Best Practice Series


A Common Vision on Biodiversity

# Managing Biodiversity in the Landscape

Government of Malaysia

Guideline for
Planners, Decision-Makers
& Practitioners

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Malaysia's policies and plans contain emphasis and provisions for holistic and integrated planning and management of natural resource and biodiversity assets as a precursor for environmentally sustainable development.

For planners, decision-makers and practitioners to meet these aspirations, stakeholders will have to view resources in a broader context. Not only must it go beyond sectors to include all stakeholders in the decision process, but it must also use the best science available to define suitable management actions.

The overall purpose of this Guideline is to support this important endeavour.

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# Tables, Figures & Text Boxes

# Abbreviations

BDFFP................Biological Dynamics of Forest Fragments Project
CEPA..................Communication, Education & Public Awareness
CBD....................Convention on Biological Diversity
DID.....................Drainage & Irrigation Department
DOA ...................Department of Agriculture
DoF.....................Department of Fisheries
DWNP ................Department of Wildlife & National Parks (PERHILITAN)
EA ......................Ecosystem Approach
EIA .....................Environmental Impact Assessment
EPU ....................Economic Planning Unit
FD.......................Forestry Department
FDs .....................Forestry Departments from Peninsular Malaysia, Sabah and Sarawak
FRIM ..................Forest Research Institute Malaysia
GEC....................Global Environment Centre
GIS .....................Geographic Information System
JKR.....................Public Works Department
KPKT .................Ministry of Housing and Local Government
KPPK.................Ministry of Plantation Industries & Commodities
LA ......................Local Authority
LU ......................Land use
MA .....................Millennium Ecosystem Assessment
MENGO .............Malaysian Environment NGOs
MOA ..................Ministry of Agriculture
MOSTE ..............Ministry of Science, Technology & Environment (now NRE)
NGO ...................Non-Governmental Organisation
NLD...................National Landscape Department
NRE....................Ministry of Natural Resources & Environment
NSSD.................National Strategies for Sustainable Development
PA.......................Protected Area
PAs .....................PA in plural. In the context of administrative bodies refers to: PERHILITAN, Sabah Parks, Sabah Wildlife Department, Sarawak National Parks & Wildlife Division
PA-PFR ..............Protected Areas and Permanent Forest Reserve (i.e. combined area)
PAMC ................Protected Areas Management Category
PERHILITAN ....Department of Wildlife & National Parks
PFR.....................Permanent Forest Reserve
PP .......................Policies and Plans
PPP .....................Policies, Plans and Programmes
SA.......................Sustainability Assessment
SEA ....................Strategic Environmental Assessment
TCPD..................Department of Town & Country Planning
TRP ....................Town & Regional Planning (Sabah)
VJR.....................Virgin Jungle Reserve

# 1 Introduction

## 1.1 Who is this Guide for?

This Guideline for managing 'biodiversity' in the landscape aims to assist planners, decision-makers and practitioners in their day-to-day functions at all planning levels from federal to regional, state and local levels.

It should be useful to any agency influencing the landscape of today and tomorrow, including entities engaged in: development planning and assessment; environmental planning and management; development of infrastructure; urban and green zone planning; as well as companies and smallholder organisations representing extensive land use systems such as oil palm and rubber.

Finally, the Guide should be helpful to NGOs, consultants, educational centres and members of civil society with an interest in biodiversity, environment and sustainable development.

It forms part of a *Best Practice Series* being prepared by the Ministry of Natural Resources and Environment – NRE.

**Term**

A simple definition of biodiversity – also called biological diversity – is:

*The variety of life on the planet – including the diversity within species, between species and of ecosystems.*

See the Glossary (p. 59) for a full definition.

## 1.2 Purpose of this Guide

This Guide aims to provide an overview of what it takes to manage biodiversity in the landscape and it should be further supported by Guidelines detailing specific management interventions such as riparian and other 'corridors'.

Using this guide will assist you in:

- Recognising why biodiversity is important and how it supports ecosystem services essential for society and human livelihood
- Understanding key issues related to biodiversity and important drivers of change affecting it
- Applying principles and promoting management interventions that support biodiversity at landscape levels
- Incorporating biodiversity concerns and priorities into planning and decision-making
- Communicating clearly and giving instructions to staff whose activities may affect biodiversity
- Saving time and optimising efforts when considering development proposals
- Mainstreaming biodiversity into the preparation, review and updating of Policies, Plans and Programmes (PPPs)
- Standardising the quality of work
- Managing natural resource and biodiversity consultants and effectively applying their reports.
- Understanding and applying Guidelines which detail more site-specific management interventions (e.g. Rehabilitation of riparian vegetation; Establishing biological corridors).

**Term**

*Mainstreaming* means integrating or incorporating actions related to conservation and sustainable use of biodiversity into strategies relating to production sectors, such as agriculture, fisheries, forestry, tourism and mining. By mainstreaming biodiversity into PPPs, we recognize the crucial role that biodiversity plays in human well-being.

In order to meet existing policy and plan provisions, Federal, State and Local Authorities may increasingly have to respond to key questions such as the examples shown in **Box 1**. This Guideline provides a framework to answer these and similar questions.

**Box 1. Key questions for Federal, State and Local Authorities.**

- Why is biodiversity important?
- What are the greatest dangers to biodiversity?
- How do changes in land use affect biodiversity?
- Why aren't Protected Areas enough to ensure ecosystem services?
- How best to understand the implications of landscape cover in a given landscape?
- What is landscape matrix management and why is it important?
- How do we get started on the ecosystem approach?
- What can we do now to preserve biodiversity in the landscape?
- How can areas of biodiversity value be protected and managed in the long term?

## 1.3 A Training Toolkit on managing biodiversity in the landscape

This Guideline is also part of a course prepared for planners and decision-makers on managing biodiversity in the landscape[1]. The complete Training Toolkit comprises:

- A *Trainer's Guide* containing:
  - Introduction with objectives and target group
  - Brief guide to preparing a course
  - Detailed description of Modules and Lessons (the latter with suggested narration). Two options for field visits have been included (for courses conducted in the Kuala Lumpur area)
  - Description of Group Activities
  - 16 slide presentations (more than 300 slides)
- A *Trainee's Guide* (i.e. the present document)
- Posters on various aspects dealt with in the training course

An accompanying CD has been included to allow for easy reproduction. It contains soft copies of the following:

- Trainer's Guide, including separately
  - Pre-course questionnaire (doc)
  - Sample course plan (xls)
  - Course evaluation (xls)
  - Certificate of completion (doc)
- Slide presentations in PowerPoint 2007 format
- Slide presentations as video files
- Guideline – Managing biodiversity in the landscape (the present document)
- *A common vision on biodiversity* (all three versions)[2]
- Posters

## 1.4 Using the Guide

Managing biodiversity in the landscape is one part of a three-pronged approach promoted by NRE to achieve environmentally sustainable development. The other two prongs are: Strengthening the Protected Areas System; and Mainstreaming of Biodiversity.

To get a more complete understanding of concepts and considerations presented here it is important that readers consult: *A Common Vision on Biodiversity – Reference Document for Planners, Decision-Makers and Practitioners* (NRE, 2008a), as well as other Guidelines produced as part of the *Best Practice Series*.

Throughout this Guideline boxes are used in the margin to summarise key points related to subject matter dealt with (e.g. Terms; Key Points).

Terms and concepts may the first time they appear be in single ‘quotation marks’ which means that they are further explained in the Glossary.

# 2 Understanding the context

## 2.1 What is biodiversity?

For people in general, biological diversity may be represented by a *collage of life* which we have learned to appreciate (**Figure 1**). For most people this may be based on their encounters with nature and individual species of plants and animals.

Some may also include landscapes which are particularly appreciated.

**Figure 1.** Biodiversity as a *collage of life* (by Yew Kiang Teh).

By contrast scientists generally consider biodiversity as genes, species and populations of an area, and the processes supporting them.

However, for planners and decision-makers to meet expectations of society as represented by national goals for sustainable development, a more elaborate conceptualisation is needed.

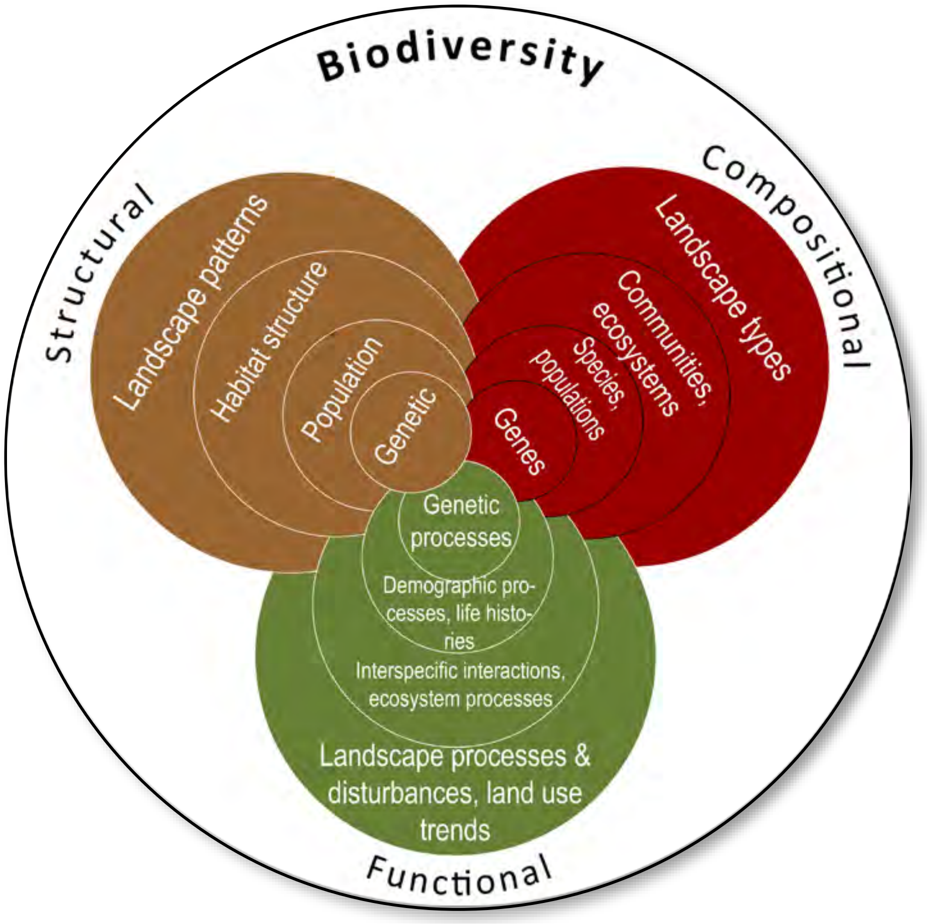



**Figure 2.** Biodiversity as a nested set of processes and interactions operating in time and space (modified from Noss, 1990).

In **Figure 2** biodiversity is shown also as a *collage* but according to: *structural, compositional* and *functional* aspects. These facets should be understood as a nested set of processes and interactions operating in time and space.[3] When we, for reasons of simplicity, refer to biodiversity as constituted by genes, species and ecosystems then we are only referring to some of the compositional elements of biological diversity. Managing biodiversity in the landscape means dealing with all the larger circles in all three facets.

It is also important to realise that changes in one element (i.e. represented as a circle) will lead to modifications in the whole system – though some alterations will manifest themselves more slowly than others.

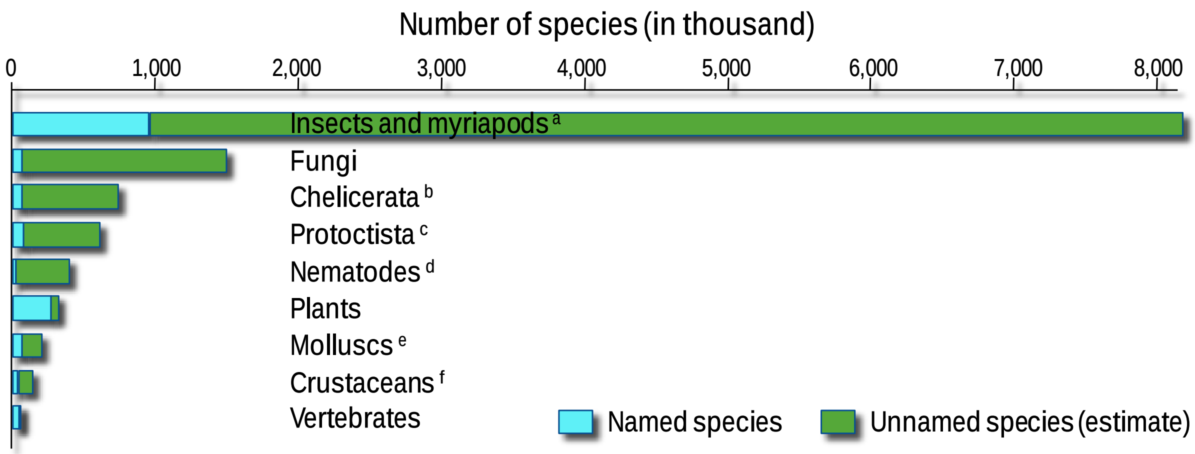
It took nature some 4 billion years to evolve a subtle balance in this "fabric of life" which has resulted in a variety of 'ecosystem services' essential for society and human well-being. What *ecosystem services* mean is explained in the following Section – but first a few words about how we measure biodiversity.

Ideally, to assess conditions and trends in biodiversity we would like to measure:

- The abundance of all organisms over space and time, using 'taxonomy' which classifies organisms in an ordered hierarchical system that indicates natural relationships
- Functional traits are unique attributes which reflect how species are born, how they live (including growth, feeding, movement, dispersion, and reproduction), and how they die.[4]
- The interaction among species in terms of for instance, predation, parasitism, competition, and pollination; and how strongly such interactions affect ecosystems.
- Finally, it would be even more important to estimate the turnover of biodiversity in space or time. Such a turnover we may think of in terms of different stages of coastal vegetation types during onset of glacial periods when water levels fell around the world.[5]

However, the multi-dimensionality of biodiversity (as indicated in **Figure 2** above) makes it a tremendous challenge to measure it.

In terms of how much life there is on the planet then estimates range from between 5 and 30 million different species, with a best working estimate of 8 to 14 million of which we have only identified 1.8 million[6] (see Figure below).




[a] Myriapods: centipeds and millipedes
[b] Arachnids
[c] Algae, slime mold, amoeboids, and other single-celled organisms (excluding bacteria)
[d] Roundworms
[e] Snails, clams, squids, octopuses, and kin
[f] Barnacles, copepods, crabs, lobsters, shrimps, krill, and kin

**Figure 3.** Number of species on the planet (redrawn from MA, 2005).

In spite of biodiversity remaining difficult to quantify precisely we are fortunate since, as planners, decision-makers and practitioners, our response options to changes in biodiversity may be defined by essentially understanding:

- *Where* biodiversity is
- *How* it is changing over space and time
- *What* drivers are causing change, and
- Drivers *impact* on ecosystem services

As we shall see later on, these elements can be revealed by largely conducting an exercise in spatial planning (i.e. using maps).

## 2.2 What are ecosystem services?

An amazing attribute of biodiversity is that it supports the functioning of 'ecosystem services', which are the benefits that people obtain from ecosystems and that ultimately affect human livelihood.

They are classified in four groups: *provisioning*; *regulating*; *cultural*; and *supporting services* (**Figure 4**).

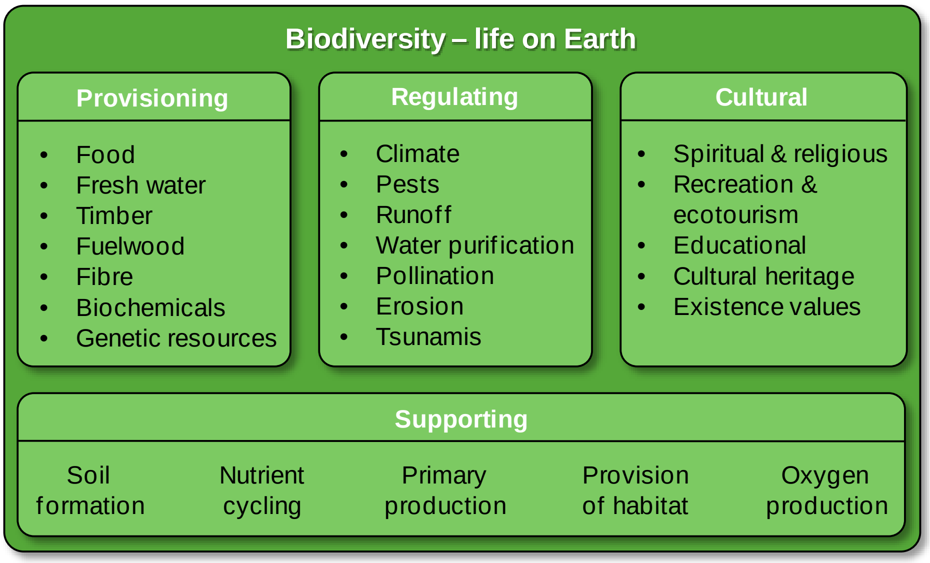



**Figure 4.** Classification of main ecosystem services provided by biodiversity (based on Pereira & Cooper, 2006).

In general we only recognise services that have a market value such as provisioning services (e.g. timber) and some cultural services (e.g. ecotourism), but we benefit tremendously from all the other services and – indirectly – from the supporting services.

The minimum constituents of human livelihood may be defined as: security; basic material; health; and good social relations (**Figure 5**).

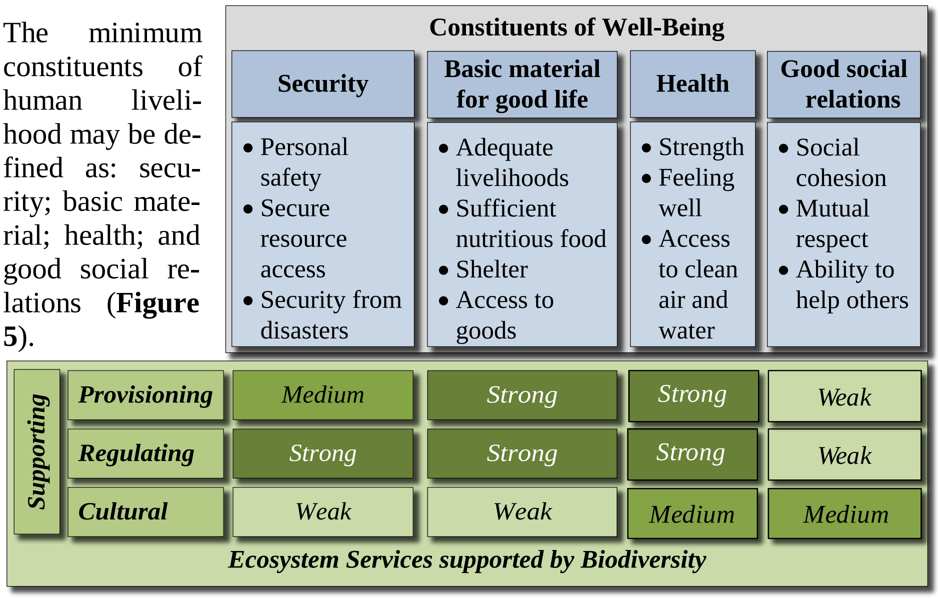



**Figure 5.** Linkages between ecosystem services and human livelihood (derived from MA, 2005).

Ecosystem services contribute significantly to each of these and particularly with respect to health, materials and security. Cultural services such as recreation and education strengthen health and good social relations.

**Term**

An 'ecosystem' is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit.

Humans are an integral part of ecosystems.

We define ecosystem boundaries by using for instance:

- Distribution of organisms
- Drainage area
- Soil types

Our choice depends on the scale (i.e. national, regional, state, or local). Sometimes we use several of the parameters together.

With the above in mind it should be clear that our very well-being is the result of numerous factors and many of these are directly or indirectly linked to biodiversity and ecosystem services.

## 2.3 How can biodiversity support ecosystem services?

Though there is no simple relationship between biodiversity and ecosystem services we know that as species adapt to one another and to their communities, they form 'niches' and associations. The development of more complex structures allows a greater number of species to coexist with one another. The increase in species richness and complexity acts to protect the 'community' from environmental stresses and disasters, rendering it more stable and facilitating a continuous flow of ecosystem services (**Figure 6**).

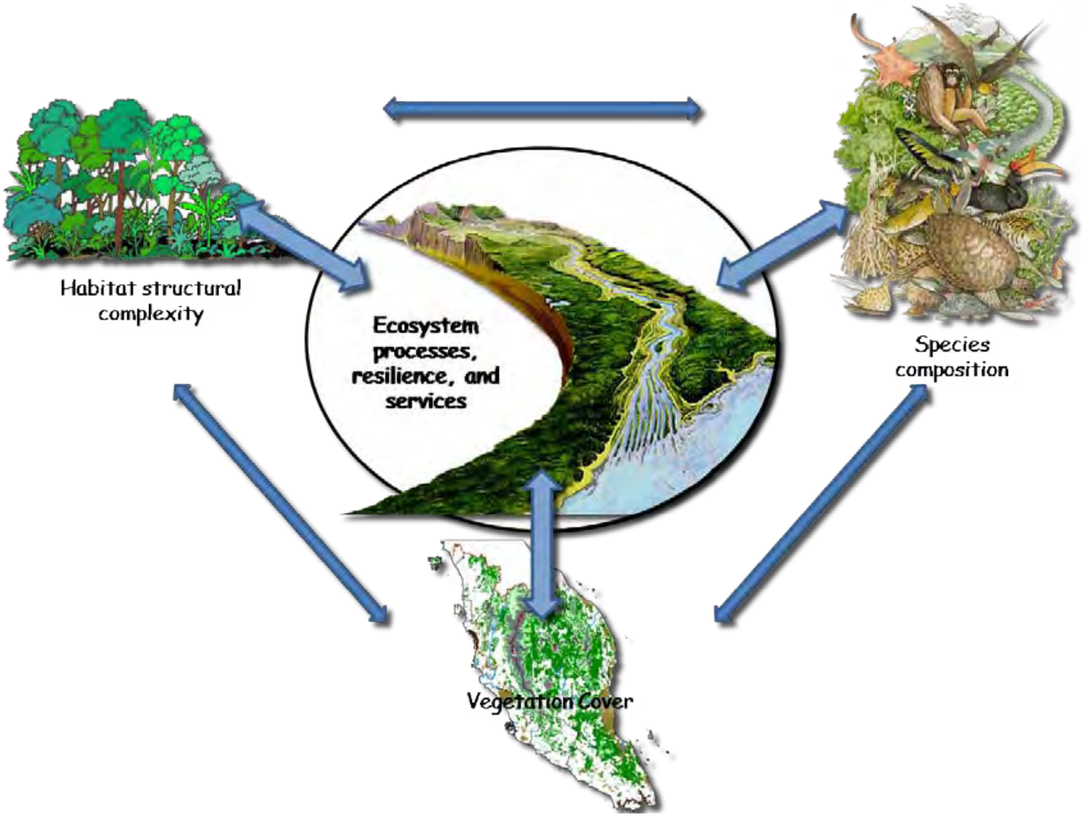



**Figure 6.** Conceptual summary of how three key ecosystem properties relate to ecosystem processes, resilience and services (modified from Lindenmayer & Fischer, 2006). (The graphic in the centre is modified from Evans, 2003; the upper two are drawn by Yew Kiang Teh; and the map is from DWNP, 1996.)

**Key Points**

For planners, decision-makers, and practitioners it is absolutely essential to understand:

- Three features of habitat in the landscape (Figure 6) are key to overall assessment and monitoring of biodiversity and ecosystem services.
- The three properties can be represented as spatial features on maps.
- Biodiversity planning and management is largely an exercise in spatial planning.

The interaction between three ecosystem properties corresponding to:

- *Vegetation cover* (the more extensive the better)
- *Structural complexity of habitat* (horizontally and vertically), and
- *Species composition* (i.e. usually the higher the number of different species the better)

supports *ecosystem processes*, *landscape resilience*, and the *quantity* and *quality of ecosystem services* at local, state, regional and national levels.

