level of data reliability and accuracy themselves, independent scientists, NGOs and civil society would, in this case, also play an important role in verifying such judgements.

(a) *Suggested indicators*

Indicators measuring sustainable use from a biodiversity perspective often take one of two different approaches: either drawing on information on the area under a sustainable use or on information about the status of biodiversity in these areas. The latter, being an outcome-based indicator, is ultimately more informative but far more difficult to measure. It also provides little direct information about progress in sustainable management (because, for example, biodiversity might show positive trends either if management was improved on an area or it ceased altogether, and the area abandoned to return to a semi-natural state). In the following proposals, we suggest a mixture of both approaches.

The CBD has already proposed some draft indicators for measuring sustainable use in forests and agriculture. The following suggestions draw on these, outline how they might be implemented in practice and make some additional suggestions for indicators that might be added to the initial list in order to complete a more rounded picture of the biodiversity implications of different management approaches. For both forestry and agriculture, a series of indicators could help to both capture and then refine information about sustainable use, which might fall into four general categories as outlined below:

- proportion of land under sustainable management of specified kinds;
- amount or value of produce from land under sustainable management;
- area of natural or high quality semi-natural land within landscapes under sustainable management;
- key indicator species (assuming that the various caveats of the indicator species approach are addressed; see discussions in Simberloff 1998; Lindenmayer *et al.* 2000; Dale & Beyeler 2001).

The first two relate directly to management, but both assume that the sustainability of broad categories of management can be agreed and measured and, furthermore, that this will have net benefits for biodiversity, or will at least not be detrimental. The third goes slightly deeper by looking at land within these use categories that remains in a condition 'likely' to be good for biodiversity, and the last proposes an outcome-related biodiversity indicator for these areas. Data collected for other indicators might also provide information likely to be useful for judging the reality of sustainable use, particularly with respect to monitoring wild species. Each of these will be outlined in further detail below.

(b) *Indicators of sustainable forest use*

Using this general template, the key indicator should be area of forest land under sustainable management; this is an obvious choice and has also already been identified by the CBD. Adding produce from sustainably managed forests would help to refine the information further by also showing the proportion of traded goods that come from these improved management systems. However, the potential problems with

Table 3. Summary of development requirements for indicators of sustainable forest use.

Form of indicator	Terms requiring definition	Methodological requirements	Survey requirements	Possible partners	Potential problems
Indicator 1: Area under sustainable forest management					
Either an indicator with a series of stages or a scoring system	'Sustainable management'	Agreement on measuring levels of sustainability	Global surveys	ITTO, World Bank, CIFOR, certification bodies, wood product companies	Agreement on what constitutes sustainable
Indicator 2: Products from sustainably managed forests					
Volume or value of products	'Sustainably managed'	Accounting methods	Existing surveys amalgamated into global figure	Certification bodies, major retailers, FAO	Agreement on what constitutes sustainable
Indicator 3: Area of natural forests					
Proportion of existing forest in natural state	'Natural'	Rapid survey methods (ideally satellite images) in tropics	Data available for most temperate forests, still needed in tropics, Southern Arc and north Asia	FAO, UNECE, ITTO, NASA, World Resources Institute	Identifying natural forests; agreement on what is 'natural' in some areas
Indicator 4: Indicator species					
Status of key species reliant on sustainably managed forests	Identification of indicator species or surrogates	Survey methods exist	Major survey task unless data already collected for other indicators	National biodiversity surveys, Red List, NGOs, universities, research institutes	Costs of identifying and surveying relevant species may be prohibitive

applying these and the limited information that they convey suggest that the overall picture might be further expanded by information on natural forest cover and if possible on key species that indicate good management.

For each of these, agreement is needed on the form that the indicator takes, and on a series of definitional and methodological requirements, along with new survey work. Table 3 summarizes these requirements, which are then discussed in greater detail.

Sustainable forest management could be measured either by completing a series of steps (for instance, existence of good governance, regulatory framework, control of illegal logging and certification of good management) or through some scoring system that uses these as fields in an assessment system. Examples from existing systems, such as the World Bank/WWF scorecard, that is currently under development, and a 'governance pyramid' developed by the International Institute for Environment and Development for use at a national level to indicate quality of forest governance (Mayers *et al.* 2002), could help to develop national assessment systems using either of these approaches. The ease with which sustainable trade data could be separated from other statistics for wood products would depend on the definition of sustainable that is adopted. Figures for trade in various forms of certified wood products are already available but if a less stringent definition were agreed upon it would be correspondingly more difficult to separate out the proportion of sustainable products in the market.

Many methods for defining 'natural' forests already exist (Dudley 1996, 2003) and data, albeit of varying quality, are available for North America, Europe, the CIS, Japan, Australia and New Zealand through the UNECE Temperate and Boreal Forest Resource Assessment (Anon. 2000). These increasingly focus on current status rather than ecological history, i.e. assuming that 'naturalness' is an attribute that can be both lost and gained rather than a condition that can only be lost once. Collecting additional data from other countries would present a major challenge, even if satellite data were available (it is not certain how easy it is to distinguish natural from disturbed forest and in addition, in some parts of the world frequent cloud cover creates major problems). The World Resources Institute's Global Forest Watch initiative can provide updated or new information for areas including Russia, Canada, Chile and the Congo Basin. This already creates a strong basis for measurement by the CBD because the areas where it is particularly important to distinguish quality of remaining forest include those where long-term management has created cultural and secondary forests such as Europe and much of North America. Aiming to refine and expand knowledge of natural forests could be a key additional indicator of sustainable use, giving information about the overall status of the forest estate.