If this representation is compared to Figure 2, which shows biodiversity as a nested set of processes and interactions, it should be possible to see that these three ecosystem properties correspond to some of the larger *functional*, *structural*, and *compositional* aspects which we have already established as key entry points for planners and decision-makers.

In spite of biodiversity being difficult to measure (as referred to in Section 2.1, p. 5, above) we should then find comfort in the fact that the three features underpinning ecosystem services are largely spatial and can (and should) play a fundamental role in support of informed decision-making.

## 2.4 Federal, state and local government responsibilities

The management of the environment and biological diversity in Malaysia is the joint responsibility of federal, state and local governments. However, present regulatory framework is based on sectoral concerns and governed by sector agencies.[7]

Under the Ninth Schedule of the Federal Constitution, state governments control land and natural resources. However, neither the *environment* nor *biological diversity* (or biodiversity) appear in the three constitutional lists as a matter for legislation. Instead the three lists refer to related subjects such as land, water, forest, agriculture, and wild animals, which have given rise to the sector-based legislation and administration we know today.

This poses special challenges for managing biodiversity since it transcends sectors and operates at multiple scales from local, state, national and international levels.

The most emphasised aspects of Policies and Plans relevant for operational conservation actions are: [8]

- Development should be environmentally sustainable [9]
- There is a recognition that human livelihood is dependent on biodiversity [10]
- Planning and management should be integrated and holistic (as opposed to sector-based) [7]
- Critical habitats should be protected (i.e. in terrestrial, freshwater and marine systems) [11]
- Protected Areas should be expanded to include all habitat/ecosystems [12]
- Planning and management should be based on river basins [13]
- Mainstreaming of biodiversity should be incorporated into Policies, Plans and Programmes (PPPs). [14]

**Key Points**

"Parliament may make laws with respect to any matter in the State List for the purpose of implementing any treaty, agreement or convention.... or any decision of an international organisation or for the purpose of promoting uniformity of laws of two or more states"

Paraphrased from Article 76 of the Malaysian Constitution.

The National Policy on Biological Diversity, the National Policy on the Environment, the National Forestry Policy, the 3rd National Agricultural Policy, the National Physical Plan, and the 9th Malaysian Plan all refer to the need for integrated, holistic, and sustainable development which safeguards the environment.

This Guide will show how multiple stakeholders can carry out complementary actions across the landscape which will help achieve both the nation's conservation goals as well as agricultural production.

## 2.5 What is the value of biodiversity?

Despite growing recognition of the importance of ecosystem functions and services, they are often taken for granted and overlooked in environmental decision-making. Economic valuation of ecosystem services is an evolving discipline and their assessment depends on a good understanding of such services (**Figure 8** overleaf).

Lack of information often causes values to be put too low. Underestimation of the economic value of ecosystem services often stems from lack of information about *non-use values*, future uses of biodiversity, and the willingness to pay of future generations for existing and prospective biodiversity uses. In general we can say that the better our ecological knowledge and understanding, the better our economic valuations will be.

**Key Points**

- Improved ecological knowledge leads to better economic valuations
- Ecosystem services represent twice the value of the Gross National Product
- Almost two-thirds of ecosystem services are in decline

The total value of ecosystem services has been conservatively estimated to be double the global Gross National Product – that is, some US$ 33 trillion – which is returned annually to human societies all over the planet (1994 figures). [15]

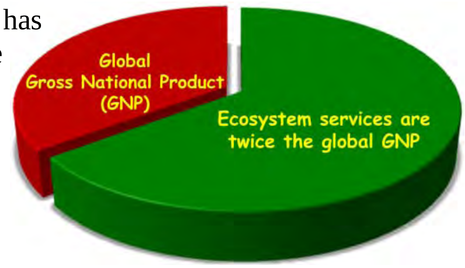



**Figure 7.** A conservative estimate of the ratio between the values of the global *Gross National Product* and *ecosystem services.*

However, the 'Millennium Ecosystem Assessment' set out to evaluate the status of 24 global ecosystem services and in 2005 reported that for the last 50 years, almost two-thirds were found to be in a state of decline, five remained steady and only four were improving in spite of Protected Areas having more than doubled during the last quarter of a century[16]. Clearly, any country aspiring to environmentally sustainable development has reasons to

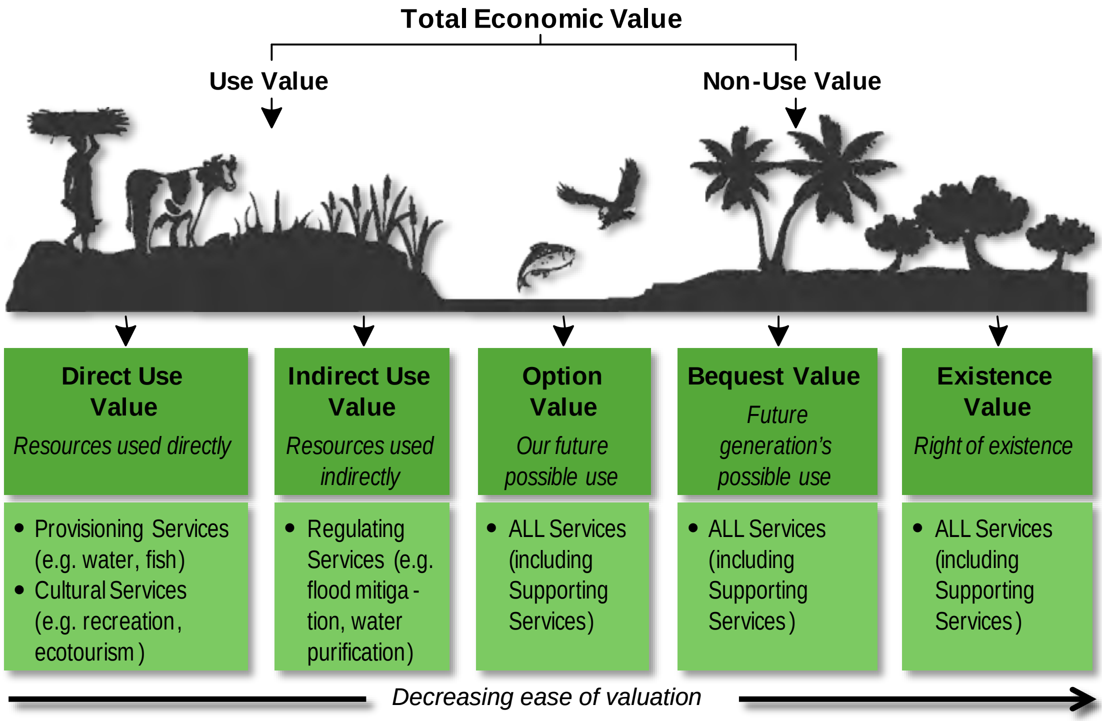



**Figure 8.** The total economic value of ecosystems (redrawn and modified from Smith *et al*., 2006).

A few examples of the value of individual ecosystem services are shown in the text Box below.

**Box 2. Examples of valuing single ecosystem services** (first two from NRC, 2004, remainder Gallai *et al.* 2009.

- In 1996 New York City invested US$ 1 – US$ 1.5 billion in natural capital expecting savings of US$ 6 – US$ 8 billion over 10 years representing an expected Internal Rate of Return of 90% - 170% in a payback period of 4 – 7 years. This represents an option of investing in 5,000 km2 of watersheds as opposed to establishing a new filtration system supplying water to some 8 million people. The replacement costs for natural processes was estimated at US$ 2 – US$ 6 billion (some US$ 4,000 to US$ 12,000 per ha). (NRC, 2004.)
- More than 200,000 plant species worldwide depend on animal pollination to produce seeds. Pollinators include in their ranks about 1,200 species of vertebrates and at least 200,000 species of insects. Pollinators affect 35% of the world's crop production increasing output of 87 of the leading food crops worldwide. (NRC, 2004.)
- Economic value of insect pollination for the world agriculture in 2005 was €153 billion (i.e. 9.5% of the total value of the world agricultural food production). Vegetables and fruits were the leading crop categories in value of insect pollination with about €50 billion each, followed by edible oil crops, stimulants, nuts and spices.
- Pollinator disappearance would translate into a consumer surplus loss estimated between €190 to €310 billion.

## 2.6 What is affecting biodiversity most?

Biodiversity is affected by all sectors of society and we have to gain these sectors' support in order to address the fundamental causes behind the current loss of biological diversity. In other words, a challenge is to make biodiversity concerns a part of how people go about their business – at all levels of society.

The main reasons why biodiversity is disappearing and ecosystem services are reduced are (in order of significance):

i) Change in land use
ii) Fragmentation and isolation
iii) Habitat change
iv) Invasive species
v) Over-exploitation
vi) Pollution

Many species and communities have already reacted to climate change[17] though the impact has so far, except for polar regions, been fairly low (which is why it is not included in the six reasons above). This is about to change, but before we explore that first a few words about ecosystem services in the context of global change.

**Key Points**

With almost two-thirds of ecosystem services degrading, the capacity of ecosystems to neutralize pollutants, protect us from natural disasters, and control the outbreaks of pests and diseases is declining significantly.

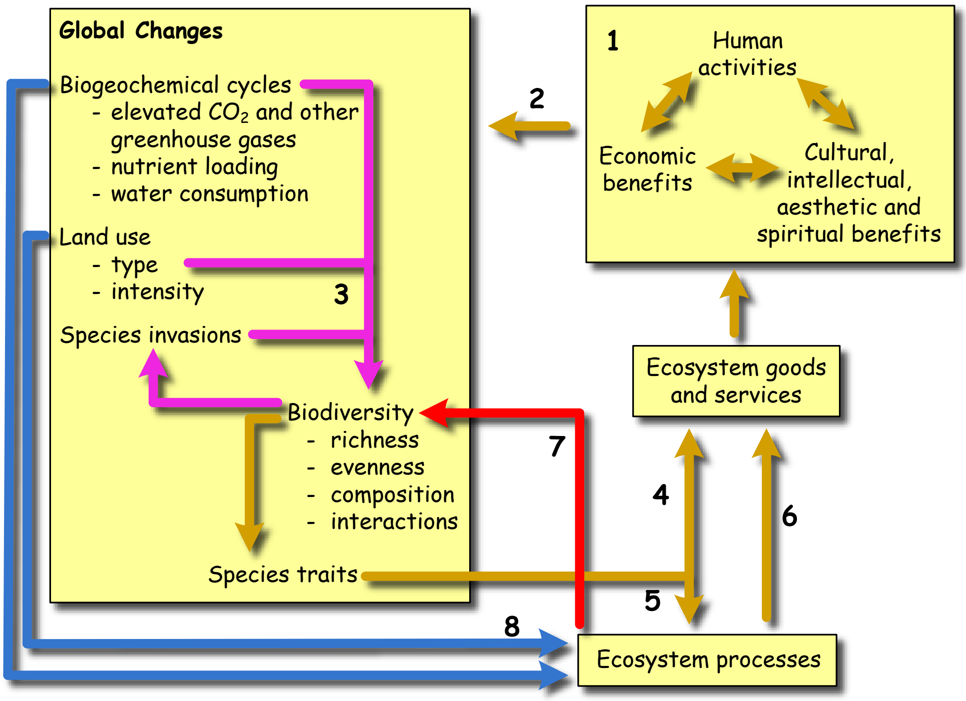



**Figure 9.** The role of biodiversity in global change (redrawn from Chapin *et al.*, 2000).

### 2.6.1 Biodiversity in the context of global change

Human activities that are motivated by economic, cultural, intellectual, aesthetic and spiritual goals (see No. 1 in **Figure 9**) are now causing environmental and ecological changes of global significance (2).

By a variety of mechanisms, these global changes contribute to change biodiversity; and changing biodiversity increases susceptibility to species invasions (3, purple arrows).

Changes in biodiversity, by provoking changes in 'species traits', can have direct consequences on ecosystem services and, as a result, on human economic and social activities (4).

In addition, changes in biodiversity can influence ecosystem processes (5). Altered ecosystem processes can thereby influence ecosystem services that benefit humanity (6) and further alter biodiversity (7, red arrow).

Global changes may also directly affect ecosystem processes (8, blue arrows). Depending on the circumstances, the direct effects of global change may be either stronger or weaker than effects mediated by changes in diversity.

The costs of loss of biotic diversity, although traditionally considered to be outside the sphere of human welfare, must be recognized in our accounting of the costs and benefits of human activities.

### 2.6.2 Drivers of change in biodiversity and ecosystems

From the Millennium Ecosystem Assessment we have information on the impact to date of a number of 'drivers of change' on biodiversity for different ‘biomes’ over the last century. For *forest* habitat change has been fairly low in boreal, higher in temperate and very high in tropical systems (**Figure 10**).

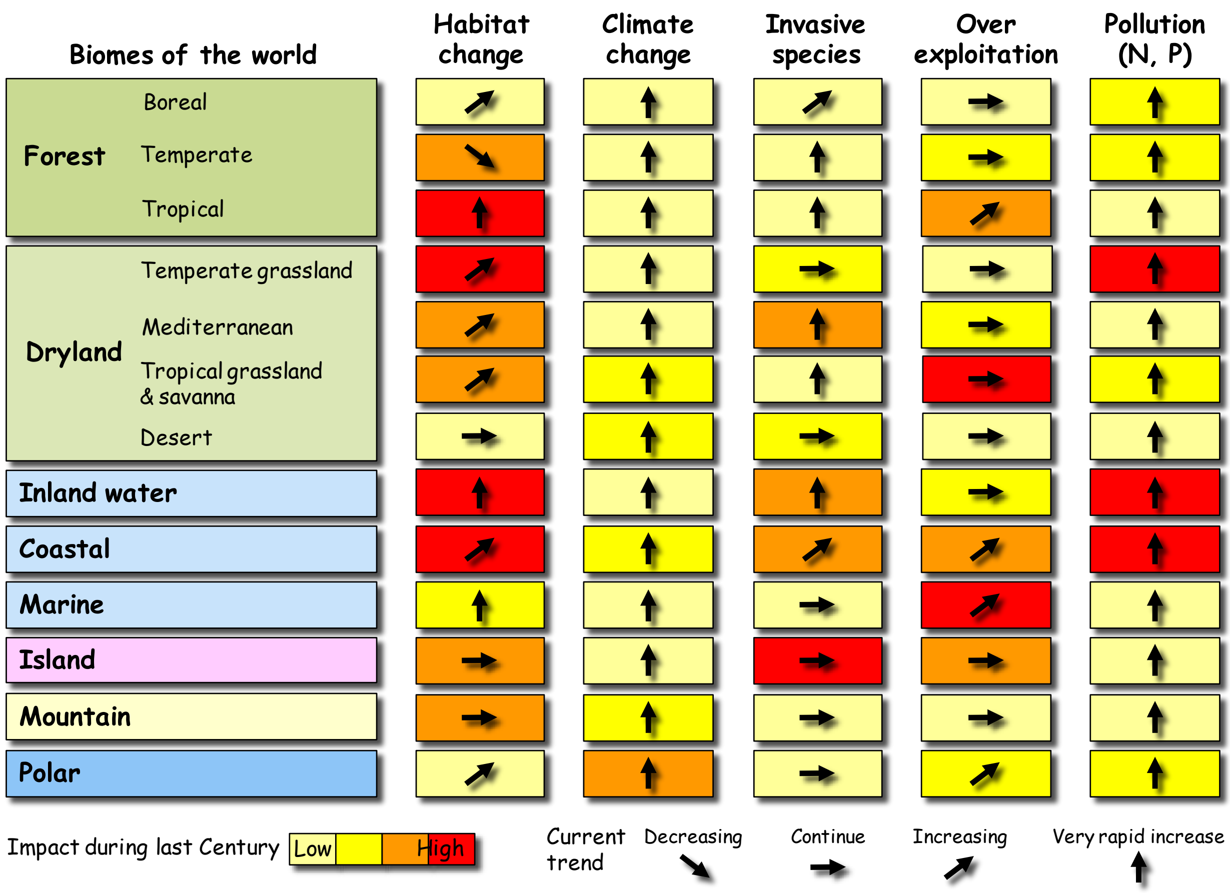



**Figure 10.** Drivers of change impacting biodiversity and ecosystem services over the last century and their current trend (redrawn from MA, 2005).

As far as *drylands* are concerned, temperate grassland had the highest impact.

In terms of *inland*, *coastal* and *marine* systems the impacts were highest for inland and coastal waters. For the last systems of *islands*, *mountain* and *polar regions*, the former two had a fairly high impact.

From the Assessment we also have information on the trend in the impact of the driver on biodiversity and it is evident that it is only decreasing for temperate forest and is continuing for island and mountain regions. For all of the remainder it is either increasing rapidly (i.e. tropical forest and marine) or increasing steadily (the remainder).

As far as climate change is concerned, then its impact has so far been fairly low in most systems though higher in polar regions. However, do notice that all systems presently experience a very rapid increase in impact.[17]

With respect to invasive species then they have affected particularly islands and, to a lesser degree, inland and coastal waters, and dryland in the Mediterranean. The current trend is an increase for forests, some drylands, and freshwater and coastal systems.

In terms of over exploitation you can see high impacts in tropical grassland/savanna and marine areas with an increasing trend in tropical forests, coastal and marine systems.

Finally, pollution has during the last century affected particularly temperate grassland, inland and coastal waters and is on a very rapid increase in all systems.

In conclusion we can say that we have radically altered ecosystems during the last half a century, and though these changes have brought gains – it is at a cost that threatens the achievement of development goals for countries throughout the world.

## 2.7 Understanding the effects of habitat loss and fragmentation

The greatest threat to biodiversity is loss of 'habitat' which refers to extreme changes that make them unable to support more than a fraction of their original processes and species. This happens with:

- Land use change
- Physical modification of rivers and/or indiscriminate withdrawal of their water
- Loss of coral reefs
- Damage to sea floors due to trawling.
- Climate change, invasive alien species, overexploitation of species, and pollution.

Habitat loss and fragmentation have affected biodiversity in terrestrial, freshwater and marine systems. At landscape level the loss of habitat is often gradual with a fragmentation process which disrupts extensive habitats into increasingly isolated 'patches' of remnant vegetation (**Figure 11** opposite page).[18]

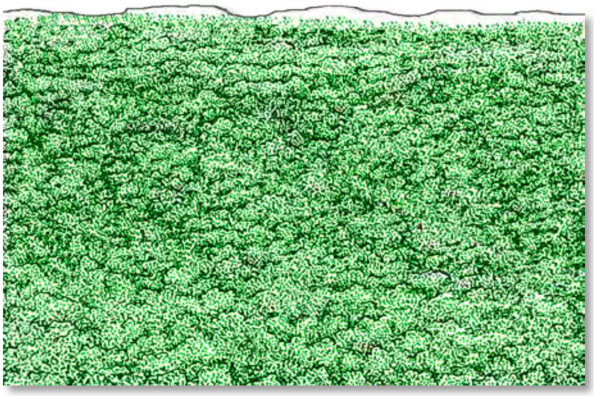
As far as terrestrial habitats are concerned, failure to embrace landscape management means that – eventually – the background 'matrix' can be readily distinguished from the habitat patches and 'corridors' it contains. Ultimately, the system will deteriorate from a *perforated* to a *fragmented* or even *relictual* landscape which is significantly less suitable to the combined flora and fauna of a region.

**Term**

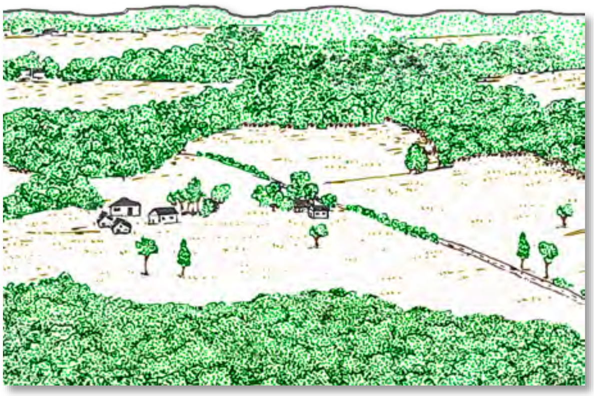
Landscape 'matrix' refers to the intervening area among a set of habitat fragments.

In highly fragmented landscapes it is difficult for individuals (e.g. juvenile animals, seeds, or spores) to disperse to other suitable patches. If mobility is prevented then the individuals occupying a fragment may effectively constitute a small independent population, which is more likely to disappear. Even when fragmentation only leads to partial isolation, this may change one large population into several patch populations which may also affect overall viability and survival.

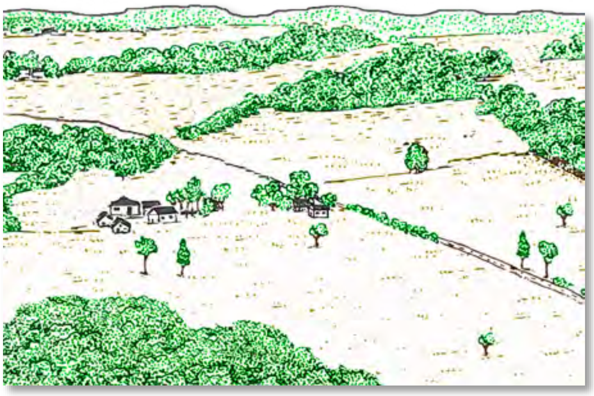
This decline in biodiversity will drastically reduce the flow of ecosystem services on which society and individuals depend.



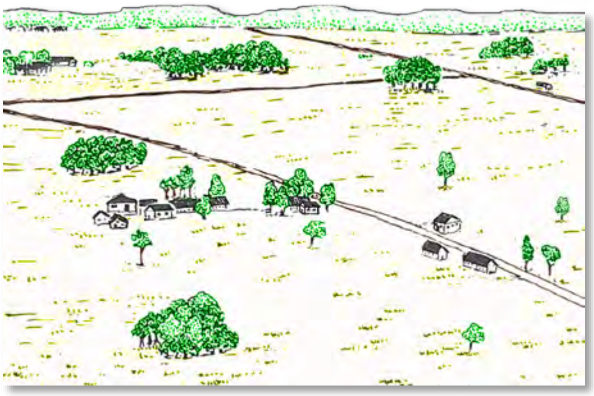
Intact landscape (more than 90% of original habitat).



Perforated landscape (60 - 90% of original habitat).



Fragmented landscape (10 - 60% of habitat left).



Relictual landscape (less than 10% of habitat left).

**Figure 11.** The process of fragmentation (redrawn from Hunter, 1996).

**Key Points**

Habitat information is fundamental to landscape management and, in turn, any comprehensive plan for preserving biodiversity and ensure delivery of ecosystem products and services.

It is obtained through the cyclic National Biodiversity Planning process (i.e. Step 2 corresponds to Biodiversity Assessment; Figure 24, p. 22).

The 'landscape matrix' that surrounds habitat fragments may be hospitable to some native species, or may allow movement among fragments. However, other species require core habitat for their survival and are incapable of traversing the intervening man-made landscape of urban areas, industrial parks, highways, agricultural crops, and so forth. Under such conditions isolation typically causes inbreeding and – eventually – local extinction. Without the inter-connectedness that natural habitat provides there will be no re-colonization (**Figure 12**).

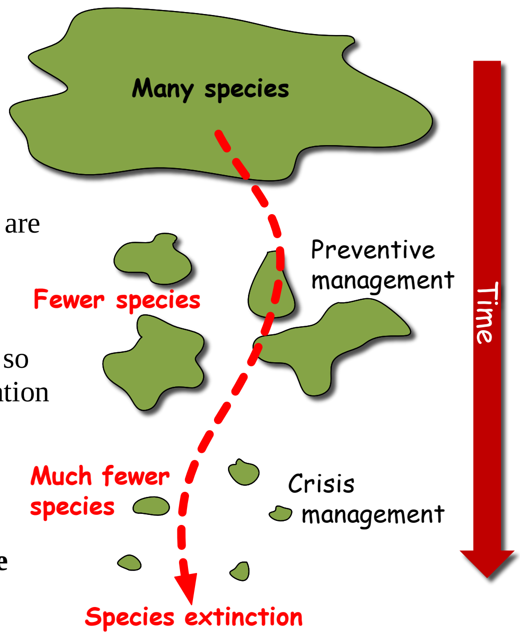



**Figure 12.** *The road to extinction* – the inter-relationship between the loss of habitat and species. The population is fragmented into smaller and more isolated components, making them prone to systematic and random factors that may arise in the environment (modified from Clark *et al.*, 1990).

With increased fragmentation and isolation of habitat patches some species become "trapped" in the landscape (i.e. when they cannot cross the intervening matrix). Examples of the so-called "living dead" include the Dusky Leaf Monkeys found in the isolated Sungai Bukit Puteh Wildlife Reserve and other species in the Bukit Nenas Wildlife Reserve in downtown

Kuala Lumpur. However, it happens throughout fragmented landscapes.

One consequence of fragmentation is that smaller patches have relatively more *edge habitat* and less *interior habitat*. The amount of interior core habitat (i.e. undisturbed) depends on the shape of the patch (**Figure 13**) and the disturbing effects of the surrounding environment.

The width of these "impact zones" (surrounding the darker core areas in **Figure 13**) varies greatly. The most striking edge effects occur within 100 m of forest edges. However, wind damages to forest can penetrate as far as 400 m from (**Figure 14**). Poachers may – of course – increase the edge effect up to several kilometres in larger patches of habitat.

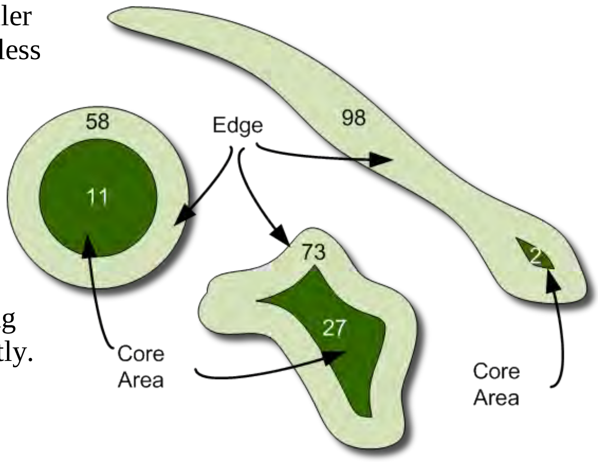



**Figure 13.** The importance of shape with respect to interior and edge-affected habitat (all three patches have the same area).

Edge penetration distances have a significant bearing on the width of corridors which is discussed under landscape mitigation strategies in Section 3.3.1, p. 30, and – in particular – in Text Box 4, p. 32.

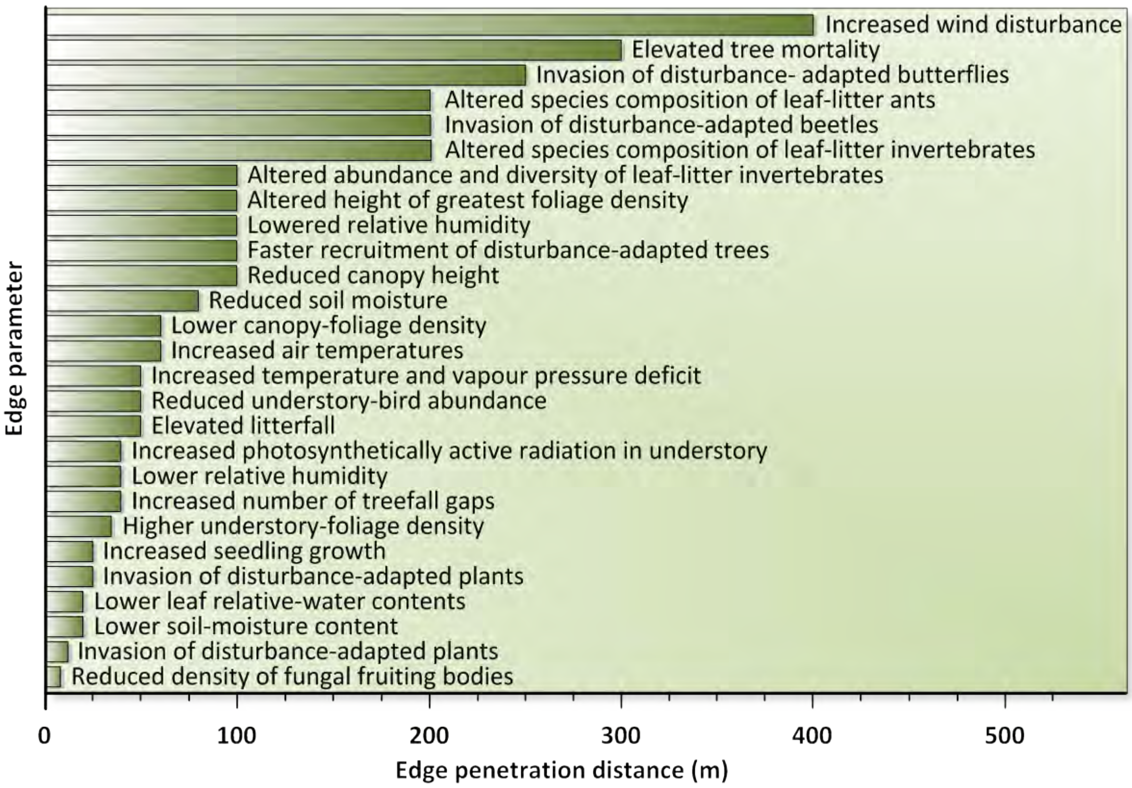



**Figure 14.** Results from a 22-year investigation into the decay of forest fragments reveals penetration distances of different edge effects in the *Biological Dynamics of Forest Fragments Project* in the Brazilian Amazon (redrawn from Laurance *et al*., 2002).

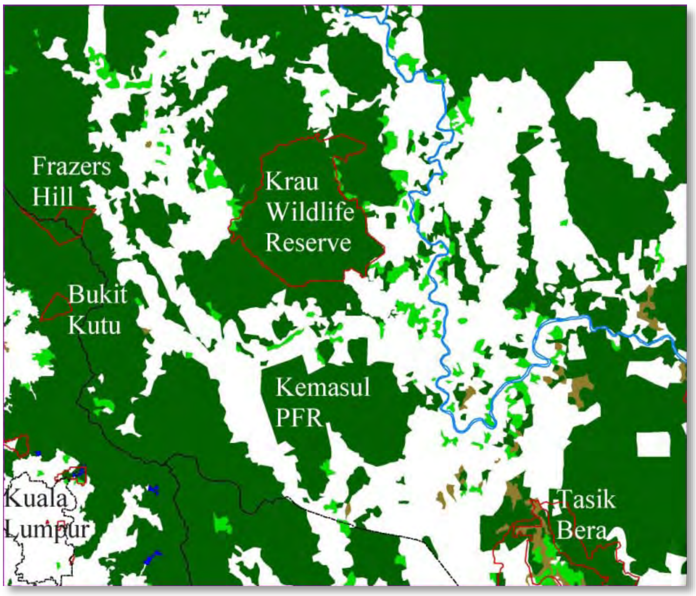



**Figure 15.** Fragmentation of habitat is very much an issue – at least in Peninsular Malaysia. Notice the linear shape of many fragments (i.e. they have less core area) and how larger patches in 1990 have lost connectivity to the Main Range (e.g. Krau Wildlife Reserve and the Kemasul (Bentong/Temerloh) of the PFR). (From DWNP, 1996.)

Habitat loss, fragmentation and increased isolation of remnant vegetation ***are*** major issues in Malaysia (see **Figure 15** which is an extract of the purple box in **Figure 16** below**)**.

For planners and decision-makers to carry out their job of managing natural resource and biodiversity assets they need updated results from the *Biodiversity Assessment*[19] which should be part of a cyclic National Biodiversity Planning process (see Section 2.11, p. 22).

Today we are beginning to understand how fragmentation reduces native biodiversity and what sorts of policy and management actions are prudent to apply.

The remainder of this Guideline provides an overview of what measures takes.

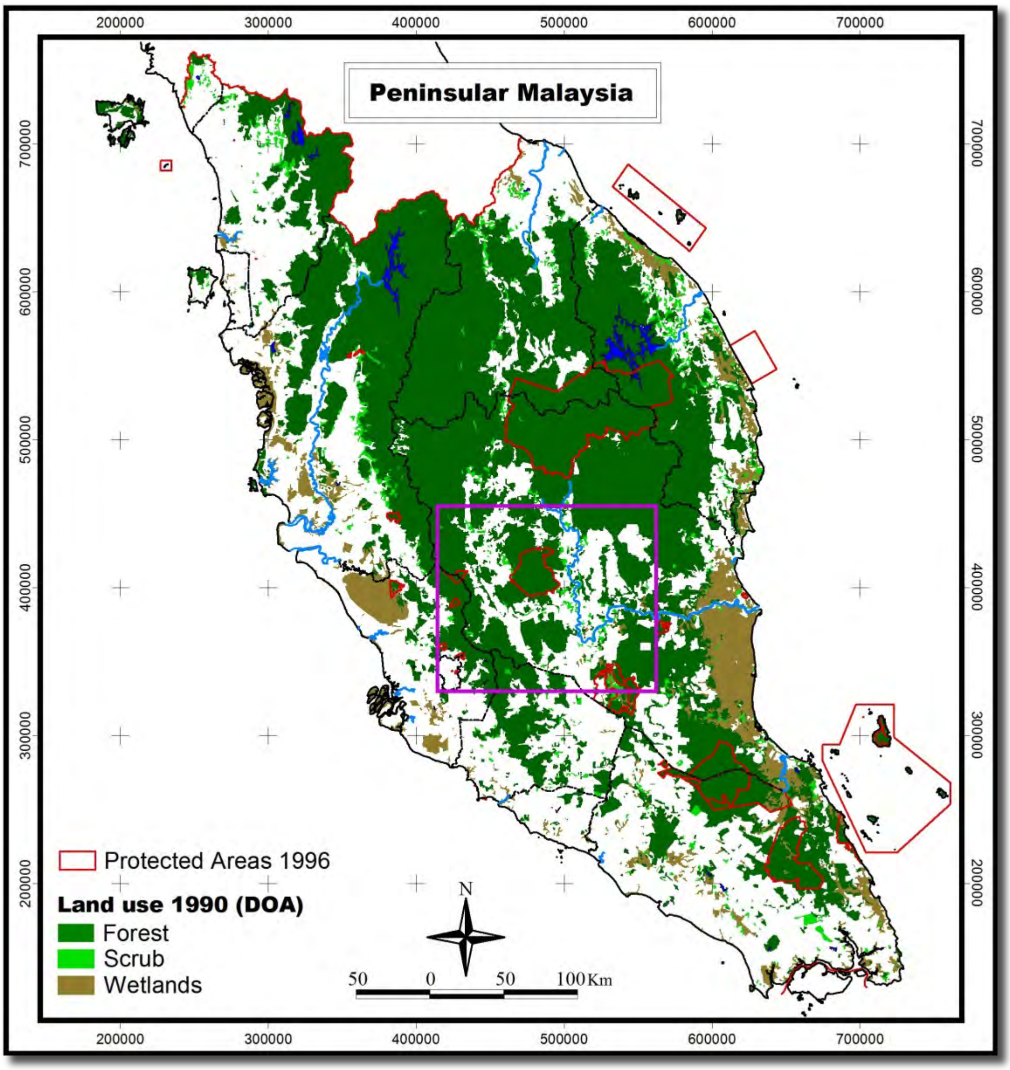



**Figure 16.** Forest, scrub and wetlands from the land use map in 1990 (DWNP, 1996). The previous Figure represents the square in the centre. (Land use data is from the Department of Agriculture – DOA.)

## 2.8 Threatened species

A list of endangered species, designed to spot troubled species before it is too late, has been published since the 1960s. It is known as *The IUCN Red List of Threatened Species* (in short the "IUCN Red List").

Assessments have in general been restricted to the better-known taxonomic groups and the number of described species is a tiny fraction of the estimated total number of species which ranges between 5 and 30 million (as referred to in Section 2.1, p. 5).[20] However, for the 2008 list, for the first time, every known mammal, amphibian, and bird was assessed.

Today it represents the conservation status of less than 2.5% of the world's described biodiversity[21] of hardly 2 million species currently known. Clearly this limits understanding of the impact of our activities on biodiversity, and with it the ability to make informed decisions on conservation planning and action.

Species unlucky enough to make the list are grouped into eight categories, from 'critically endangered' (extremely high risk of extinction in the wild in the near term) to 'least concern' (low risk of extinction) – see the Glossary.

The 2008 update of The IUCN Red List includes nearly 45,000 species, which are classified as follows (see the Glossary for terms used and Endnote 6 for full details):

2% : *Extinct* or '*extinct in the wild*'

38% : Threatened with extinction (almost half of which are *critically endangered* or *endangered* and the remainder half are '*vulnerable*')

8% : '*Near threatened*'

12% : Insufficient information to determine their threat.

The 2008 IUCN Red List update includes:

- Nearly one-quarter of mammal species are globally threatened with extinction. However, the number of species with insufficient data means the real figure could be as high as 36%.
- The addition of 366 new amphibians, many listed as threatened, and the confirmed extinction of two additional species, reaffirming the extinction crisis faced by amphibians; nearly one-third (31%) are threatened or Extinct and 25% are Data Deficient.
- A complete reassessment of the world's birds indicates that one in seven (14%) are threatened or Extinct; birds are one of the best-known groups with less than 1% Data Deficient.
- 845 species of warm-water reef-building corals have been added to the Red List, with more than one-quarter (27%) listed as threatened and 17% as Data Deficient.
- All 161 grouper species; over 12% are threatened with extinction because of unsustainable fishing; a further 30% are Data Deficient.
- All 1,280 species of freshwater crab, 16% of which are threatened with extinction, but 49% are Data Deficient.

The 2008 IUCN Red List also includes some notable new species, for example 14 tarantulas from India (8 of them threatened); 3 orchids from the Americas; a striking Rafflesia species from the Philippines; and a bumblebee which has declined dramatically in North America, as have other key pollinators world-wide.

**Key Points**

The Red List is an annual "health check of the planet"

Julia Marton-Lefèvre
IUCN director general

**Key Points**

The 2008 Red List covers nearly 45,000 species of which:

- 2% are extinct
- 38% are threatened with extinction

The following groups are threatened with extinction:

- One in every four mammals
- One in every four of warm-water reef-building corals
- A third of amphibians
- One in seven of birds

It is not all bad news; species can recover with concerted conservation efforts. In 2008, 37 of the recorded improvements in status were for mammals. An estimated 16 bird species avoided extinction over the last 15 years due to conservation programmes. Conservation does work, but to mitigate the extinction crisis much more needs to be done, and quickly.

The 2008 IUCN Red List

A summary of 2008 data on threatened species for South and South East Asia reveals that Malaysia, with a total of 1,141, has the highest number of threatened species in the region[22].

**Table 1.** Data for South and South-East Asia from the 2008 Red List of Threatened Species.

| South & Southeast Asia | Mammals | Birds | Reptiles | Amphi-bians | Fishes | Molluscs | Other inverts | Plants | Total |
|---|---|---|---|---|---|---|---|---|---|
| Bangladesh | 34 | 28 | 20 | 1 | 12 | 0 | 2 | 12 | 109 |
| Bhutan | 28 | 17 | 1 | 1 | 0 | 0 | 1 | 7 | 55 |
| British Indian Ocean Territory | 0 | 0 | 2 | 0 | 9 | 0 | 65 | 1 | 77 |
| Brunei Darussalam | 35 | 21 | 5 | 3 | 8 | 0 | 0 | 99 | 171 |
| Cambodia | 37 | 25 | 12 | 3 | 18 | 0 | 67 | 31 | 193 |
| Disputed Territory (Spratly Islands) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| India | 96 | 76 | 25 | 65 | 40 | 2 | 109 | 246 | 659 |
| Indonesia | 183 | 115 | 27 | 33 | 111 | 3 | 229 | 386 | 1,087 |
| Lao People's Democratic Republic | 46 | 23 | 11 | 5 | 6 | 0 | 3 | 21 | 115 |
| Malaysia | 70 | 42 | 21 | 47 | 49 | 19 | 207 | 686 | 1,141 |
| Maldives | 2 | 0 | 3 | 0 | 12 | 0 | 38 | 0 | 55 |
| Myanmar | 45 | 41 | 22 | 0 | 17 | 1 | 63 | 38 | 227 |
| Nepal | 32 | 32 | 7 | 3 | 0 | 0 | 0 | 7 | 81 |
| Philippines | 39 | 67 | 9 | 48 | 60 | 3 | 199 | 216 | 641 |
| Singapore | 12 | 14 | 4 | 0 | 22 | 0 | 161 | 54 | 267 |
| Sri Lanka | 30 | 13 | 8 | 53 | 31 | 0 | 119 | 280 | 534 |
| Thailand | 57 | 44 | 22 | 4 | 50 | 1 | 179 | 86 | 443 |
| Timor-Leste | 4 | 5 | 1 | 0 | 5 | 0 | 0 | 0 | 15 |
| Viet Nam | 54 | 39 | 27 | 17 | 33 | 0 | 91 | 147 | 408 |

When we compare extinctions with the distant past, the fossil record shows that the long-term average extinction rate is up to 1 species per 1,000 species per 1,000 years.

Current extinction rates, however, are up to 1,000 times higher than the fossil record, and projected future rates are still 10 times higher than the present rates which have led most people to conclude that the extinction crisis continue to ravage the planet's animals and plants (**Figure 17**).

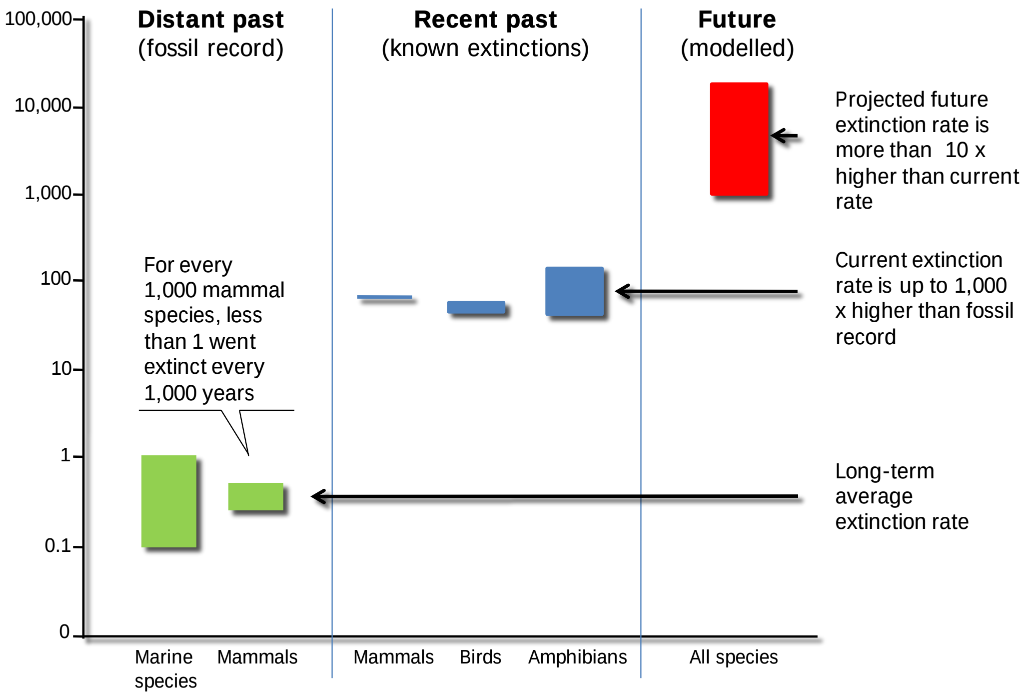



**Figure 17.** Extinction rates from the fossil record, the recent past and modelled for the future (MA, 2005).

## 2.9 Biodiversity is multi-scale in nature

In planning and management of land, it is essential to look well beyond the boundaries of a given area of concern (e.g. a structure or local plan; a development site), since conditions in the landscape and biodiversity planning goals have a bearing on a given area. The inverse is also true – what happens within a given planning area can have major ecological impacts well beyond the boundaries of a given site.

Imagine a 20 ha farm which includes fields, buildings, a stream and wetlands, as well as some forest. Like many maps and plans for site development it does not include any information about the context surrounding the farm (**Figure 18**).

**Figure 18.** This shows a site map for a 20 ha farm (*kebun*) with agricultural land, buildings, wetland and some forest (This and the following three drawings are redrawn by Yew Kiang Teh from Perlman & Milder, 2005).

*Scenario 1*

In the situation shown in **Figure 19** the *kebun* is shown with a black outline above the middle of the Figure. It would seem that it is only one of few farms in what appears to be a forested landscape. However, as will be revealed later, we have to treat the aquatic system very carefully and protect its integrity, which extends downstream where another wetland area is found. Prescriptions for site management (development) should protect the riparian vegetation and ensure that waterborne pollutants do not reach the wetland and the river.

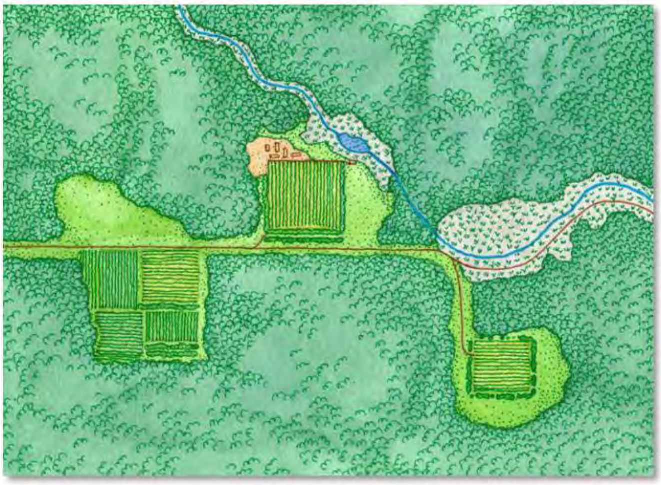


**Figure 19.** Here the *kebun* is one of few farms in a forested landscape.

*Scenario 2*

Here the river and wetlands are particularly vulnerable as part of a complex that may provide water for urban areas. The forest in the northwestern part of the *kebun* is part of a smaller fragment where the wetland vegetation provides connectivity to a larger fragment to the East. Clearing the forest in the East of the farm will threaten the integrity of the aquatic system and may cause the forest complex to become further fragmented into three patches. This again will have a negative impact on the coastal vegetation and the estuary. Sediments and waterborne pollutants in the river will be detrimental to any coral reefs off shore.

Pollutants will also be harmful to mudflats, which are common in large estuaries and harbour a variety of organisms that feed on

**Figure 20.** It is here revealed that the *kebun* has habitat which is part of a larger fragment to the East. Clearing may cause further fragmentation, as well as endanger the aquatic integrity and near-shore marine resources.

organic matter brought by the tides and the river runoff. The mudflats are also important feeding habitats for numerous resident and migratory water birds.

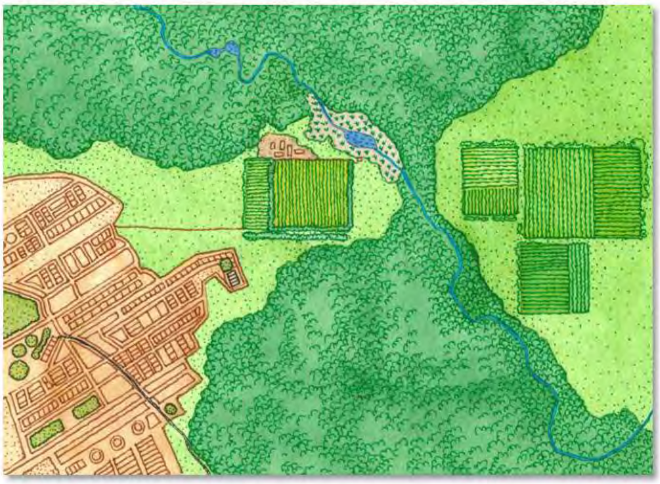


**Figure 21.** In this situation the *kebun* practically constitutes a corridor connecting two larger habitat fragments as well as their river system (see text for further details).