If our ability to track trends in wild populations dependent on the larger forest estate improves, it would permit the use of outcome measures to back up those looking at management practices and overall habitat area. This would be an important failsafe against misinterpretation. In some regions, such information is already available or will become so, for instance the dead wood and biodiversity surveys now obligatory in the signatory countries to the Ministerial Conference on the Protection of Forests in Europe. In other cases, information may be transferable from that collected in other surveys, inside or outside the CBD framework.

Table 4. Summary of development requirements for indicators of sustainable forest use.

Form of indicator	Terms requiring definition	Methodological requirements	Survey requirements	Possible partners	Potential problems
Indicator 1: Area under sustainable farm management					
Could use a scoring system and might need to to distinguish between crop and rangeland	'Sustainable management'	A widely applicable method for measuring levels of sustainability	Global surveys	FAO, European Commission/ Parliament, governments, organic sector bodies, etc.	Practical assessment system and typology
Indicator 2: Products from sustainably managed farms and rangeland					
Volume or value of products	'Sustainably managed'	Accounting methods	Existing surveys amalgamated and extended	Certification bodies, major retailers, FAO, governments	Agreement on what constitutes sustainable
This indicator would be easy to monitor if an existing system, such as organic agriculture, could be adopted as the standard, but far more difficult if sustainability were defined more generally					
Indicator 3: Area of semi-natural habitats within farmland					
Natural habitat on farmland	'Natural' and 'semi-natural'	Rapid survey methods possibly using satellite imagery	Detailed surveys needed	FAO, NASA, governments, World Resources Institute	Lack of data; costs may be prohibitive
Indicator 4: Indicator species					
Status of key species reliant on sustainably managed forests	Identification of indicator species or surrogates	Survey methods exist	Information becoming available for Europe but surveys needed elsewhere	National biodiversity surveys, Red List, NGOs, universities, research institutes	Costs may be prohibitive; substantial time delays

(c) *Indicators of sustainable agricultural use*

As identified earlier, fewer methodologies and less data exist for measuring trends in farmland biodiversity in a satisfactory way and European experience (which itself remains limited) will not transmit easily to other regions, particularly in the tropics. Table 4 builds on the generalized indicators identified earlier and summarizes what would be needed to apply these to farming systems.

In general, more work would be needed to improve and to refine these than is the case for forest systems, because of the slower rate of development in the field of agricultural criteria and indicators. Other possible indicators to consider could be the relative evolution of areas under cultivation and under natural or near natural land use; the ratio between areas intensively managed for one crop (maize, rice, oil palm) and areas managed for multiple crops (agroforests, mosaics of farmlands, smallholdings, etc.); and perhaps the ratio of perennial to annual crops. Relatively unrefined indicators such as the level of nitrogen input per hectare, which gives a measure of intensity, may also have a role.

7. CONCLUSIONS

Terrestrial biodiversity is too widely dispersed to allow its measurement to be focused solely within strict protected areas. Managed landscapes will continue to play vital roles as buffer zones and corridors supporting protected areas and more generally as habitat for wild species, some of which are likely to never be adequately represented within the protected area network. Measurement across the whole mosaic of land-use type is therefore essential, including in areas of sustainable use, particularly forests and agricultural land, both inside and outside protected areas.

There is already considerable experience in developing indicators of sustainable use in both these habitats, although currently this is concentrated in the richer temperate countries (where biodiversity is generally less rich). This existing experience stretches from intergovernmental institutions to governments, independent academic researchers, non-governmental organizations and also to commercial companies, consequently the list of potential partners in developing and measuring biodiversity in these conditions is much wider than in some other cases, although the challenges are probably also correspondingly greater.

The range of different levels of expertise and existing information means that any indicators that are developed should include an indication of the character and strength of the data source and whether this is based upon quantitative or qualitative information. Some methodological work will be required to refine and develop existing indicators and to collect data in those parts of the world where it is currently missing. However, this is not so daunting a task as to be impossible and concerted effort over the coming 18 months could mean that a viable, if preliminary, set of indicators for sustainable use, and an initial baseline of information, would be ready by the time of the next Conference of the Parties of the Convention on Biological Diversity in February 2006.

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GLOSSARY

CBD: Convention on Biological Diversity
C&I: criteria and indicators
CIFOR: Center for International Forestry Research
FAO: Food and Agricultural Organization of the United Nations
ITTO: International Tropical Timber Organisation
MCPFE: Ministerial Conference on the Protection of Forests in Europe
OECD: Organisation for Economic Co-operation and Development
UNECE: United Nations Economic Commission for Europe
WDPA: World Database on Protected Area