*Scenario 3*

The situation depicted in **Figure 21** shows the forest and wetland to the East as the major part of connectivity between what appears to be two large forest fragments. It would be the highest priority to ensure that the corridor is not further severed by expanding agriculture and/or urban settlements. Indeed, reference to state and national scale maps may show how the whole area fits into a regional and national network for habitat connectivity. What has already been stated with respect to maintaining the integrity of the aquatic system also applies to this case.

Hopefully these examples help to illustrate that our actions on a given site in the landscape affect a number of processes, all of which will have a bearing on the 'ecology' of a larger region.

To manage for biodiversity, we have to consider various geographic scales in our assessment, planning, implementation and monitoring of activities which also point to the importance of engaging the key actors who operate at these various scales.

## 2.10 The importance of the drainage area

Water is essential for our survival and well-being and it is important to many – if not all – sectors of the economy. However, it is also tied in to the provisioning of ecosystem services since aquatic features of landscapes are critically important to biodiversity and ecosystem function.

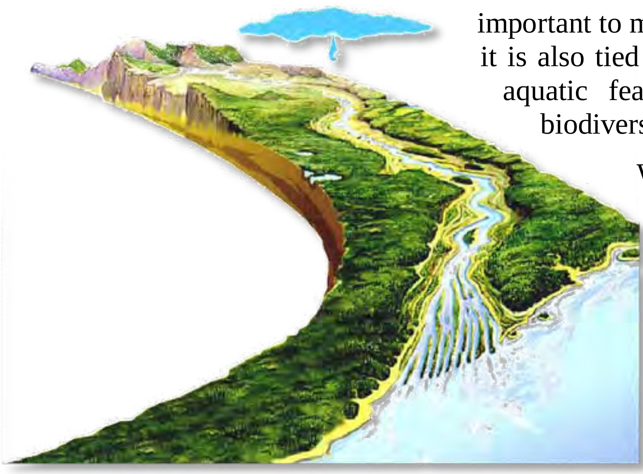


**Figure 22.** Before reaching the sea the path of a raindrop will pass through numerous land use systems and management jurisdictions (modified from Evans, 2003).

When rain falls on the land surface some of it evaporates, drains into the soil, or runs off the surface into streams, then to a river and finally it will reach the sea (**Figure 22**). During its journey, the water picks up eroding soil, nutrients, dissolved pollutants and other contaminants. Some of the material may constitute food for aquatic plants and animals (e.g. nutrients, leaf litter, fine particles of organic matter and other substances). Land use and practices have a tremendous bearing on the amount of elements that are picked up by water as it drains through the landscape.

Thus, there is a close relationship between: (i) how we manage the land; (ii) the impact this has on freshwater biodiversity; and – further downstream – (iii) coastal and marine resources. It means that the three will have to be considered together when making planning and management decisions for a given site.

The inter-connectedness which exists between the three systems is shown by the fact that today – unfortunately – practically all chemicals created on land have found their way downstream into the marine system.

‘River basins’ and their subdivisions are natural geographical and hydrological units and represent the best starting point for a unified system of water management (**Figure 23**).

The relationship between a river system and its ‘catchment’ in the landscape is linked most strongly in the riparian areas. Riverbank vegetation exerts a powerful influence on maintaining river courses, decreasing erosion, improving water quality, keeping a healthy river system, retaining nutrients, keeping ecotourism potential, and so forth.

Most importantly, riverbank vegetation is an integral part of river ecology and should not be considered an area to be converted to other land use activities.

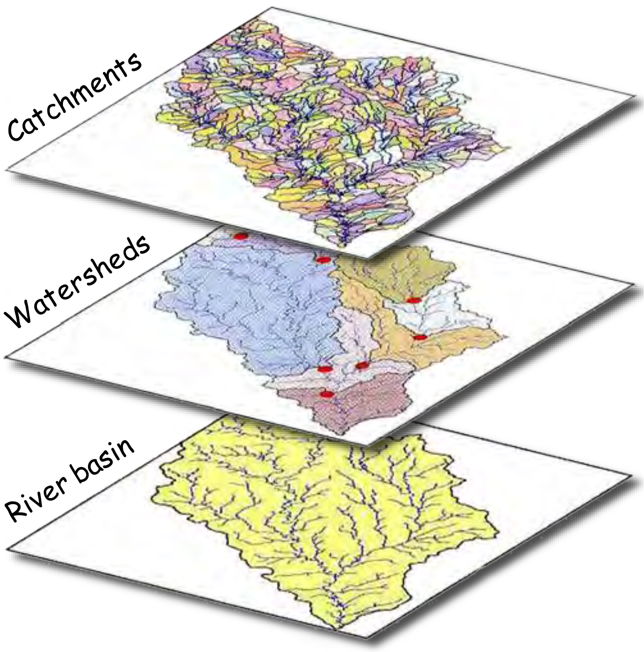



**Figure 23.** Malaysia has some 190 river basins (drawing modified from Maidment, 2003).

## 2.11 The National Biodiversity Planning in relation to the National Development Planning Framework

Managing natural resources, biodiversity, and ecosystem services is all about accomplishing optimum planning for a variety of spatial features – some of which will have to be reconciled as part of achieving Malaysia’s goals for sustainable development.

We have previously seen that the interaction between *vegetation cover*, *structural complexity of habitat*, and *species composition* supports ecosystem processes, landscape resilience and the quantity and quality of ecosystem services at multiple scales from local to national levels (Section 2.3, p. 9).

In spite of biodiversity being difficult to quantify precisely, as planners and decision-makers we also know that our response options to changes in biodiversity may be defined by essentially understanding *where* and *how* biodiversity is changing, *what* is causing changes, and how it *impacts* on ecosystem services. This largely calls for an exercise in spatial planning.

Thus it is hardly a surprise that *biodiversity assessment* (which should not be confused with biodiversity inventory[23]) is *the* starting point for the National Biodiversity Planning Framework (**Figure 24**). This process not only includes such a fundamental planning capacity but other elements to ensure that Malaysia’s aspirations of achieving environmentally sustainable development are fulfilled.

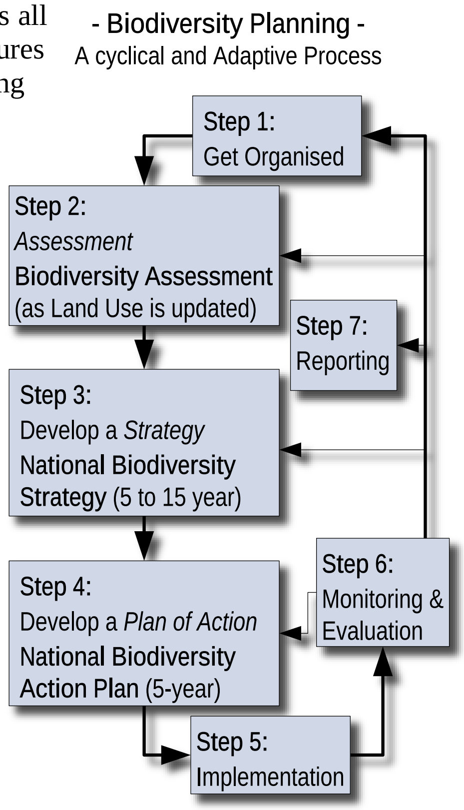



**Figure 24.** National Biodiversity Planning steps (see further in NRE, 2008a).

Presently, there is a dire need to update both the fairly simple *biodiversity assessment* which was done by MOSTE more than 10 years ago (even more so given it was basically non-spatial in nature[24, 19]) and the subsequent *strategy* and *action plans* contained in the National Policy of Biological Diversity[25]. Indeed, when consulting land use maps it becomes clear that the Malaysian landscape has – and probably still is – changing[18] and updates to the biodiversity assessment should be tied into the release of new land use maps.

**Key Points**

Five objectives can be achieved through the planning process and should be considered for every major development scheme. They are to:

- *Protect* current habitats and species
- *Enhance* existing habitats or create new areas
- *Mitigate* against potentially damaging impacts
- *Compensate* where damage is unavoidable (should only be needed in limited circumstances where the loss is fully justified, since recreating habitat is very difficult)
- *Monitor* and enforce to assess the success of enhancement and compensatory measures.

Biodiversity is a multi-scaled and multi-temporal concept shaped by ecological and evolutionary processes operating at various spatial scales from local, to state, regional, national and international levels. An example may be to think of it from genetic diversity within populations to ecosystem diversity across the wider landscape.

Planning and decision-making requires compliance with national planning goals for sustainable development in accordance with the existing National Development Planning Framework. This framework is equally multi-scaled and multi-temporal – for reasons which may be more than obvious to the reader (e.g. when JKR establishes a district road they make sure it fits into the road infrastructure at also state, regional and national levels).

The multi-dimensionality and multi-temporality of the National Development Planning Framework is why it is accepted as a shared responsibility between Federal, States and Local Authorities. It should be no different for planning and management of natural resources, biodiversity, and ecosystem services since they share the same basic characteristics.

Thus, it should come as no surprise that the Framework is highly suitable for also the National Biodiversity Planning process which significantly complements Development Planning by contributing specific spatial features essential to achieving *environmentally* sustainable development (**Table 2**).

**Table 2.** Contributions of National Biodiversity Planning to the Development Planning Framework.

| Planning Level | Planning Tools (PPPs) | Spatial elements from National Biodiversity Planning | Approximate scales | Flow of data |
|---|---|---|---|---|
| 1 National | • Malaysian Plan(s)<br>• National Physical Plan<br>• Sectoral Policies/Plans<br>• National Biodiversity Strategy & Actions Plans (NSAPs) | • PA System design<br>• Overall network for habitat connectivity (riparian and other corridors)<br>• Critical habitats and other special issues identified<br>• Managing BioD in the landscape | 1: 500,000 to 1:1,000,000 | |
| 2 Regional/ State | • State Development Plans<br>• Regional/Structure Plans<br>• Sectoral Policies/Plans | • Integration with above / below<br>• Increased landscape level focus | 1: 200,000 to 1:500,000 | |
| 3 Local Planning | • Local Plans<br>• Special Area Plans | • Integration with above<br>• Increased site specific focus | 1: <10,000 to 1:200,000 | |

**Key Points**

Findings at any scale of multi-scale planning will be improved by information and perspectives from other scales

In conclusion we can say that neither the National Biodiversity Planning process nor the National Development Planning Framework can perform using only one spatial scale. Fundamentally, the reasons are the same why this should be the case and, consequently, planning and management of biodiversity in the landscape has to be coordinated between these levels – it cannot be solved at only one spatial scale. Examples of this basic feature will be presented in the following Sections.

Importantly, the National Biodiversity Planning process also provides essential input in terms of results from biodiversity assessment, priority setting, strategy and action plans to assist the National Development Planning efforts at all three levels. This is a critical aspect which permits Malaysia to properly target, pursue and archieve national goals of sustainable development. [8]

For further information and guidance on the subjects of regulatory and administrative framework for planning and management of biodiversity see NRE 2008b and 2008c.

## 2.12 Summary of key issues

The key issues related to biodiversity may be summarised as:

- Biodiversity is essential for the functioning of ecosystems and supports a vast array of ecosystem services that critically contribute to human livelihood.
- Ecosystem services represent tremendous value to society and human well-being and have been conservatively estimated to be almost double the global Gross National Product.
- During the last 50 years, almost two-thirds of ecosystem services have been declining.
- The most important drivers of change affecting biodiversity are: change in land use; fragmentation and isolation of habitat; habitat change; invasive species; over-exploitation; and pollution.
- Though Protected Areas have increased it is now clear that these alone cannot safeguard biodiversity which must be managed as part of the wider landscape.
- Biodiversity is affected by all sectors of society and a challenge is to make biodiversity concerns a part of how people go about their business.
- High levels of biodiversity (e.g. genes, species, ecosystems, and landscape types) increase resilience to changing environmental conditions and stresses. Genetically diverse populations and species-rich ecosystems have greater potential to adapt to climate change.
- Biodiversity is multi-scaled in nature and transcends jurisdictional and administrative boundaries.
- To manage for biodiversity we have to consider various geographic scales in our assessment, planning, implementation and monitoring of activities which also point to the importance of engaging the key actors who operate at these various scales.
- River basins and their subdivisions are natural geographical and hydrological units and they represent the best starting point for a unified system of water management.
- The National Biodiversity Planning process fits into the National Development Planning Framework. Both are multi-scale and multi-temporal planning tools. Findings at any scale are improved by information and perspectives from other scales, resulting in overall better planning.
- Several Policies and Plans have defined as critical habitat lowland dipterocarp forest, swamps and mangroves (i.e. require total protection, together with sensitive coastal ecosystems).

# 3 How to go about it?

## 3.1 How to understand a landscape?

**Term**

A *landscape* is a territory that is characterized by a particular configuration of topography, vegetation, land use, and settlement pattern that delimits some coherence of natural, historical, and cultural processes and activities.
A landscape is best delineated functionally — that is, drawn on a map within the context of a particular issue or problem that we would like to investigate.

Landscapes are composed of elements – the spatial features that make up the landscape. A convenient and popular model for conceptualising and representing these elements is known as the 'patch-corridor-matrix model' (**Figure 25**). Under this model, the three major landscape elements are typically recognised, and the extent and configuration of these elements defines the pattern of a given landscape.[26]

This Guide uses the following definitions:

- *Patches*: are relatively homogenous non-linear areas that differ from their surroundings and serve to conserve biodiversity, natural ecosystems, ecological processes, and ecosystem services
- *Corridors*: are narrow, linear features of a patch type that differ from those on either side
- *Matrix*: landscape areas not designated primarily for conservation of biodiversity, natural ecosystems, ecological processes, and services (regardless of their current condition as natural, modified or man-made).

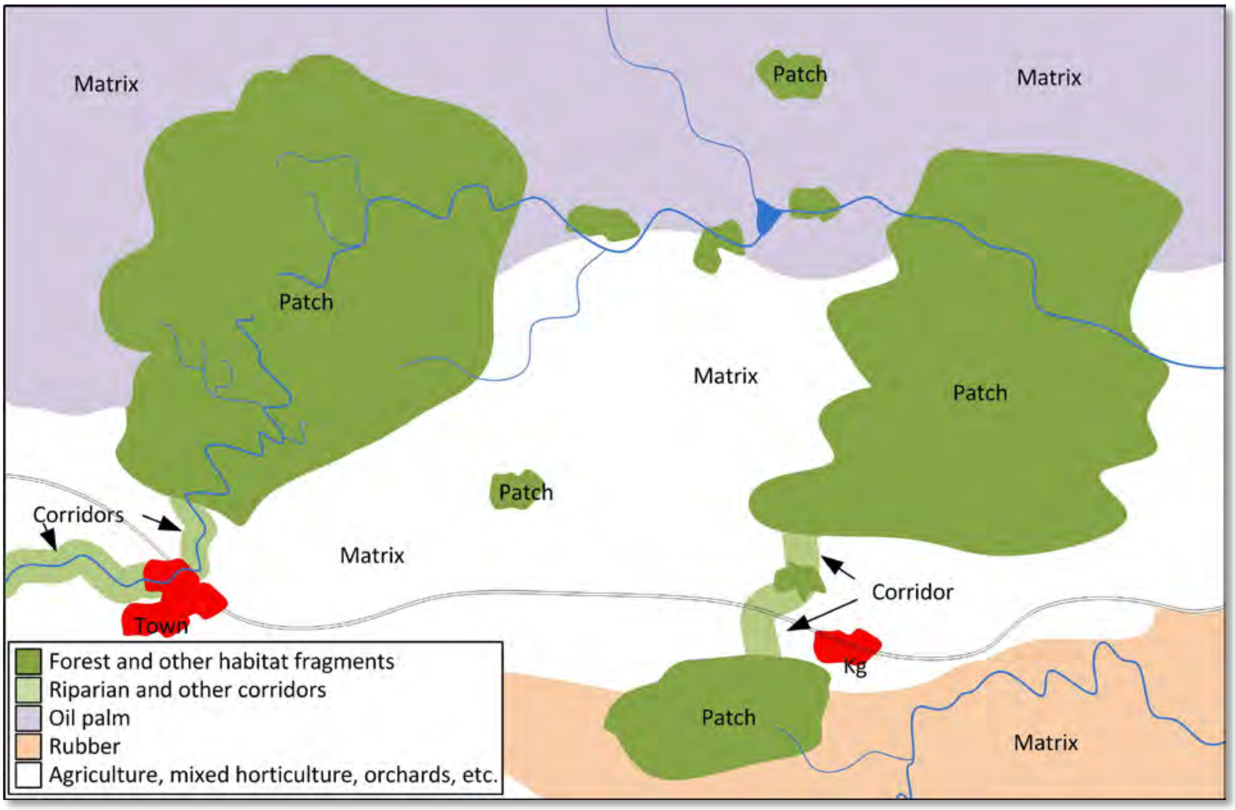



**Figure 25.** Patch-corridor-matrix applied to a typical Malaysian landscape.

In the context of supporting planners, decision-makers and practitioners acting on landscapes from national to regional and local levels, the generalisation adopted here is that patches and corridors typically represent habitat and dispersal pathways for a broad variety of species (plants and animals).

It is fairly easy to produce map outputs using Geographic Information Systems (GIS) which have been used to define patches and corridors. Nevertheless, it is important to keep in mind that definitive patch and corridor suitability must ultimately be based on the habitat requirement, movement patterns, and other attributes of the organism of interest. Additionally, the scale of the matrix will vary according to the organism or ecological process under examination and may vary from, say, the area made up by a small patch of forest to an entire region.

## 3.2 How a landscape supports biodiversity, ecological processes, and ecosystem services

Maintaining species in large Protected Areas and in the matrix is only possible by maintaining suitable habitat elsewhere and at multiple spatial scales. This is at the very core of any comprehensive planning for (forest) biodiversity since:

- Habitat loss is the primary factor influencing species loss
- Different species perceive habitat over a range of spatial scales
- We cannot make Protected Areas large enough to include entire ecosystems
- Biodiversity is eroding in spite of Protected Areas having doubled globally during the last quarter of a century.

Thus we can conclude that biodiversity is important in managed as well as natural ecosystems. This also explains why Malaysia's key policies and plans contain provisions for achieving holistic and integrated planning and management of natural resource and biodiversity assets.

A suitable strategy involves management of landscape structure through the strategic placement of managed and natural elements, so the services of natural ecosystems are available across the landscape matrix (e.g. pest control by natural predators; pollination by animals; mitigation of erosion, floods and tsunamis; filtration of runoff by riparian vegetation; continuous production of freshwater).

However, before defining the specifics of our strategy we first must understand how a landscape supports biodiversity, ecological processes, and ecosystem services.

There are five critical roles for the landscape matrix that relate specifically to conserving biodiversity:

**1** Supporting populations of species

**2** Facilitating the movement of species

**3** Buffering sensitive areas and parts of the Protected Areas System [27]

**4** Maintaining the integrity of the aquatic system

**5** Supporting ecosystem services

These five roles of the matrix are interrelated. Managing the matrix to buffer sensitive areas such as riparian zones, promotes the conservation of aquatic systems, contributes to improved connectivity for wildlife and increases the ability of the matrix to support populations of species.

The extent to which planners, decision-makers and practitioners are aware of these roles will determine the degree to which the matrix contributes positively or negatively to these functions.

*1 Supporting populations of species*

The matrix can be managed to support broadly distributed populations of many species able to thrive or at least partly incorporate the matrix into their range. Some estimates suggest that more than half of all wild species exist principally outside Protected Areas, mostly in agricultural landscapes. Such populations may, to a significant degree, supplement populations in the combined Protected Areas System, Permanent Forest Reserve (PA-PFR) and forest on state land - thus ensuring their survival. Species which survive in the matrix are also the ones most likely to be found in remnant patches and they may play a crucial role in reversing localised extinctions within forest fragments.

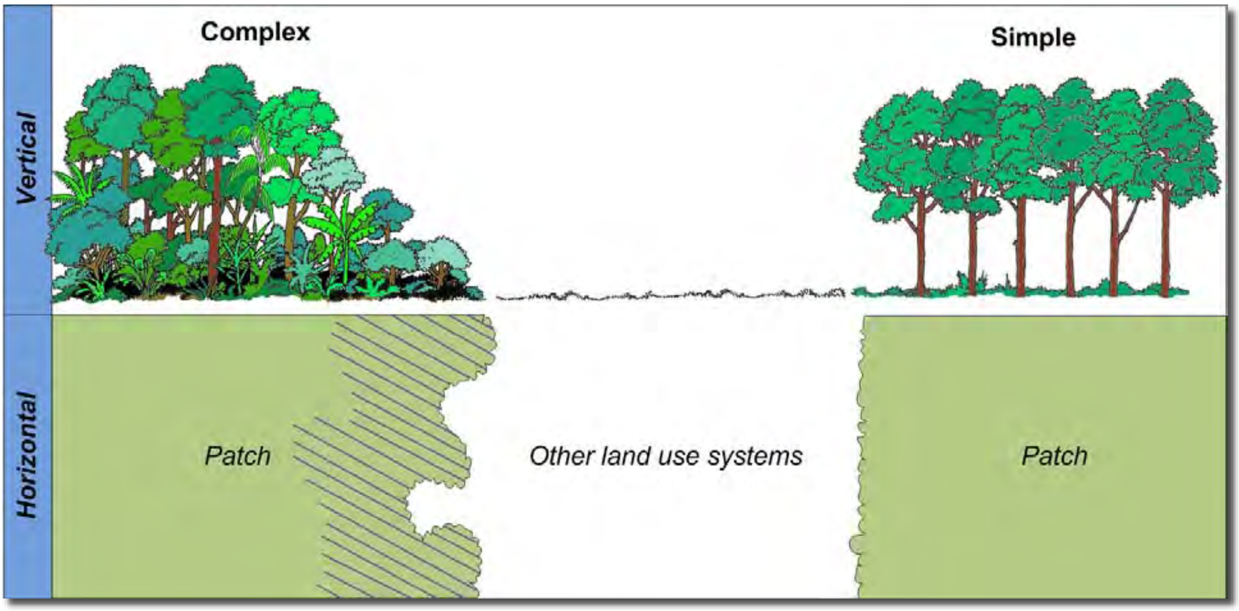



**Figure 26.** Low contrast edges with high structural diversity (to the left) are richer in species than high contrast borders (to the right). The matrix corresponds to urban areas, mixed agriculture and estates of oil palm and rubber (upper drawing in black and white by Yew Kiang Teh).

The shape of patches significantly influences the amount of core area on which many species depend (as shown in Figure 13, p. 16). Much habitat today falls within small to medium size patches and managing the matrix-to-buffer edges can substantially increase their effective area within the matrix.

The intensity of the edge interactions between a patch and the surrounding matrix is typically directly related to their level of structural contrast. Most natural edges are curvilinear, complex and soft, and follow terrain features. However, we humans tend to make straight, simple and hard edges ignoring natural topographic features (**Figure 26**).

Matrix management strategies that reduce the contrast in structural and biophysical conditions between neighbouring areas can therefore significantly reduce the intensity and depth of the edge effects.

*2 Facilitating the movement of species*

Facilitating 'connectivity' and movement of species in the matrix may prevent populations of species in the PA-PFR from becoming isolated and fragmented. It may also allow populations to maintain or increase their demographic and genetic size, thereby enhancing chances of long-term survival. For plants, connectivity allows for movement of spores, pollen and seeds, and thus species and populations. For animals connectivity is controlled by conditions such as appropriate vegetation cover or key structures (e.g. logs and dead trees).

> **Key Points**
>
> Landscape connectivity should be maintained at multiple scales and for as wide a group of plant and animal species as possible.

A matrix that provides a high degree of connectivity is critical since habitat loss, fragmentation of remnant vegetation, and increased isolation of patches are major reasons for the ongoing depletion of biodiversity.

*3 Buffering sensitive areas and parts of the Protected Areas System*

In the development of comprehensive strategies for biodiversity conservation, identification and protection of sensitive ecologically important habitats within the matrix are essential. Some of these habitats are widely distributed, such as streams and their associated riparian vegetation; and lakes and wetlands with associated littoral zones.

Others such as limestone hills, rock out-crops and caves may be important for species found nowhere else (i.e. 'endemics'). Such habitats may not be adequately represented in a PA System but may constitute important small and medium sized reserves and PAs embedded within the matrix. Proper matrix management may significantly increase their contributions to overall biodiversity conservation.

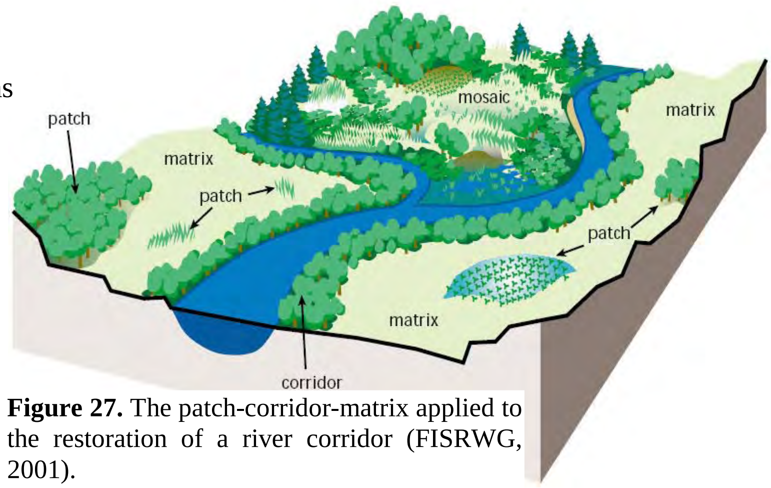



**Figure 27.** The patch-corridor-matrix applied to the restoration of a river corridor (FISRWG, 2001).

Aquatic features of landscapes such as streams, rivers, wetlands and lakes are critically important to biodiversity conservation and ecosystem processes. A very large proportion of biodiversity is associated with aquatic ecosystems. However, the status of aquatic systems is significantly influenced by neighbouring land use practices. Even so, the habitat and functional relationship between spatially adjacent terrestrial and aquatic habitats have rarely received sufficient consideration in forest management and landscape planning. Adjacent terrestrial habitats such as riparian and coastal zones should be viewed as integral components of aquatic ecosystems because of the extensive functional relationship between adjacent terrestrial and aquatic communities of species.

Maintaining and/or restoring the integrity of aquatic systems should also receive high priority for its bearing on coastal and marine diversity. Riparian vegetation not only provides animals with movement corridors, it also stops surface 'run-off' from heavy rainfall events, preventing sediments and water-borne pollution from reaching the rivers. Sediments and pollution are detrimental to freshwater biodiversity and have serious negative impacts on the status of marine resources (e.g. sediments shade corals and prevent them from re-establishing themselves, resulting in severely impoverished coral reef diversity, which also has an influence on offshore catch).

*5 Support ecosystem services*

A conservative estimate is that the environment returns ecosystem services in the order of nearly twice the Gross National Product (as already referred to). In Malaysia, management practices and conditions in the Protected Areas, the Permanent Forest Reserve and the landscape matrix surrounding them determine the quality, quantity and sustainability of ecosystem services obtained.

However, many elements of biodiversity need to be conserved within the landscape matrix to sustain long-term production of wood, potable water and other ecosystem products and services – this includes soil biodiversity.

Losses of elements of forest biodiversity may impair essential ecosystem functions. Examples include organisms that play key roles in the decomposition of organic matter, pollination, seed dispersal, biological pest control, and the formation of associations between fungi and plants (i.e. mycorrhiza). Changes in biodiversity will also influence the long-term floristic composition and stand structure of forest habitat, which will have negative ramifications for the sustained production of commodities.

Many of the components of biodiversity that play an important role in ecosystem processes are inconspicuous invertebrates (i.e. bugs) which have received little attention in conservation programmes (see also **Box 3** and **Endnote 28**).

Landscape matrix management is important for conserving ecosystem processes by emphasising the importance of biodiversity in the matrix (as illustrated in Figure 2, p. 6) as well as conservation of genes, species, and populations for their own sake.

Beyond species diversity, genetic diversity within populations is also important because it allows continued adaptation to changing conditions through evolution, and ultimately, for the continued provision of ecosystem goods and services. Likewise, diversity among and between habitats, and at the landscape level, is also important in multiple ways for allowing adaptive processes to occur.

> **Box 3.** What is soil biodiversity and why is it important?
>
> Soil is one of the most diverse habitats on earth and contains one of the most diverse assemblages of living organisms. Nowhere in nature are species so densely packed as in soil communities. For example a single gram of soil may contain millions of individuals and several thousand species of bacteria. Soil biota includes micro-organisms such as bacteria and fungi, insects, earthworms and roots that interacts with species above and below the ground.
>
> Soil organisms contribute to a wide range of essential services to the sustainable function of all ecosystems, by acting as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission; modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation, and enhancing plant health. These services are not only essential to the functioning of natural ecosystems but constitute an important resource for the sustainable management of agricultural systems.
>
> From www.fao.org/AG/AGL/agll/soilbiod/fao.stm

High levels of diversity of landscape types, ecosystems, species and genetics provide higher adaptability to changing conditions, caused for instance by climate change. As far as land/seascapes are concerned, the more diverse we keep them the more resilient they seem to become.[29] The outcome is a substantial contribution to rebuilding and maintaining the resilience of landscapes which benefits terrestrial, freshwater and marine systems.

Impaired ecosystem processes result in reduced production of goods and services in the matrix, and this has substantial social and economic costs for society.

## 3.3 Principles and management interventions

The loss of species and biodiversity threatens the availability of ecosystem services across the landscape. It is predominantly driven by habitat loss followed by fragmentation, increased isolation of habitat patches, and change in habitat quality.

Consequently, an overarching goal of planning and management of forestry and biodiversity should be to reduce – to the very extent possible – further habitat loss and device ways of maximising biodiversity across the full range of spatial scales. Suitable measures fall into the two complementary categories of *managing landscapes* and *managing individual species and ecological processes*. For both categories apply that they should be deployed at multiple scales.

### 3.3.1 Managing landscapes

Managing every individual species and every single ecological process represents an insurmountable challenge to practitioners. A useful approach is to mitigate the negative impacts of our landscape modifications on biodiversity and ecosystem services by managing landscape patterns in a way that will benefit many species simultaneously.

This step is an efficient starting point towards achieving environmental sustainability because – even in the absence of detailed ecological knowledge – the implementation of a few principles and pattern-based management interventions is likely to provide conservation benefits in many situations.

Five general principles can help in achieving Malaysia's policy and planning goals with respect to conservation actions and they are: [30]

i) Maintain connectivity
ii) Maintain the integrity of aquatic systems
iii) Maintain habitat structural complexity
iv) Maintain landscape heterogeneity
v) Manage disturbances

Further details on each of these are provided below.

#### *i) Maintain connectivity*

Connectivity is the linkage of habitats, interacting organisms and ecological processes at multiple spatial and temporal scales. Connectivity influences essential processes such as population survival and recovery after disturbance, the exchange of individuals and genes in a population, and the occupancy of habitat patches. It is important to note, that corridors not only increase the exchange of animals between patches, but also facilitate two key plant-animal interactions: pollination and seed dispersal. Increased plant and animal movement through corridors is likely to have positive impacts on plant populations and community interactions in fragmented landscapes.[31]

Connectivity in the landscape will – for most species – be determined by conditions in the landscape matrix. This is because connectivity is fundamentally controlled by the degree to which the matrix is perceived to be hostile or permeable.

What constitutes effective connectivity varies among species due to interspecific differences in movement patterns and dispersal behaviour. How these species-specific traits intersect with patterns of landscape cover will determine the ultimate level of connectivity.

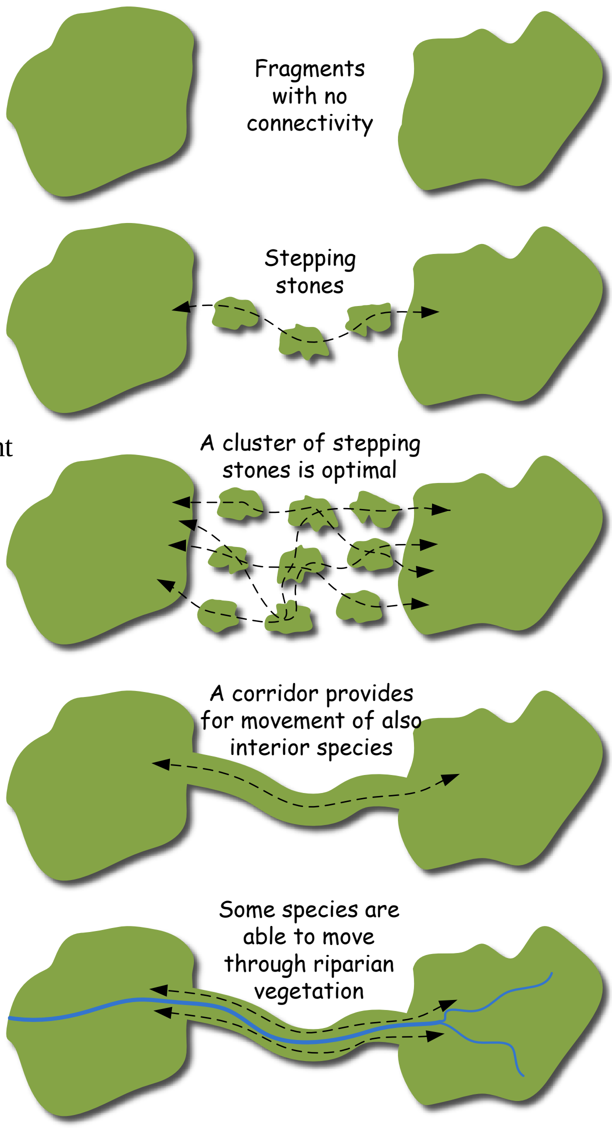



**Figure 28.** Providing connectivity with stepping stones, corridors, and riparian vegetation.

In view of the international consensus that climate change *is* taking place[32] species are expected to respond to the changing climate by migrating to track the environmental conditions to which they are adapted. For many terrestrial species this entails to move to higher altitude and/or higher latitude.[17] The ability of species to track future climates will be tested not only by the rate of change (many predict it will be faster than the post-glacial periods), but also by the loss and fragmentation of habitats that – unfortunately – is characteristic of the modern landscape.

Connectivity may be achieved by strips of retained (or rehabilitated) habitat also called "biological corridors" or "wildlife corridors".

Research has confirmed that this may work for some species but not for all since some will not pass through anything but appropriate vegetation cover throughout the landscape.

If conditions in the matrix are perceived hostile, then wide corridors linking (large) remaining patches may be required to retain connectivity for some species (e.g. Sumatran rhino requires undisturbed lowland dipterocarp forest).

Other species may be able to use small, discrete patches as 'stepping stones' – which then provide connectivity[33] (**Figure 28**, previous page).

Riparian corridors are by some called "river zones" or "river reserves"[34] and they can make a substantial contribution to connectivity in the landscape – in addition to essential safeguarding of the integrity of the aquatic system and river basins in general (dealt with below).

Riparian zones provide habitat for large numbers of terrestrial and aquatic flora and fauna. Though they are useful for some terrestrial species inhabiting forests, linkages outside the riparian corridors may be needed to maintain connectivity for upland species.

**Figure 29.** Connecting remnant habitat patches with corridors should be one part of a comprehensive plan to address the decline in species diversity in agriculturally dominated landscape. Note how the restoration in the photo to the right has achieved linking rehabilitated riparian habitat to patches elsewhere which has increased habitat value across the landscape. In tropical climates corridor width will have to be wider (photos from USDA/NRCS, 2004).

**Key Points**

Landscape connectivity should be part of any comprehensive physical plan to address the decline of terrestrial and freshwater biodiversity. It may be achieved by a combination of biological corridors connecting important habitat fragments and restored riparian vegetation.

In summary, the maintenance and – if necessary – rehabilitation of connectivity is critical for any comprehensive plan for terrestrial biodiversity conservation and essential for successful matrix-based biodiversity management (**Figure 29**).

That addressing connectivity issues in landscape planning should have the highest priority is reflected in Malaysia's policies, the Convention on Biological Diversity (to which Malaysia is a signatory) and further corroborated by a wide international consensus.[35]

Managing the matrix to increase its suitability as habitat and increase its permeability to movement is fundamental to the maintenance of connectivity. An answer to how wide corridors should be is found in **Text Box 4**.

## Box 4. How wide should a corridor be?

The *Biological Dynamics of Forest Fragments Project* (BDFFP) was initiated in 1979 and is the world's largest and longest-running experimental study of habitat fragmentation. Results suggest that edge effects play a key role in fragment dynamics, that the matrix has a major influence on fragment connectivity and functioning, and that many Amazonian species avoid even small (100 m wide) clearings. The effects of fragmentation are highly diverse, altering species richness and abundances, species invasions, forest dynamics, the 'trophic' structure of communities, and a variety of ecological and ecosystem processes. Moreover, forest fragmentation appears to interact together with ecological changes such as hunting, fires, and logging, collectively posing an even greater threat to the rainforest biota.

The most spectacular edge effects occur within 100 m of forest edges. However, wind damage to forests can penetrate 400 m from edges (as shown in Figure 14, p. 16), and changes in beetle, ant, and butterfly communities can be detected as far as 200 – 400 m from edges[36].

A recent study appears to agree with a critical-width threshold of 400 m suggested by BDFFP. It shows that many forest bird and mammal species in southern Amazonia use riparian forest corridors and that narrow remnant corridors fail to provide suitable habitat for many forest vertebrate species. Narrow, unconnected corridors typically retained only one third of the bird and one-quarter of the mammal species richness found in riparian forests within large forest patches. Corridor width was the most important determinant of species richness and wider corridors usually had more intact canopy structure. The study recommends that riparian strips should be more than 400 m wide (i.e. 200 m on either side of streams) particularly for streams wider than 10 m[37]. In Australia's tropical Queensland only the widest (more than 200 m) corridors composed of continuous, old-growth rainforest can sustain the lemuroid ringtail possum, the most vulnerable of all arboreal 'folivores' to fragmentation[38].

A significant body of evidence suggests that corridors can increase biodiversity in fragmented landscapes by partially countering the harmful effects of isolation of species and populations dependent on forest habitat[39]. It would, however, be a mistake to assume that corridors are a universal remedy. **All but the widest corridors suffer significant edge effects and are likely to be selective filters, facilitating movements of some species but not forest-interior specialists, which are often the most vulnerable to fragmentation.** Overcrowding of species and edge effects are reduced as corridor width increases, and wider corridors accommodate greater spatial heterogeneity (i.e. increased structural complexity). This provides a broader range of microhabitats that is often correlated with increased species richness.

In conclusion we can say that corridors ideally should be primary forest and as wide as possible. Exactly how well they will function is species-dependent, so linkages should be designed to meet the requirements of multiple 'focal species' likely to serve as a collective umbrella for all native species and ecological processes. The most dramatic edge effect occurs within 100 m, but wind damage extends up to 4 times that. The suggested minimum width of 400 m will for riparian vegetation translate into 200 m on either side of streams wider than 10 m. To benefit core specialists like Sumatran rhino, Clouded leopard, Orangutan and Gibbons (to mention a few) corridors will have to be significantly wider and more than two times 400 m in order to leave some core habitat in the corridor. [40]

Importantly, connectivity alone will not safeguard biodiversity in the landscape and should be complemented by implementation of the full range of principles and management interventions dealt with in this Chapter 3 (i.e. for landscapes, species, and ecological processes). The subsequent Chapter 4 details the complementary nature of multiple stakeholder actions on the landscape.

### *ii) Maintain the integrity of aquatic systems*

A central goal of matrix management is to preserve the integrity of the aquatic ecosystem and the hydrologic and 'geomorphological' processes upon which much biodiversity depends. Given its fundamental importance to human societies, the maintenance of a well-regulated, high-quality supply of water is (or should be) one of the chief objectives in the management of (forest) lands.

The degree to which the integrity of aquatic ecosystems and associated processes is maintained is largely determined by conditions in the matrix.

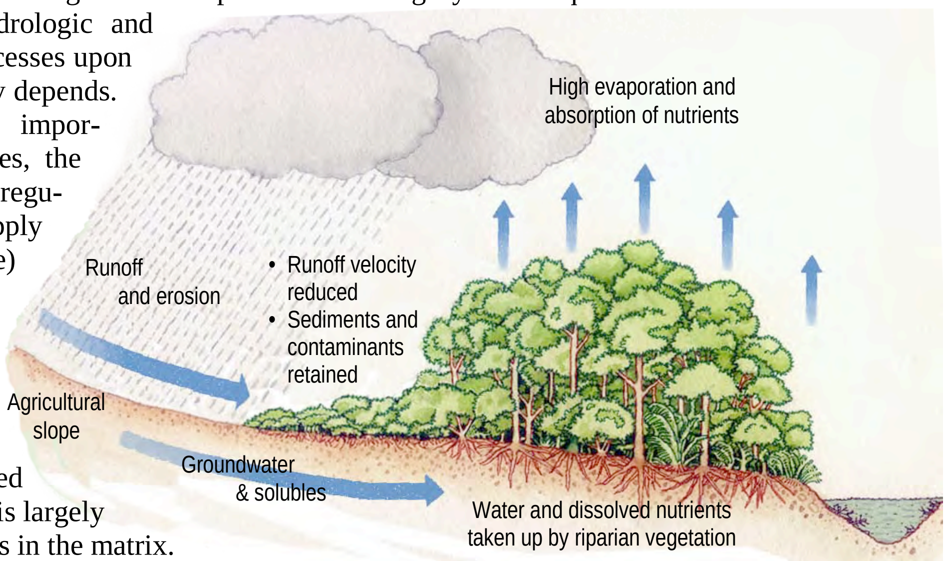



**Figure 30.** How a riparian buffer protect the stream from contaminants (drawing by Yew Kiang Teh).

Forests have powerful influences on hydrological processes such as the interception of rainfall, and the condensation, evapotranspiration, and infiltration of moisture.

Forest conditions also strongly affect nutrient retention and soil stability, especially on slopes.

Riparian vegetation stabilises riverbanks against erosion; filters sediments, nutrients, pesticides and microbes; provides aquatic and wildlife habitat; and mitigates floods (**Figure 30**).

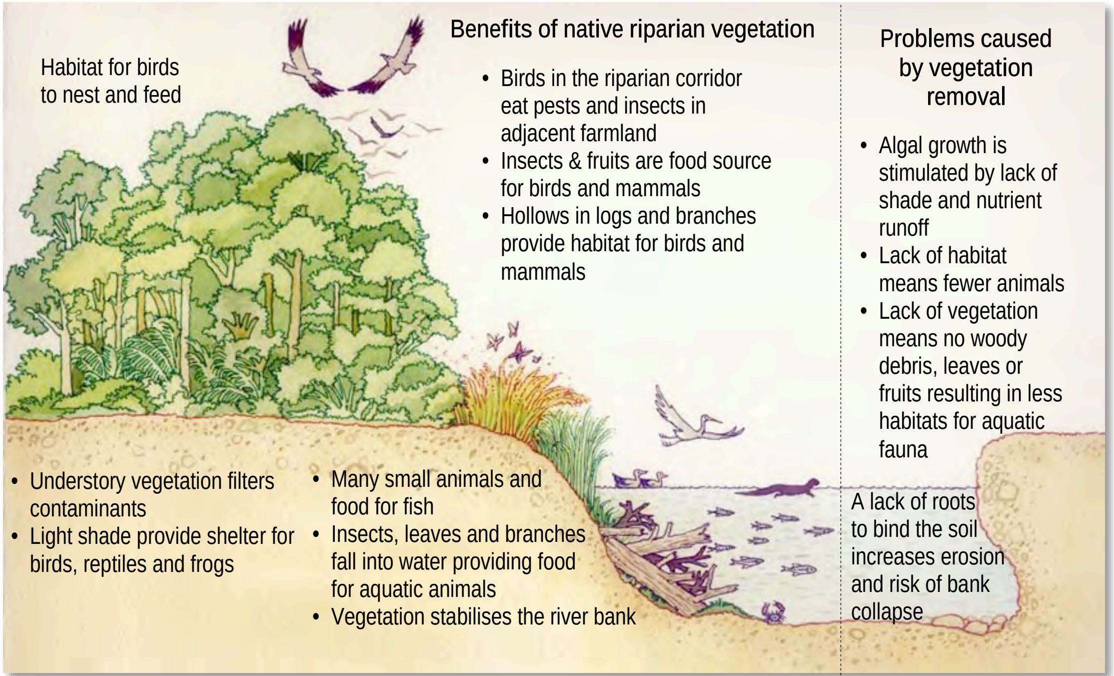



**Figure 31.** Riparian vegetation is part of the river ecology and it performs essential functions such as stabilising the river bank, filter sediments and contaminants, thermal buffering, connectivity, etc. (drawing by Yew Kiang Teh).

Riparian vegetation also has a direct influence by controlling light and temperature regimes and providing inputs of organic matter and nutrients in the form of litter. Forests also provide large woody debris, which is a significant structural element of riparian, riverine, and many wetland and pond ecosystems that affects stream hydrodynamics and habitat suitability for aquatic plants and animals (**Figure 31** and **26**).

**Figure 32.** Riparian vegetation maintained in oil palm plantation to protect the aquatic system and provide habitat for indigenous plants and animals (from Unilever, 2003).

Though roads may not occupy such a big area, they do exert disproportionate and intense impacts on the aquatic ecosystem. The hydrological changes arising from road networks are permanent because subsurface flows and patterns are interrupted and altered flows rerouted into extensive constructed channels (e.g. ditches and culverts).

In many areas it would seem that the relationships between riparian vegetation and aquatic ecosystems is insufficiently acknowledged and so is the fact that the status of the aquatic system has an impact on coastal and near shore marine life.

In summary, it is clear that in watersheds that are predominantly matrix lands, issues such as the rotation of extensive mono-cultural crops, quality and density of road networks, and levels of buffering by riparian vegetation will determine the degree to which aquatic biodiversity and water quantity and quality will be maintained.

At a larger scale, river basins dominated by matrix lands is also where there is likely to be the highest return on conservation actions which will also benefit marine biodiversity (i.e. by reduced pollution load in river run off to coastal mudflats, seagrass meadows and coral reefs).

### *iii) Maintain habitat structural complexity*

Structural complexity is a common feature of natural habitat throughout the world and it is commonly associated with greater species richness than simpler systems (as indicated in Figure 26, p. 27). [41]

However, it is important that also in man-made systems it applies that the more structural complex the production system the more scope exists for the five critical roles of the landscape in supporting biodiversity (i.e. support species and facilitate their movements; buffer sensitive areas; maintain integrity of aquatic systems; and support ecosystem services – as explained in Section 3.2, p. 26). Examples of structural "simple" agricultural production systems include mono-cultural crops (e.g. rice and oil palm but the same applies to plantation with only one tree species) which are contrasted by - for instance – sustainably managed mixed tropical forest; and mixed home gardens with a great variety of crops from trees, to bushes, and a variety of other agricultural produce[42].

**Key Points**

The extent to which resources supplied by native ecosystems are *also* available in the matrix will affect many species and vegetation structure can be a key attribute in this context.

As far as forest is concerned, 'stand' structural complexity includes a wide variety of habitat features such as:

- Multiple age classes within a stand
- Large living trees and 'snags'
- Large diameter logs on the forest floor
- Vertical heterogeneity created by multiple or continuous canopy layers (or strata)
- Canopy gaps and anti-gaps (i.e. areas with very dense canopy coverage under which understory development can be limited)

Structural complexity refers not only to particular types of stand attributes, but also the way they are spatially arranged within stands. High levels of spatial heterogeneity are characteristic of essentially all old-growth forests.

Logging may lead to marked medium- to long-term changes in stand structure and plant species composition that can negatively impact plants and animals dependent not only on particular structural attributes but also on presently abundant generalist species (as has been seen in temperate forests of northern Europe [43]).

Active management to maintain structural complexity is vital to prevent the decline and eventual loss of key structural attributes. Maintenance of stand structural complexity can be valuable in four ways. [44]

It may:

1. Allow organisms to persist in logged areas from which they would otherwise be eliminated (i.e. a "lifeboat" function). [45]
2. Allow logged and regenerated stands to more quickly return to suitable habitat for species that have been displaced (i.e. a "structural enrichment" function). [46]
3. Enhance dispersal of some animals through a logged area (i.e. a "connectivity" function). [47]
4. It is essential to provide the within-stand variation in habitat conditions required by some groups of plants and animals (i.e. "habitat heterogeneity" function). [48]


**Figure 33.** Envisioning the future with local people (**A**: the present day landscape dominated by sugarcane; **B** and **C**: how local people in the wet tropics of North Queensland would like their landscape to appear. In both cases they opted for significantly higher landscape heterogeneity with higher level of protection of biodiversity and ecosystem processes, thus balancing environmental, social and economic needs (from Bohnet, 2004).

### *iv) Maintain landscape heterogeneity*

Ecosystems are naturally diverse and landscape heterogeneity is a feature reflecting environmental gradients (i.e. differences) such as topography, climate, soils, drainage, and so forth.[49]

Maintaining appropriate levels of spatial complexity – or landscape diversity – is an essential principle for conserving biodiversity. In *a managed forest landscape*, it may be understood as corresponding to a mosaic of areas representing different forest composition and age classes – each with a different structural condition. In *an agricultural landscape* it would mean that natural and rehabilitated habitat is interspersed in accordance with landscape matrix management (i.e. to support populations of species; facilitate their movements; buffer sensitive areas; maintain the integrity of the aquatic system; and support ecosystem services) (**Figure 33**).

Different species inhabit different environmental conditions in natural landscapes and the diversity, size, and spatial arrangement of habitat patches is important for many groups of plants and animals.

Landscape diversity is also important because of its relationships with the impacts of habitat fragmentation. Thus, heterogeneity is likely to provide more living space for plants and animals except for core specialist which are rarely – if ever – found outside larger undisturbed habitat fragments (e.g. Sumatran rhino).

Managing the landscape (i.e. the matrix) to increase its suitability as habitat and increase its permeability to movement (i.e. re-establish/maintain connectivity) may significantly complement species otherwise restricted to Protected Areas and (parts of) the Permanent Forest Reserve (as already referred to above in Section 3.2, p. 26).

Recognising that not all parts of a landscape are created equal in their productivity and biodiversity is often vital in planning matrix management for biodiversity conservation and sustained production of environmental services. Examples include limestone hills (which typically have an unusual high rate of endemics), springs, and wetland areas – all of which may significantly complement larger Protected Areas (i.e. by offering in the landscape a combination of "lifeboat", "enrichment", and "connectivity" functions).

Great care should be taken in assessing the extent and type of landscape heterogeneity required in the matrix, where it seems that the more diverse we keep the landscapes the more resilient they become ensuring a constant flow of ecosystem services and greater capacity to cope with the oncoming varied impacts of climate change.[32]

#### *v) Manage disturbances*

The maintenance of habitat is the overarching goal for biodiversity to support a great variety of highly valuable ecosystem products and services. However, what is suitable habitat varies with each species. Similarly, what constitutes suitable connectivity, stand complexity, landscape heterogeneity and aquatic ecosystem integrity will also be defined on an organism-specific basis and can vary markedly between species.

Enabling or creating spatial and temporal variation in a range of conditions at multiple spatial scales is a practical response to the problem of defining these variables for a large set of species. Conditions needed by different species should then be provided in at least some parts of a landscape where we apply the five principles and the various management interventions (referred to above).

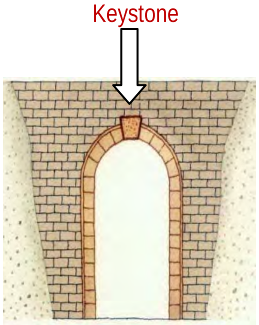
Organisms are likely to be best adapted to the disturbance regimes under which they have evolved. Adoption of natural disturbance regimes is the best template to guide human-made disturbance regimes (e.g. selective logging in the forest mimics natural windfall and gaps created in the stand structure).

Managing disturbances is also a risk-spreading approach which aims at ensuring that strategies are varied in the landscapes and across multiple scales (i.e. "do not do the same thing everywhere").

### 3.3.2 Managing species and ecological processes

Though landscape pattern-based mitigation strategies (i.e. the Section above) are an excellent starting point for conservation in modified landscapes, they cannot guarantee that all important species or ecological processes are adequately safeguarded. For this situation, particular species and ecological processes should be targeted through five general management strategies. [50]

However, for these strategies to succeed, in several cases further applied research may be required to get a better understanding of the ecology of species in question and the processes that link interspecies interactions. Such research should focus on threatened species (plants and animals) and habitat types; as well as possible changed status of 'keystone species'. These issues should be included as part of the frequent biodiversity assessments[19] carried in the cyclic National Biodiversity Planning process (Section 2.11, p. 22). [51]

> **Key Points**
>
> A 'keystone species' is a species whose loss from an ecosystem would cause a greater than average change in other species populations or ecosystem processes.
>
> Just as a keystone maintains the integrity of a Roman stone arch, a keystone species maintains the integrity of an ecological community.
>
> Keystone
>
> 

*Strategy 1: Maintain key species interactions and functional diversity*

Landscape modifications of habitat loss, degradation, fragmentation and increased isolation of patches lead to changes in species interactions in terms of behaviour and biology. Some types of species interactions are particularly important for ecosystem functioning and examples include predation by large mammals; pollination; and seed dispersal.

Species involved in such interactions are sometimes called 'keystone species' and their continued survival is important to avoid 'cascading effects' of landscape change (e.g. 200,000 plant species depend on animal pollinators to produce seeds [52] and pollinators such as bees, birds and bats affect 35% of the world's crop production, increasing the output of 87 of the leading food crops worldwide [53]).

Non-keystone species may wrongly be considered as not needed to maintain ecosystem functioning (i.e. by definition their loss will not result in immediate and disproportionate changes). However, maintaining a diversity of species within different functional groups provides a safeguard for continued effective ecosystem functioning and is likely to enhance the ability of ecosystems to recover in response to disturbance. [54]

In other words, though non-keystone species do not have the same immediate importance as do keystone species, they are nevertheless important because of their "insurance role" and contribution towards ecosystem resilience.

*Strategy 2: Maintain or apply appropriate disturbance regimes*

Our landscape modifications often result in a change to historical disturbance regimes (e.g. through logging, intensive agriculture, and large-scale rotational crops). Extensive landscape-scale disturbances can substantially alter vegetation structure (e.g. excessive extraction of forest products; the spread of invasive weeds) and may trigger cascading effects of landscape change that cause fundamental – and potentially irreversible – changes to ecosystems.

Such series of successive stages may be caused by simultaneous changes to vegetation cover, structural complexity, and species composition which: (i) at a landscape scale may result in the loss of native ecosystems; (ii) while at the local scale, remnant patches of natural ecosystems are too small or insufficiently connected to support key species. This intrinsic balance and how it may ultimately affect ecosystem processes, resilience and services was conceptualised in Figure 6, p. 9.

Landscape changes affect not only habitat at the horizontal level (e.g. patchiness) but also causes changes in the vertical structural complexity of ecosystems (e.g. due to edge effects, excessive harvesting, grazing).

The conditions of the landscape matrix will play a major role in the stability of ecosystems and their overall susceptibility to cascading effects of landscape change. The extent to which resources supplied by native ecosystems are also available in the matrix will affect many species and vegetation structure can be a key attribute in this context.

With respect to species compositions then – as we have seen above – no species exist in isolation, but interact with one another through processes like competition, predation and mutualisms (i.e. each organism benefits). Ecosystem and landscape resilience refers to a system's capacity to absorb disturbances while still retaining essential processes and services. The likelihood of species loss causing irreversible ecosystem change is linked to the functional redundancy of species. Though some species are more replaceable / irreplaceable than others we can conclude that the more redundancy we can maintain (i.e. species diversity) the more resilient the matrix and/or an ecosystem. Retaining many species fulfilling similar ecological functions provides important safeguard and insurance against management mistakes and environmental change (e.g. climate change).

*Strategy 3: Maintain species and habitats of particular concern*

Managing the landscape for conservation of biodiversity (i.e. previous Section 3.3.1, p. 30) will effectively protect the habitat of many species. However, we have also established that habitat is a species-specific concept since different species perceive the same landscape pattern in different ways – and surely differently from humans.

In consequence, ongoing assessments of threatened species (animals and plants) and habitat are needed to identify concerns that are insufficiently addressed by managing landscape patterns alone (i.e. applying principles and interventions as discussed in the Section above).

Examples of actions to take include: focus on key areas critical for the breeding and survival of a species; captive breeding, reintroduction and translocation[55]; control of predators of highly competitive (introduced) species; and control of diseases and parasites.

A critical aspect of focused conservation actions is rigorous diagnosis of the underlying causes of decline of a species or habitat type and then targeted efforts to mitigate the impacts of the threatening processes[56]. Such an approach is represented by the National Biodiversity Planning framework (Figure 24, p. 22).

As far as threatened species is concerned this is best done by adopting the IUCN Red List guidelines for national purposes[57] and use regularly updated lists as part of the routine biodiversity assessments[19] of the National Biodiversity Planning process. The very same assessments will also yield an update on the status of the nation's key habitat types of which a minimum extent have to be included in a Protected Areas System. [12, 27]

*Strategy 4: Control aggressive, overabundant, and invasive species*

Land use changes tend to result in habitat loss for many species – as was explained in Section 2.7, p. 14. However, it also often provides favourable conditions for a small number of native or introduced species (e.g. creepers and climbers which completely cover habitat openings from ground level to canopy).

Plants and animal species which are benefitted from such landscape changes may become overly abundant and can negatively affect other species by their aggressive behaviour, competition, or predation. It is therefore important to control and monitor invasive or overabundant plant and animal species to ensure well functioning and diverse ecosystems.

*Strategy 5: Minimise ecosystem-specific threatening processes*

The drivers of change affecting biodiversity include more than change in land use. To protect species and ecosystems in modified landscapes it is important to identify and control additional potential threats.

An example is that proper landscape management (e.g. resulting in enhanced connectivity between habitat fragments) can do little to cope with the impact and devastation caused by uncontrolled hunting.

Other common processes threatening ecosystem processes may include chemicals which are allowed into the food web affecting a range of species from plants (i.e. primary producers) to animals such as predators (i.e. highest in the food chain).

**Table 3.** Summary of species/process-oriented strategies to minimise the negative effects of human landscape modification on species and ecosystems (from Lindenmayer & Fischer, 2006).

| Management Strategies | Purposes / Interventions |
|---|---|
| 1 Maintain key species interactions and functional diversity | • Protect important ecosystem processes<br>• Protect characteristic ecosystem structure |
| 2 Maintain / apply appropriate disturbance regimes | • Encourage characteristic vegetation structure<br>• Create characteristic spatial / temporal variability in vegetation patterns |
| 3 Maintain species and habitats of particular concern | • Ensure the survival of threatened species (plants and animals) and habitats |
| 4 Control aggressive, overabundant, and invasive species | • Reduce competition and predation by undesirable species that could negatively affect desirable species<br>• Maintain characteristic species composition |
| 5 Minimise ecosystem-specific threatening processes | • Identify problems that may affect biodiversity but are not directly related to landscape modification<br>• Establish protocols to eliminate these problems |

*Summary of managing species and ecological processes*

Managing biodiversity in the landscape is off to a good start by managing landscape patterns to mitigate the negative impacts of our landscape modifications on biodiversity and ecosystem services. Though such an approach will benefit many species, additional management efforts may be required to mitigate the impacts of particular threatening processes.

A summary of suitable species/ process-oriented management strategies to complement landscape-based mitigation strategies are presented in **Table 3**.

Key Points

The *ecosystem approach* is considered one of the most important principles of sustainable environmental management. It is based on the application of appropriate scientific methodologies focused on levels of biological organisation which encompass the essential processes, functions and interactions among organisms and their environment.

It recognises that humans, with their cultural diversity, are an integral component of ecosystems.

Secretariat to CBD

## 3.4 The ecosystem approach

Now that we know how a landscape supports biodiversity, ecological processes and ecosystem services (Section 3.2, p. 26) and what principles and management interventions we can deploy to further safeguard these (Section 3.3, p. 29), we must consider how to bring about change.

The 'ecosystem approach' is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It essentially requires the taking into consideration of the effects of actions on every element of an ecosystem, based on the recognition that all elements of an ecosystem are linked.[58]

Malaysia and the other parties to the Convention on Biological Diversity have in 1995 recognised that the ecosystem approach should be the primary framework for actions to be taken under the Convention. [59]

The ecosystem approach is:

> *A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.*

This definition is to a large extent reflected in several of Malaysia's policies and plans including the National Policy on Biological Diversity and the National Policy on the Environment. [60]

A 5-point operational guidance has been prepared to assist in the implementation of the Ecosystem Approach: [61]

1. **Focus on the relationships and processes within ecosystem**

   The many components of biodiversity (see Figure 2, p. 6) control the stores and flows of energy, water and nutrients within ecosystems, and provide resistance to major perturbations. Functional biodiversity in ecosystems provides many goods and services of significant economic and social importance. While there is a need to accelerate efforts to gain new knowledge about functional biodiversity, ecosystem management has to be carried out even in the absence of such knowledge. The ecosystem approach can facilitate practical management by ecosystem managers (whether local communities or national policy makers).

2. **Enhance benefit-sharing**

   Benefits that flow from the array of functions provided by biological diversity at the ecosystem level provide the basis of human environmental security and sustainability. The ecosystem approach seeks that the benefits derived from these functions are maintained or restored. In particular, these functions should benefit the stakeholders responsible for their production and management. This requires, inter alia: capacity building, especially at the level of local communities managing biological diversity in ecosystems; the proper valuation of ecosystem goods and services; the removal of perverse incentives that devalue ecosystem goods and services; and, where appropriate, their replacement with local incentives for good management practices.

3. **Use adaptive management practices**

   Ecosystem processes and functions are complex and variable (Figure 2, p. 6). Their level of uncertainty is increased by the interaction with social constructs, which need to be better understood. Therefore, ecosystem management must involve a learning process, which helps to adapt methodologies and practices to the ways in which these systems are being managed and monitored. Implementation programmes should be designed to adjust to the unexpected, rather than to act on the basis of a belief in certainties. Ecosystem management needs to recognize the diversity of social and cultural factors affecting natural-resource use. Similarly, there is a need for flexibility in policy-making and implementation. Long-term, inflexible decisions are likely to be inadequate or even destructive.

4. **Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to lowest level, as appropriate**

   An ecosystem is a functioning unit that can operate at any scale, depending upon the problem or issue being addressed. This understanding should define the appropriate level for management decisions and actions. Often, this approach will imply decentralization to the level of local communities. Effective decentralization requires proper empowerment, which implies that the stakeholder both has the opportunity to assume responsibility and the capacity to carry out the appropriate action, and needs to be supported by enabling policy and legislative frameworks.

5. **Ensure inter-sectoral cooperation**

   To be fully comprehensive, the ecosystem approach should be fully taken into account in developing and reviewing national biodiversity strategies and action plans. There is also a need to integrate the ecosystem approach into agriculture, fisheries, forestry and other production systems that have an effect on biodiversity. Management of natural resources, according to the ecosystem approach, calls for increased inter-sectoral communication and cooperation at a range of levels (government ministries, management agencies, etc.)[62]. This might be promoted through, for example, the formation of inter-ministerial bodies within the Government or the creation of networks for sharing information and experience.

**Key Points**

There is no single ecosystem approach, but multiple approaches which will need to be adapted and applied pragmatically in each situation.

An increased body of international experiences in application of the ecosystem approach is accumulating. The Secretariat to the Convention on Biological Diversity maintains a continuously updated web site with further guidelines as well as case studies – one of which refers to a *Large-scale ecosystem health study of the Langat Basin, Malaysia.* [63]

## 3.5 Spatial data

**Key Points**

The availability of habitat is one of the primary factors influencing the distribution and abundance of organisms. Thus it plays a key role in the disciplines of landscape ecology and conservation biology.

Knowledge of where what type of habitat is found is essential since habitat is an organism-specific concept.

Habitat information across multiple scales is also fundamental to landscape matrix management and, in turn, to any comprehensive plan for conserving biodiversity and ecosystem services.

As we have seen, biodiversity planning is largely an exercise in spatial planning and today *the* knowledge-based tool of choice for such undertakings is a Geographic Information System - GIS. A GIS permits cost-effective and efficient inter-sectoral synthesis, query and analysis of numerous spatial features to support planning and decision-making on a routine basis. If only hardcopies of individual maps – such as topographic sheets, land use, Permanent Forest Estate, Protected Areas, and so forth – are made available to planners then the preparation of decision-support in terms of synthesis and analysis of spatial features will be severely hampered[64].

Many planners and decision-makers have manifested that the present practice of difficult access to GIS thematic data is an effective deterrent to generating much needed spatial synthesis and analysis to support preparation of strategies and action plans. The lack of exposure to spatial analysis in day-to-day operations may also be behind why a few even consider that biodiversity can be planned and managed without detailed knowledge of *where biodiversity is*, *how it is changing over time*, *what* is causing changes, and drivers *impacts* on ecosystem services (as dealt with in Sections 2.1 and 2.2).

Finally, access to proper spatial data is prerequisite to carrying out Strategic Environmental Assessment (also referred to as Sustainability Assessment), and 'Agenda 21' with its National Strategies for Sustainable Development.

Not only does National Biodiversity Planning require routine access to such data, but analytical results as part of strategies and action plans have to be conveyed to multiple stakeholders for them to effectively safeguard biodiversity, ecological processes, and valuable ecosystem services in accordance with national goals for sustainable development.

## 3.6 Summary of how to go about it

Key issues discussed include:

- Landscapes are composed of elements and the patch-corridor-matrix model is a convenient model for understanding a given setting.
- Landscape (matrix) management is important since Protected Areas are insufficient to safeguard biodiversity. It aims at strategic placement of managed and natural elements, so the services of natural ecosystems are available across the landscape.
- The National Biodiversity Planning process is tied into the National Development Planning Framework and makes use of the same approximate scales from National to Regional/State and Local levels. Planning for biodiversity to support ecosystem services will have to address issues at all three scales.
- Landscape matrix management aims at conserving ecosystem processes by preserving high levels of diversity of landscape types, ecosystems, species and genetics. Impaired ecosystem processes result in reduced production of goods and services in the landscape and this has substantial social and economic costs for society as a whole.

- A useful approach to mitigate our landscape modifications on biodiversity and ecosystem services is by: (i) managing landscape patterns in a way that will benefit many species simultaneously; and complement with (ii) managing important species and ecological processes which are insufficiently addressed in the former. The approach is summarised in **Table 4**.

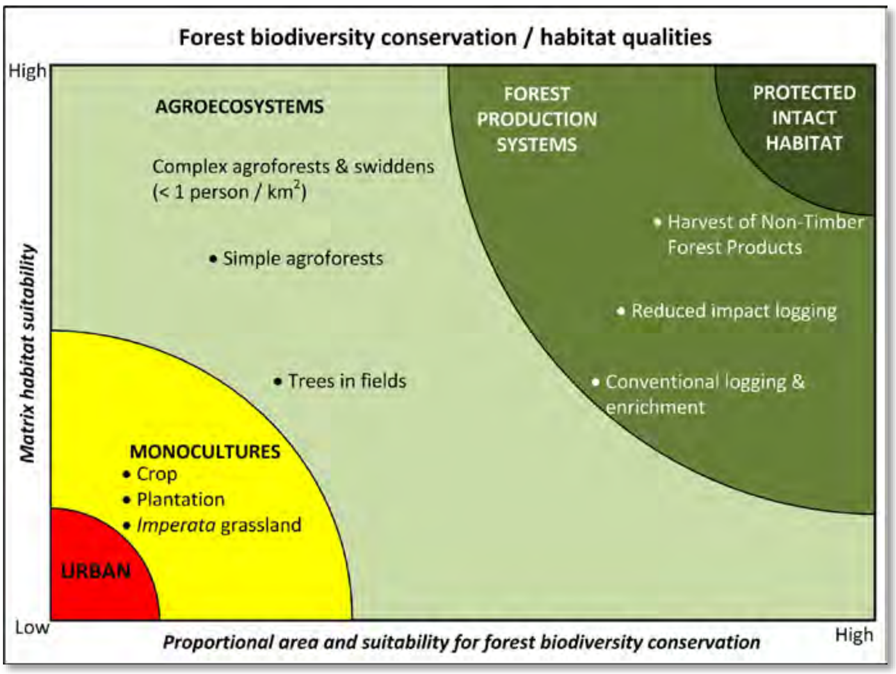
**Table 4.** Principles for managing biodiversity in the landscape (from Lindenmayer *et al.*, 2006; Lindenmayer & Fischer, 2006).

| | Managing landscapes |
|---|---|
| 1 | Maintain connectivity |
| 2 | Maintain the integrity of aquatic systems |
| 3 | Maintain habitat structural complexity |
| 4 | Maintain landscape level heterogeneity |
| 5 | Manage disturbances |
| | **Managing individual species and ecological processes** |
| 1 | Maintain key species interactions and functional diversity |
| 2 | Maintain / apply appropriate disturbance regimes |
| 3 | Maintain species and habitats of particular concern |
| 4 | Control aggressive, overabundant, and invasive species |
| 5 | Minimise ecosystem-specific threatening processes |

**Key Points**

Compared to extensive segregated land use systems, landscape diversity appears to enhance landscape resilience and thus safeguarding of valuable ecosystem services

- The ecosystem approach is a suitable strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is based on 12 principles with a 5-point operational guidance for its application.
- Efficient inter-sectoral synthesis, query and analysis of numerous spatial features to support planning and decision-making is required for multiple stakeholders to safeguard biodiversity, ecosystem processes and valuable services.




**Key Points**

Of the landscape scenarios depicted in Figure 33, p. 35, (A) would be in the yellow *monocultures* and (B) as well as (C) would probably fall somewhere between *complex* and *simple* agroforestry systems.

**Figure 34.** Conceptual representation of forest biodiversity conservation in relation to the different habitat qualities and relative areas of a given landscape (redrawn from Cunningham *et al.*, 2002).

# 4 Complementary interagency actions

## 4.1 How does it all fit together?

A growing body of research suggests that agricultural landscapes can be designed and managed to host wild biodiversity of many types (though not all), with neutral or even positive effects on agricultural production and livelihoods, through innovations in farming systems and in the spatial layout and management of natural areas within agricultural landscapes.

**Key Points**

It would have an immediate positive impact on natural resource and biodiversity assets if federal and states encourage their agencies, Local Authorities, and others to move beyond the dominant site-based focus of analysis to embrace the wider perspective at landscape level.

Innovative practitioners and scientists, as well as indigenous land managers, are adapting, designing and managing diverse types of 'ecoagriculture' landscapes to generate positive co-benefits for production, biodiversity and local people. [65]

Malaysia's policies and plans speak for holistic planning and management of natural resource and biodiversity assets in order to achieve sustainable development. [60]

More specifically – and at an operational level – it should be considered in terms of accomplishing complementary inter-agency actions around a multi-scaled and multi-functional landscape approach that encompasses the entire mosaic of land use systems including forests, agriculture, human settlements, and waterways. Taking into account the natural and semi-natural systems that interact with agricultural systems is critical for identifying and fostering synergies between conservation and production, thus safeguarding the delivery of ecosystem services.

At the core of the strategy is a Protected Areas System[27] but it is now clear that this measure alone cannot safeguard the results of four billion years of evolution which includes biodiversity's support for ecosystem services vital for human livelihood. It is now realised that Protected Areas are part of a landscape with interacting and interdependent systems which are linked together through the exchange of energy, matter and genetic information. In consequence, a new paradigm has emerged that integrates Protected Areas into the broader landscapes of human use – that is, the landscape matrix (as elaborated upon in the previous Chapter). In response to this, the very nature of organisations dealing with planning and management of natural resources and biodiversity is also changing.

**Key Points**

A stakeholder supported multi-scaled and multi-functional landscape approach that encompasses the entire mosaic of land use systems (including Protected Areas), helps to ensure that biodiversity supports key ecosystem processes and functions.

This builds and maintains a resilient landscape which permits the steady flow of ecosystem services vital for society and human livelihood.

The challenge is visualised in the conceptual diagram shown in **Figure 34** (previous page). It represents forest biodiversity conservation in relation to the different habitat qualities, and relative areas and suitability of different land-use systems across the landscape matrix. In other words, the Figure summarises what needs to be considered when taking a multi-scaled landscape approach to conserving biodiversity and ecosystem services.

The upper right corner of **Figure 34** (i.e. darkest green) represents ideal conditions for forest biodiversity and the other extreme (red – to the lower left) stands for a situation where major problems exist for many forest organisms which will significantly reduce the underpinning of ecosystem services provided by biodiversity.

In between these two extremes exists a zone where matrix management has the potential of becoming part of a comprehensive strategy ensuring ecosystem services across multiple spatial and temporal scales.

A conceptual framework for comparing land use and trade-offs of ecosystem services is presented in **Figure 35**. To the left, the Main Range in the distance is providing high levels of a multitude of valuable ecosystem services, and only a minimum (if any) agricultural crop (e.g. shifting cultivation by Orang aslis).

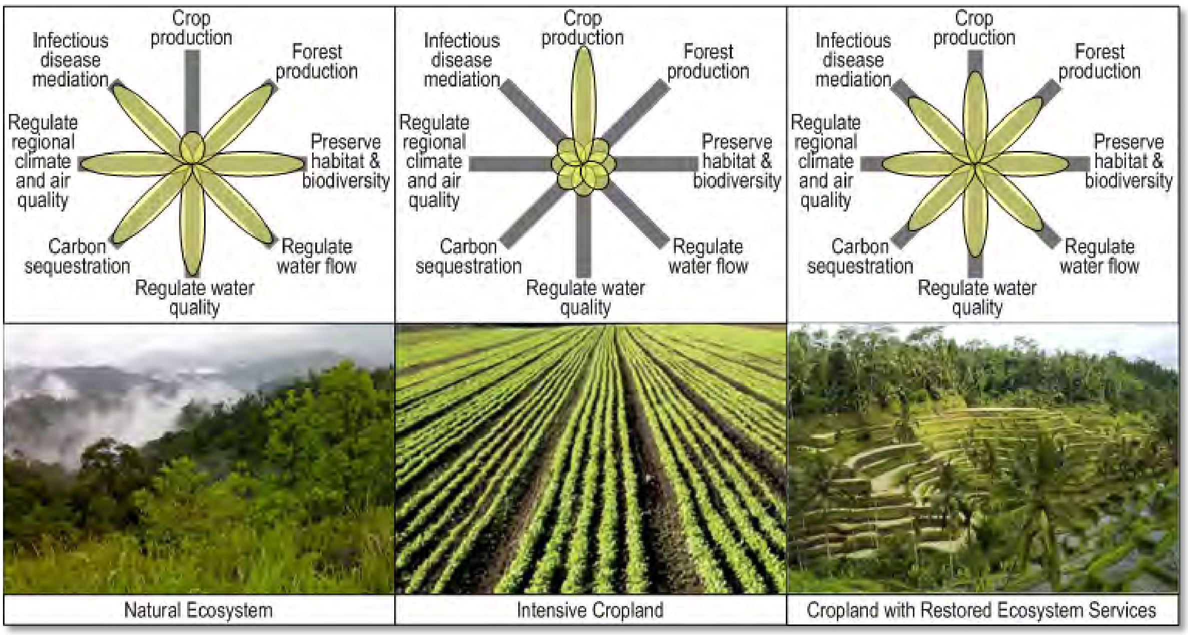



**Figure 35.** Conceptual framework for comparing land use and trade-offs of ecosystem services (redrawn and modified from Foley *et al*., 2005).

This is contrasted by intensive cropping (in the middle of the Figure) which provide a highly valuable crop but only an absolute minimum (if any) of environmental services.

In between the two extremes we find an example of cropland where restoration efforts have resulted in high levels of all ecosystem services (to the right in the Figure). Other examples of restored ecosystem services at landscape level were shown in (B) and (C) of Figure 33, p. 35.

## 4.2 Stakeholder management of landscapes

The five principles and specific management interventions presented in Section 3.3.1 (p. 30) are summarised in **Table 5** (next page) and they represent an approach by which the availability of ecosystem services across the landscape may be enhanced by managing the landscape structure through strategic placement of managed and natural elements.

Importantly, this line of actions may also represent a more tangible entry point to implementation of the *ecosystem approach* and should – during implementation – be guided by particularly its Five-Point Operational Guidance (Section 3.4, p. 39).

For each of the five principles suitable management interventions have been defined together with key stakeholders required for their successful implementation (**Table 5**). The interventions listed for Principle 3 refer mainly to forest habitat but any measures taken in agricultural production systems which increases structural complexity is likely to be beneficial for biodiversity and provide further support for ecosystem services (e.g. inter- and under-cropping in monocultures such as oil palm and forest tree plantations).

**Key Points**

Managing diversity requires diverse management interventions on behalf of multiple stakeholders.

In the process we have to embrace complexity and an 'adaptive management' style is our best approach to systematically test our assumptions, share information, adapt and learn.

The landscape mitigation strategies shown in the Table are an excellent starting point for managing biodiversity in the landscape to the benefit of increased resilience and delivery of ecosystem services. However, in several cases they will have to be complemented with additional safeguards to ensure that important species and ecological processes are adequately protected (as discussed in Section 3.3.2, p. 36, above).

**Table 5.** Principles, management interventions, and key stakeholders to safeguarding biodiversity, ecological processes, and ecosystem services in landscapes (*Principles* and *interventions* based on Lindenmayer *et al*., 2006).

| How to build and maintain a resilient landscape | | *Note 1* |
|---|---|---|
| **Principles** | **Management strategy/interventions** | **Key stakeholders** |
| 1 Maintain connectivity | • Riparian and other corridors<br>• Protection of sensitive habitats within the matrix<br>• Vegetation retention on logged areas throughout the landscape<br>• Careful planning of road infrastructure<br>• Landscape reconstruction | FDs, PAs, DID, DOA, NLD, TCPD/TRP, JKR, State Authorities, extensive land use systems (oil palm/ rubber, etc.) |
| 2 Maintain integrity of aquatic systems | • Riparian and other corridors<br>• Protection of sensitive habitats within the matrix<br>• Mid-spatial-scale Protected Areas<br>• Spatial planning of cutover sites<br>• Increased rotation lengths<br>• Landscape reconstruction<br>• Careful planning of road infrastructure<br>• Use of natural disturbance regimes as templates | Same as No. 1 plus Departments of: Marine Park Malaysia; Fisheries; and Environment |
| 3 Maintain / build habitat structural complexity | • Use multiple (indigenous) species<br>• Retention of structures and organisms during (regeneration) harvest / rotation<br>• Habitat creation (e.g. undercropping; promotion of cavity-tree formation)<br>• Stand management practices<br>• Increased rotation lengths<br>• Use of natural disturbance regimes as templates | All |
| 4 Maintain landscape heteroge-neity | • Riparian corridors<br>• Protection of sensitive aquatic habitats<br>• Careful planning and maintenance of road infrastructure<br>• Midspatial scale Protected Areas within the matrix | All |
| 5 Manage disturbances | • Ensure that strategies are varied between different habitats and landscapes ('do not do the same thing everywhere') | All |

**Note 1:** FDs correspond to Forestry Departments Peninsular Malaysia, Sabah and Sarawak; PAs: PERHILITAN, Sabah Parks, Sabah Wildlife Department, Sarawak National Parks & Wildlife Division; TCPD refers to Town & Country Planning Departments in Peninsular Malaysia and Sarawak; and TRP to Town & Regional Planning Sabah. In addition to the agencies listed here, research institutions such as FRIM and various universities can contribute tremendously in making operational the management principles for terrestrial, freshwater and marine systems.

From **Table 5** it should also be clear that successful management of biodiversity at the landscape level indeed requires multiple stakeholders to conduct diverse management interventions. However, it is encouraging that many parties share the same objectives and are already pursuing these.

For instance, the National Landscape Department may be promoting riparian vegetation for reasons of beautification, but these may nevertheless contribute to three of the five management principles shown in **Table 5**; JKR is now considering habitat linkages such as under-passes for wildlife in their design of new road infrastructure (in collaboration with PERHILITAN several under-passes have been built as part of new roads in Terengganu and Kedah – see **Figure 36**).

Bennett, G. 2004.

Gerik – Kupang highway, Kedah (photo by Dylan Jefri Ong 12 Jun 08).

Gua Musang – Kuala Berang highway, Terengganu (photo by Dylan Jefri Ong 11 Jun 08).

Bennett, G. 2004.

**Figure 36.** The *under*passes for wildlife in Kedah (upper right) and Terengganu (lower left) will soon recover vegetation. Examples of *over*passes are shown in the other two pictures (the lower right is a drawing).

In April 2007 FRIM embarked on a UNDP-GEF-ITTO Conservation of Biodiversity Project which, among other things, will consider how setting aside un-logged areas within production forests will assist biodiversity (i.e. all of the principles in **Table 5** – see also Endnote 41).

To some extent the challenge is to promote a cohesive and concerted approach in order to achieve a greater impact and reduce the risk of management mis-takes and counter-productive measures.

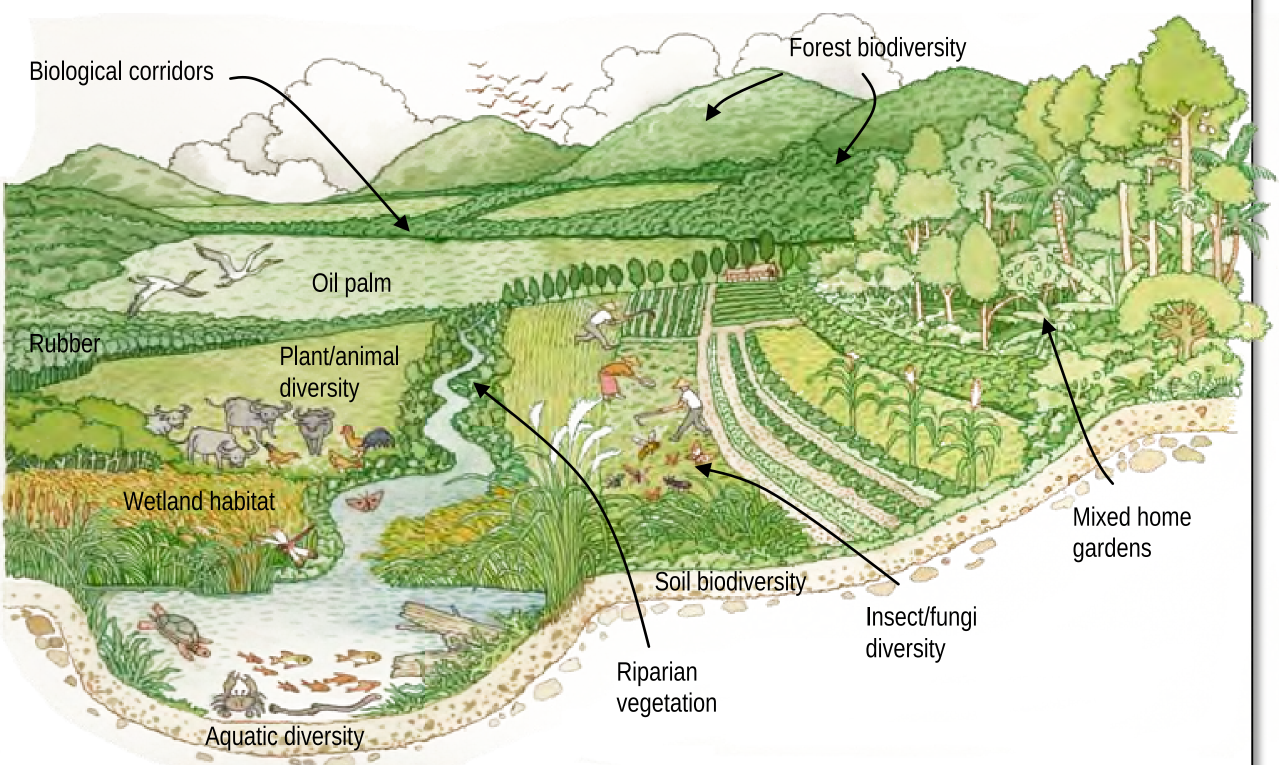
**Key Points**

To protect ecosystem services, any land use system which does not comply with the management principles for conserving biodiversity at landscape level should be improved upon.

## 4.3 Applying the ecosystem approach to biodiversity conservation in agricultural landscapes

Humans in the present 21st century will place unprecedented demands on the world's limited land base while seeking to increase global food production, improve living standards for poor people while simultaneously protecting wild biodiversity and ecosystem services that sustain human well-being. Though undisturbed areas remain absolutely essential for long-term preservation of biodiversity, agricultural regions must play a significant role as well.

Box 5. Elements of biodiversity in agricultural landscapes (drawing by Yew Kiang Teh).




Agricultural landscapes are mosaics of natural features and agricultural (and other) land uses in a particular geographic region. A landscape perspective is necessary if the goals of biodiversity and maintenance of ecosystem services, agricultural production, and improved livelihoods for local people are to be achieved. Farm or plot management alone will simply not provide the opportunities for spatial and temporal planning required for sustainable management. Neither will an approach in which managers simply select areas of most important biodiversity near agricultural land and protect them. Protected Areas (PAs) must be fully integrated within participatory planning frameworks. Agricultural lands should be managed as part of the matrix surrounding PAs; while natural habitat areas should be managed in relation to surrounding agricultural lands.

**Key Points**

Species needed by agriculture and forestry – such as pollinators – need habitat to survive.

An ecosystem consists of a dynamic mix of plant, animal and micro-organism communities and their non-living environment. Some agricultural ecosystems have biodiversity levels comparable to natural ecosystems. The management of agricultural biodiversity is essential in an overall approach to the conservation of ecosystems on the whole. Thus, estates, individual farmers and their families play an important role as ecosystem managers (**Box 5**).

Ecologically compatible agricultural production areas can significantly enhance nearby Protected Areas, improve the effectiveness of biological corridors that cross the intervening landscape, and provide smaller patches of critical habitat in uncultivated and farmer-protected spaces (as explained in Section 3.2, p. 26).

Agricultural landscapes can also support *in situ* conservation of crop and livestock varieties and wild species that are necessary for sustainable agricultural production and rural livelihoods. To achieve these goals, conservation and agricultural planning must be coordinated in agricultural landscapes[66] (as was referred to above and conceptualised in Figure 34 and Figure 35).

Biodiversity in agricultural landscapes can contribute significantly to agricultural productivity, food security, financial returns and sustainable livelihoods of rural populations.[67] A good starting point is to recognise that there are ecological relationships and mutual interdependencies between agriculture, biodiversity and ecosystem services (**Figure 37**).

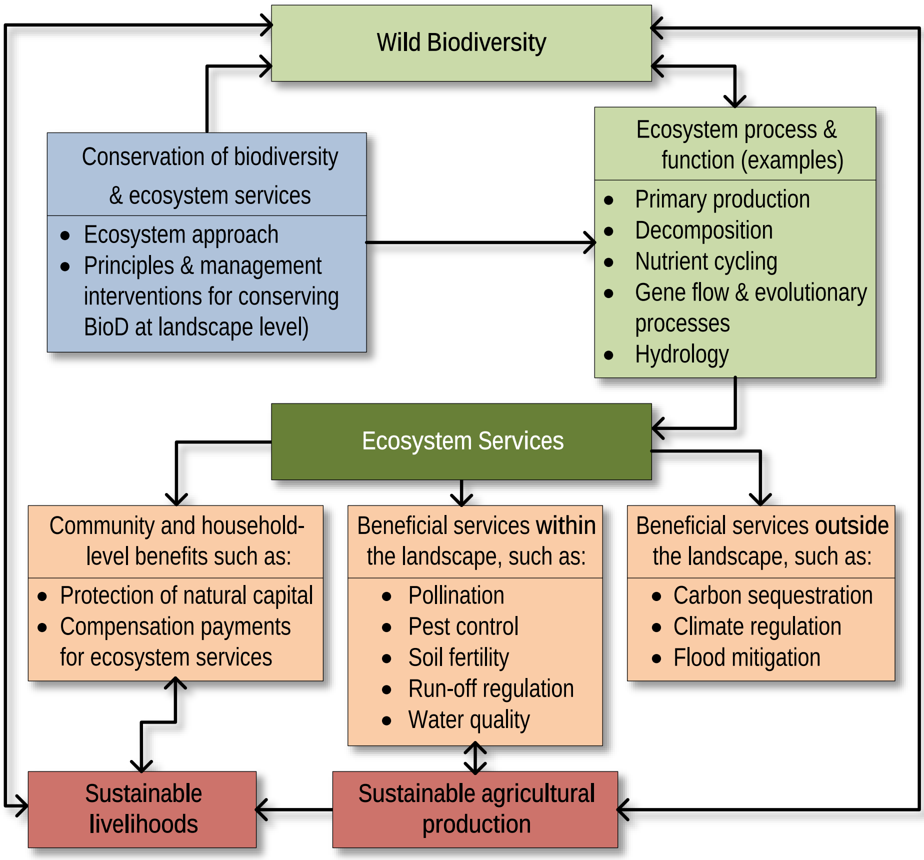



**Figure 37.** Ecosystem services are a key to the synergies between conservation, sustainable agricultural production and sustainable livelihoods (modified from Buck *et al*., 2006).

Thus, the Figure shows that "wild" biodiversity (as opposed to "domesticated" diversity of for instance agricultural crops) supports ecosystem processes and functions which should be further secured / rehabilitated by applying an ecosystem/landscape approach (i.e. the blue box). The enhanced ecosystem services provide sustainable livelihoods for local communities; fundamental services to support sustainable agricultural production; and also deliver services beneficial to society and the global community as a whole (i.e. the three boxes below "Ecosystem Services").

In landscapes dominated by extensive long-term rotational crops (e.g. monocultures of forest tree species, oil palm and/or rubber plantations) this means strategic placement of managed and natural elements, so the services of natural ecosystems are available across the landscape matrix (as discussed in the previous Section above).

For smallholders diverse crop, livestock, tree and wild species can enhance livelihood security and generate income by opening commercial options in agriculture and other sectors (including potential Payment for Environmental Services), and by supporting adaptability and resilience to changing environmental and economic conditions. Diversity is often a central element of livelihood strategies for such farmers and – not surprisingly – the higher levels of heterogeneity constituted by for instance mixed home gardens help protect ecosystem processes while balancing environmental, social and economic needs.[42]

**Key Points**

Biodiversity is the origin of all crops and domesticated livestock and the variety within them.

Biodiversity in agricultural landscapes provides and maintains ecosystem services essential to agriculture.

Agriculture contributes to conservation and sustainable use of biodiversity but is also a major driver of biodiversity loss (Section 2.6, p. 12).

Sustainable agriculture both promotes and is enhanced by biodiversity.

## 4.4 An illustrated guide to managing biodiversity in the landscape

The following Figures aim to further clarify concepts introduced with particular emphasis on riparian and other corridors' contributions towards maintaining and rebuilding a resilient landscape. These two measures alone are relevant for three of the five principles discussed above in Section 3.3.1, p. 30 (i.e. maintaining: connectivity; integrity of aquatic systems; and landscape heterogeneity).

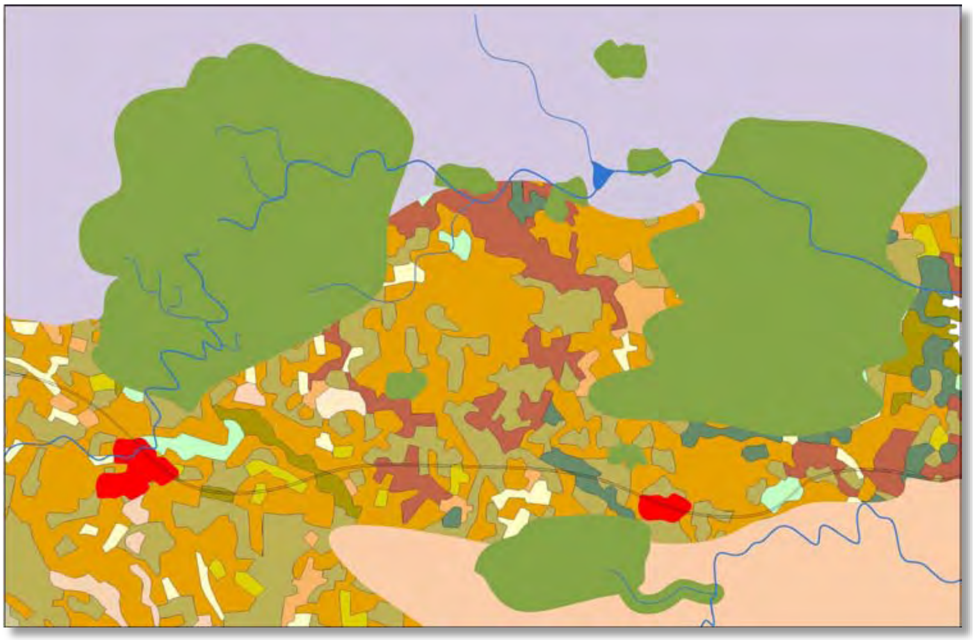


**Figure 38.** When looking at a land use map it can be quite confusing with more than 30 different land use types in the landscape matrix.

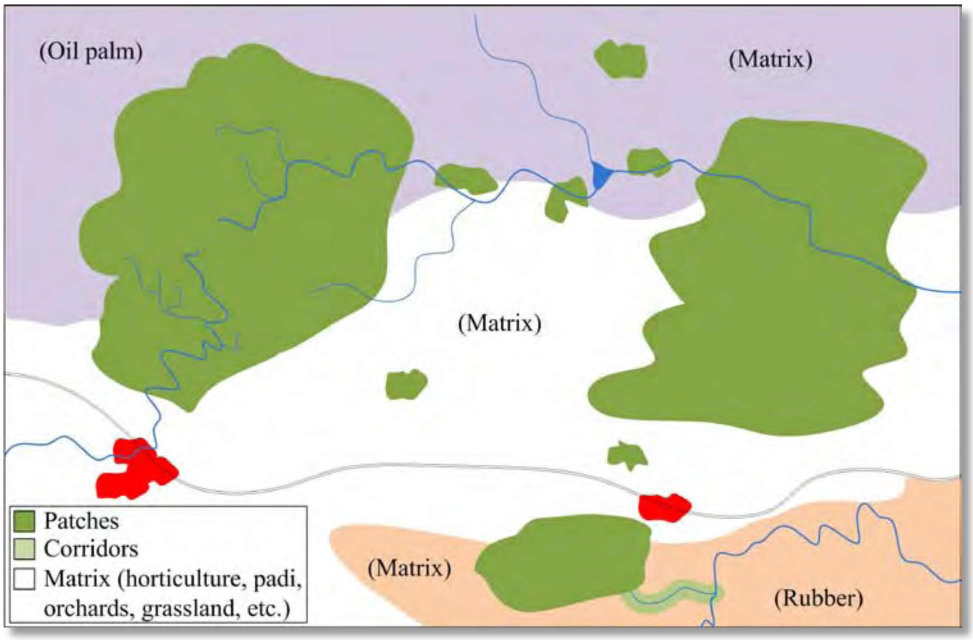



**Figure 39.** Applying the *patch-corridor-matrix model* reveals three larger forest fragments; and several smaller patches (all in dark green). Given their dominance in the landscape, also shown here are extensive oil palm plantations to the North (purple); and rubber to the South-Southeast (pink). Two smaller urban areas (red) are linked by a road. Note a stretch of remnant riparian vegetation in the rubber plantation to the South (light green).

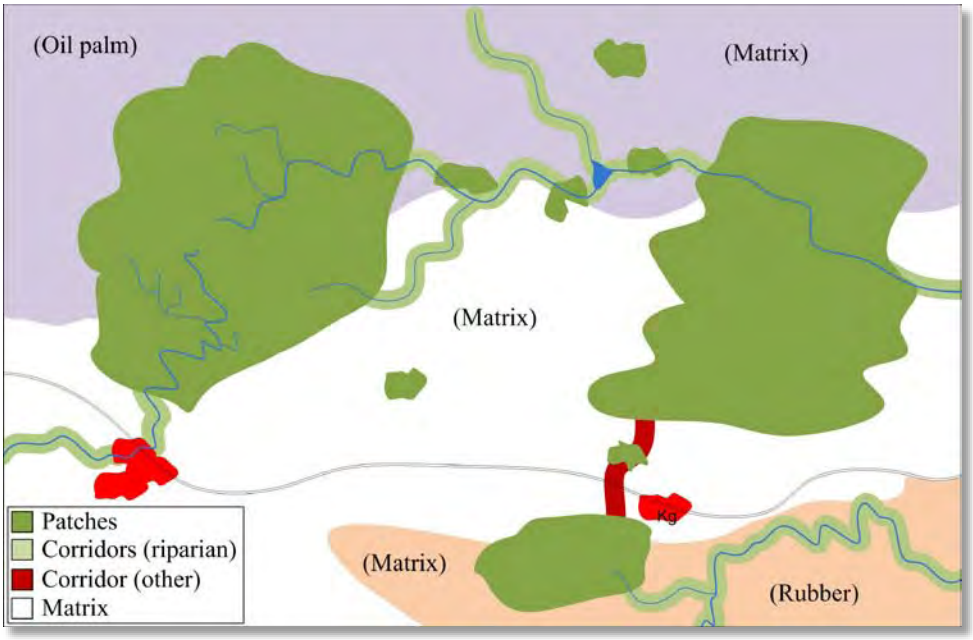



**Figure 40.** Applying principles and management interventions to make ecosystem services available across the landscape, we would, among other things, like to re-establish riparian vegetation (i.e. protect the integrity of the aquatic system – light green) and provide for connectivity between two important habitat fragments (i.e. dark red).

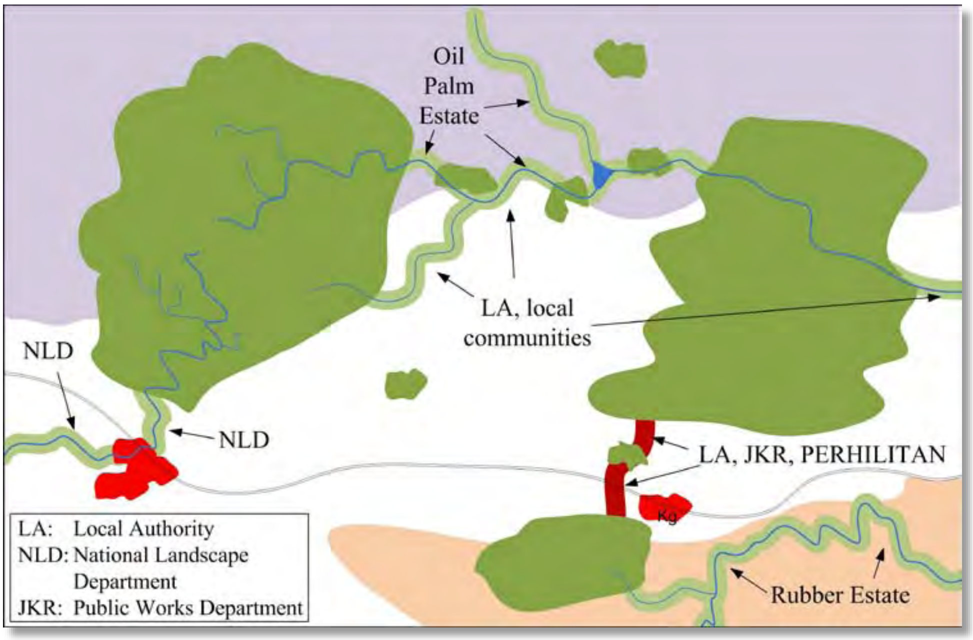



**Figure 41.** In addition to the key stakeholders indicated here, the interventions are coordinated with agencies which have management jurisdition over the various habitat patches.

Importantly, it is also linked into the various levels of the National Development Planning Framework and appears in Local, Structure and National Physical Plans.

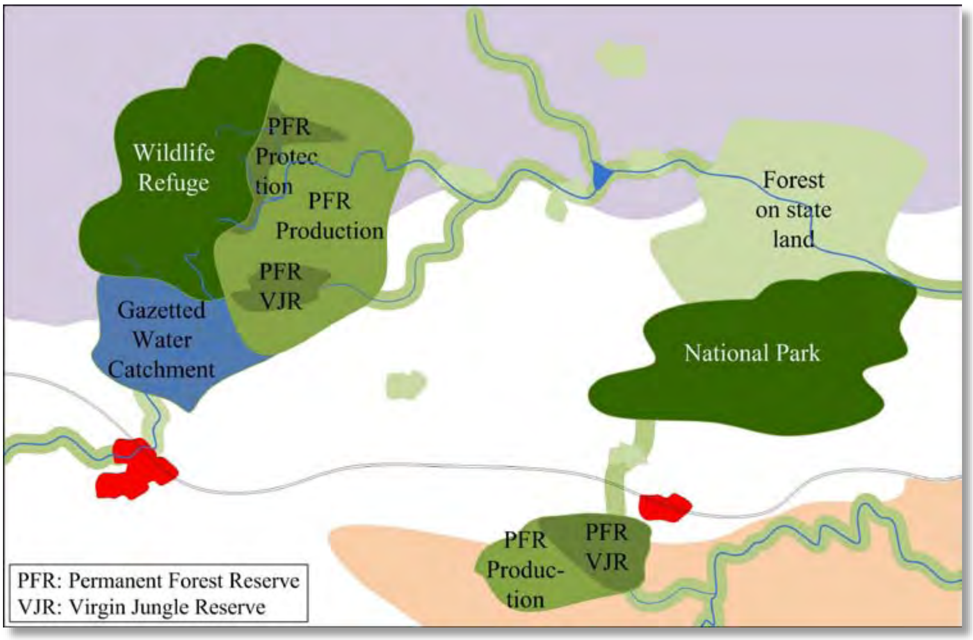



**Figure 42.** Remnant habitat patches may fall under different management authorities, but agencies apply norms and standards in pursuing overall national priorities for sustainable development.

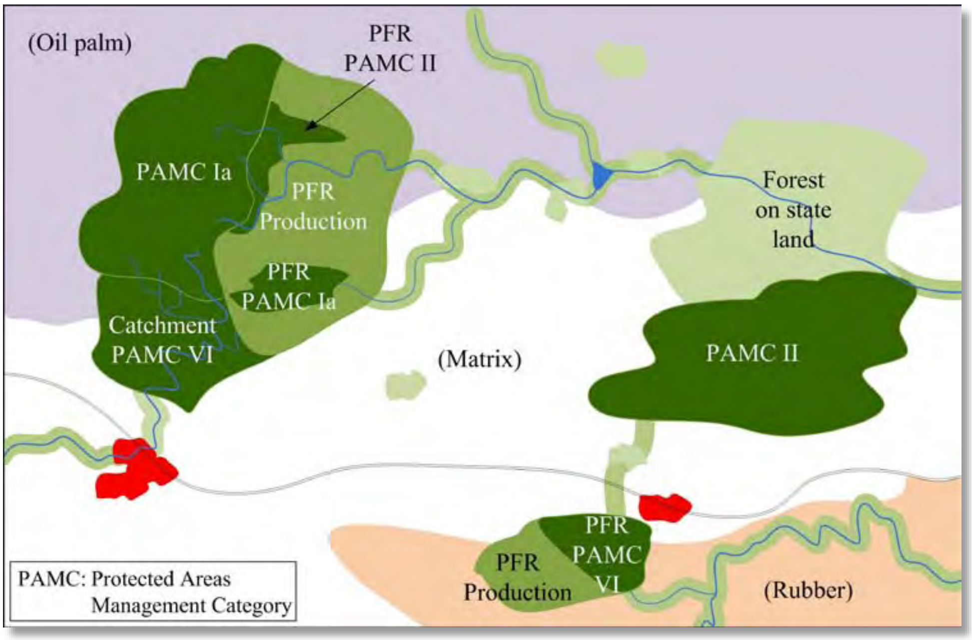



**Figure 43.** Several agencies contribute to a comprehensive Protected Areas System (i.e. dark green) which constitutes the core part of national biodiversity planning in support of sustainable ecosystem services. The result includes an estimated tripling of the total extent in Protected Areas (PAs) without gazetting any new sites.

PA Management Categories (PAMC) are needed to assess the extent to which individual PAs contribute to the System which has a bearing on the overall strategy and action plans.

## 4.5 Summary of complementary interagency actions

- Agricultural landscapes can be designed and managed to host wild biodiversity of many types (though not all), with neutral or even positive effects on agricultural production and livelihoods, through innovations in farming systems and in the spatial layout and management of natural areas within agricultural landscapes.
- A Protected Areas System is at the very core of such a strategy, but it is also clear that this measure alone cannot safeguard biodiversity's support for valuable ecosystem services. A broader perspective is required that integrates Protected Areas into landscape management.
- For each of the principles for managing biodiversity in the landscape (i.e. maintain connectivity; aquatic systems; habitat structural complexity; landscape heterogeneity; and manage disturbances) suitable management interventions have been defined together with key stakeholders, several of which already have embarked on highly compatible activities.
- The principles and management interventions represent a tangible entry point to implementation of the more comprehensive ecosystem approach.
- Managing diversity to safeguard ecosystem services requires diverse management interventions on behalf of multiple stakeholders. In the process we have to embrace complexity and an adaptive management style is our best approach to systematically test our assumptions, share information, adapt and learn.
- There are important ecological relationships and mutual interdependencies between agriculture, biodiversity and ecosystem services. Ecosystem services are key to unlocking the synergies between protecting biodiversity, sustainable agriculture and sustainable livelihoods.
- To meet the national aspiration of holistic and integrated planning of natural resource and biodiversity assets, planners and decision-makers will have to view resources in a broader context which goes beyond individual sectors to include all stakeholders in the decision process, while making use of the best science available.

# 5 Checklists

The checklists presented below aim to be a day-to-day reference for planners, decision-makers, and practitioners and should be considered the minimum required for mobilising complementary inter-agency actions in support of national goals for environmentally sustainable development.

## 5.1 Stakeholder participation in the National Biodiversity Planning Framework

The cyclic National Biodiversity Planning process is tied in to the release of new land use maps by the Department of Agriculture every three to five years.

A general checklist of key parties to the process is shown in **Table 6** and essentially corresponds to agencies, private sector and civil society which to a large degree influence the present and future landscapes of Malaysia.

**Table 6.** Stakeholder participation in key steps of National Biodiversity Planning Framework.

| Stage | Purposes / Interventions |
|---|---|
| 1 Biodiversity assessment | NRE (FDs, PAs, FRIM, DID, DMPM, DOE), DOA (land use), DoF, extensive land use systems, etc. |
| 2 Strategy and Action Plans | Same as (1) plus TCPD/TRP, JKR, NLD, State & Local Authorities, extensive land use systems, local communities, NGOs |
| 3 Implementation | Same as (2) |
| 4 Monitoring and evaluation | Cross-sectoral involving all parties |
| 5 Reporting | NRE with key stakeholders |

**Note:** FDs correspond to Forestry Departments Peninsular Malaysia, Sabah and Sarawak; PAs: PERHILITAN, Sabah Parks, Sabah Wildlife Department, Sarawak National Parks & Wildlife Division; TCPD refers to Town & Country Planning Departments in Peninsular Malaysia and Sarawak; and TRP to Town & Regional Planning Sabah; and DoF: Department of Fisheries. In addition to the agencies listed here, various universities and environment NGOs can contribute tremendously in making operational the management principles for terrestrial, freshwater and marine systems.

Whereas *No. 1 Biodiversity Assessment*[19] engages primarily natural resource agencies with respect to terrestrial, freshwater and marine biodiversity, *No. 2* broadens the participation to ensure that critical issues and priorities are synthesised into relevant Strategy and Action Plans. The distribution of stakeholders to Stages should not be considered rigid since experiences from elsewhere have demonstrated the benefits of engaging key parties early on and in all phases.

Importantly, local surveys and detailed knowledge about biodiversity, threatened species and so forth should feed into the assessment to ensure that generated information from all levels is capitalised upon and reflected in synthesis, strategies and action plans. Initially, detailed site data may be somewhat limited and overall assessment is more based on coarse scale thematic and tabular data, together with specialist knowledge about key aspects. However, with time the knowledge base expands and more and more synthesis will incorporate site-specific data.

Throughout the process NRE will act as a consultation and facilitation body.

## 5.2 Mainstreaming of biodiversity into PPPs

The Strategy, Action Plans and other elements of the National Biodiversity Planning process identifies critical issues, priorities, targets, criteria and indicators for monitoring, as well as an implementation plan for a five-year period.

These outputs are essential to guide the nation towards environmentally sustainable development and they relate directly to the National Development Planning Framework as summarised in **Table 7** with respect to key spatial features to be considered at each of the three planning levels.

**Table 7.** The use and integration of key spatial aspects of biodiversity planning with respect to the National Development Planning Framework.

| Planning Level | Planning Tools (PPPs) | Spatial elements from National Biodiversity Planning | Flow of data |
|---|---|---|---|
| 1 National | • Malaysian Plan(s)<br>• National Physical Plan<br>• Sectoral Policies/Plans<br>• National Biodiversity Strategy & Actions Plans (NSAPs) | • PA System design<br>• Overall network for habitat connectivity (riparian and other corridors)<br>• Critical habitats and other special issues identified<br>• Managing BioD in the landscape | ↑ Site specific data (incl. community)<br>↓ Overall synthesis, strategy, actions |
| 2 Regional/ State | • State Development Plans<br>• Regional/Structure Plans<br>• Sectoral Policies/Plans | • Integration with above / below<br>• Increased landscape level focus | |
| 3 Local Planning | • Local Plans<br>• Special Area Plans | • Integration with above<br>• Increased site specific focus | |

The key targets (and entry points) for the biodiversity mainstreaming process are stakeholders preparing, reviewing, or updating Policies, Plans and Programmes (PPPs).[68]

**Key Points**

Findings at any scale of multi-scale planning will be improved by information and perspectives from other scales resulting in overall better planning

As already mentioned above, the National Biodiversity Planning Framework integrates local knowledge about biodiversity to ensure that it is properly considered in the overall planning process (e.g. critical habitats, threatened species, and underrepresented habitat in the Protected Areas System).

To guide the process of cross-sectoral integration and mainstreaming of biodiversity, NRE is assuming the role of a consultation and facilitation body with outreach through a network of communicators which include its various line agencies, MENGO and private sector initiatives.

In addition to spatial features suggested in **Table 7**, national biodiversity planning should also address issues such as: biodiversity assessment in support of planning and decision-making[19]; benefit sharing / equitable access; institution building; and establishing an extensive programme for Communication, Education & Public Awareness – CEPA.

## 5.3 Stakeholder management of landscapes

The principles and management interventions for biodiversity conservation at landscape level and with reference to key stakeholders was shown in Table 5, p. 45, and it is reproduced here below.

It represents an overview of the crucial complementary activities that key parties can and should implement in order to achieve national goals for environmentally sustainable development.

**Table 5.** Principles, management interventions, and key stakeholders to safeguarding biodiversity, ecological processes, and ecosystem services in landscapes (with reference to key stakeholders; *Principles* and *interventions* based on Lindenmayer *et al*., 2006).

| How to build and maintain a resilient landscape | | *Note 1* |
|---|---|---|
| **Principles** | **Management strategy/interventions** | **Key stakeholders** |
| 1 Maintain connectivity | • Riparian and other corridors<br>• Protection of sensitive habitats within the matrix<br>• Vegetation retention on logged areas throughout the landscape<br>• Careful planning of road infrastructure<br>• Landscape reconstruction | FDs, PAs, DID, DOA, NLD, TCPD/TRP, JKR, State Authorities, extensive land use systems (oil palm/ rubber, etc.) |
| 2 Maintain integrity of aquatic systems | • Riparian and other corridors<br>• Protection of sensitive habitats within the matrix<br>• Mid-spatial-scale Protected Areas<br>• Spatial planning of cutover sites<br>• Increased rotation lengths<br>• Landscape reconstruction<br>• Careful planning of road infrastructure<br>• Use of natural disturbance regimes as templates | Same as No. 1 plus Departments of: Marine Park Malaysia; Fisheries; and Environment |
| 3 Maintain / build habitat structural complexity | • Use multiple (indigenous) species<br>• Retention of structures and organisms during (regeneration) harvest / rotation<br>• Habitat creation (e.g. undercropping; promotion of cavity-tree formation)<br>• Stand management practices<br>• Increased rotation lengths<br>• Use of natural disturbance regimes as templates | All |
| 4 Maintain landscape heteroge-neity | • Riparian corridors<br>• Protection of sensitive aquatic habitats<br>• Careful planning and maintenance of road infrastructure<br>• Midspatial scale Protected Areas within the matrix | All |
| 5 Manage disturbances | • Ensure that strategies are varied between different habitats and landscapes ('do not do the same thing everywhere') | All |

**Note 1:** FDs correspond to Forestry Departments Peninsular Malaysia, Sabah and Sarawak; PAs: PERHILITAN, Sabah Parks, Sabah Wildlife Department, Sarawak National Parks & Wildlife Division; TCPD refers to Town & Country Planning Departments in Peninsular Malaysia and Sarawak; and TRP to Town & Regional Planning Sabah. In addition to the agencies listed here, research institutions such as FRIM and various universities can contribute tremendously in making operational the management principles for terrestrial, freshwater and marine systems.

NRE will be preparing guidelines, factsheets, training events and other CEPA activities to further support implementation of activities.

## 5.4 Biodiversity in land use decisions

The following checklist should be considered a summary of issues that need to be factored in when making land use decisions from local to national scales.

The list is relevant for any government and private sector activities that have a bearing on natural resource and biodiversity assets. However, the list is also an excellent starting point for developing prescriptions for actions and monitoring of activities.

1) Examine the impacts of local decisions in a larger context (see also previous two Sections above).

2) Maintain large areas of protected native vegetation within the region, to serve as sources of species, individuals, and genes.

3) Apply the following landscape management principles and associated interventions (see further details in Section 3.3.1, p. 30):

    i) Maintain connectivity
    ii) Maintain the integrity of aquatic systems
    iii) Maintain habitat structural complexity
    iv) Maintain landscape heterogeneity
    v) Manage disturbances

4) For species and/or ecological processes which are insufficiently safeguarded by measures taken in (3), apply specific conservation strategies (see further details in Section 3.3.2, p. 36).

    i) Maintain key species
    ii) Maintain/apply appropriate disturbance regimes
    iii) Maintain species and habitats of particular concern
    iv) Control aggressive, overabundant, and invasive species
    v) Minimise ecosystem-specific threatening processes

5) Prevent further destruction, fragmentation, or degradation of native habitat within the agricultural landscape. Give priority to patches that are large, intact, and ecologically important.

6) Avoid land uses that deplete natural resources over a broad area.

7) Maintain landscape connectivity at multiple scales for as wide a group of plant and animal species as possible.

8) Actively manage the landscape to maintain heterogeneity at both the patch and the landscape level.

9) Minimize the introduction and spread of non-native species.

10) Use good management practices to make agricultural systems more compatible with biodiversity conservation.

11) Identify and address threats to the conservation of native habitats and biodiversity.

12) Restore areas of native habitat in degraded parts of the landscape and take marginal lands out of production allowing them to revert to native vegetation.

13) The five objectives to be achieved through the planning process are:

   i) *Protect* current habitats and species
   ii) *Enhance* existing habitats or create new areas
   iii) *Mitigate* against potentially damaging impacts
   iv) *Compensate* where damage is unavoidable (should only be needed in limited circumstances where the loss is fully justified, since recreating habitat is very difficult)
   v) *Monitor and enforce* to assess the success of enhancement and compensatory measures.

# Glossary

*Adaptive management:* The mode of operation in which an intervention (action) is followed by monitoring (learning), with the information being used at the time in designing and implementing the next intervention (acting again) to steer the system towards a given objective or to modify the objective itself.

*Agenda 21:* Is a programme run by the United Nations related to sustainable development at global, national and local levels in every area in which humans impact the environment. The number 21 refers to the 21st century. Agenda 21 called on all countries to introduce National Strategies for Sustainable Development (NSSDs).
www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm (Accessed 25 Sep 2008).

The Malaysian government announced in 2000 its intention to launch a national Local Agenda 21 program by year 2002. Today in Malaysia there is no published document formally representing a NSSD and Malaysian Plans are considered to include this fundamental aspect of societal development.

*Agricultural biodiversity:* is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes (COP decision V/5 www.cbd.int/decisions/?m=COP-05&id=7147&lg=0)

*Biodiversity:* The Convention on Biological Diversity (CBD) defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." A simpler definition is: "The variety of life on the planet. This includes the diversity within species, between species and of ecosystems."

*Biodiversity Action Plan:* (BAP) is an internationally recognised program addressing threatened species and habitats and is designed to protect and restore biological systems. The original impetus for these plans derives from the 1992 Convention on Biological Diversity (CBD). As of 2008, 189 countries have ratified the CBD, but only a fraction of these have developed substantive BAP documents. The principal elements of a BAP typically include: (a) preparing inventories of biological information for selected species or habitats; (b) assessing the conservation status of species within specified ecosystems; (c) creation of targets for conservation and restoration; and (d) establishing budgets, timelines and institutional partnerships for implementing the BAP. (Wikipedia, accessed 14 July 2008).

*Biome:* Biomes are climatically and geographically defined areas of ecologically similar climatic conditions such as communities of plants, animals, and soil organisms, and are often referred to as ecosystems. Biomes are defined by factors such as plant structures (e.g. trees, shrubs, and grasses), leaf types (e.g. broadleaf and needles), plant spacing (forest, woodland, savanna), and climate. (Wikipedia, accessed 22 April 2009).

*Biota:* The combined flora and fauna of a region.

*Biotic:* Has to do with life or living organisms.

*Cascading effect:* in ecology is a series of secondary extinctions that is triggered by the primary extinction of a key species in an ecosystem. Secondary extinctions are likely to occur when the threatened species are: dependent on a few specific food sources, mutualistic (dependent on the key species in some way), or forced to coexist with an invasive species that is introduced to the ecosystem (Wikipedia, accessed 14 July 2008).

*Catchment:* is a topographical sub-division of a *Watershed* and may drain to a point on a river network, river segment or to water bodies (e.g. lakes, dams, wetlands). See Figure 23, p. 22. In Malaysia the term *catchment* or *water* *catchment* is often associated with gazetted Water Catchment Reserve established to ensure a sustainable supply of freshwater. See also *Drainage area.*

*Community:* in biology refers to a group of interacting organisms sharing an environment.

*Connectivity:* refers to the linkage of habitats, communities (see its definition) and ecological processes at multiple spatial and temporal scales.

*Corridor:* Regions of the landscape that facilitate the flow or movement of individuals, genes, and ecological processes.

*Critically endangered:* See *Threatened species*

*Data Deficient:* See *Threatened species*

*Development goals:* See *Millennium Development Goals*

*Drainage area:* is all of the area from which a river collects the water that runs in it. Rain falling within a *River basin* (or *Watershed* or *Catchment*) will run downhill until it reaches a stream. Small streams join other streams and eventually flow into a river and eventually that river flows into the sea. Each large river is made up of many smaller rivers and streams. See Figure 23, p. 22.

*Driver of change:* The Millennium Ecosystem Assessment (MA, 2005) defines a *driver* as "any natural or human-induced factor that directly or indirectly causes a change in an ecosystem." A *direct driver* unequivocally influences ecosystem processes. An *indirect driver* operates more diffusely, by altering one or more direct drivers. Categories of *indirect drivers* of change are: demographic, economic, socio-political, scientific and technological, and cultural and religious. Important *direct drivers* include: land conversion leading to habitat change, climate change, nutrient pollution, overexploitation, and invasive species and diseases.

*Ecoagriculture:* explicitly recognises the economic and ecological relationships and mutual interdependence among agriculture, biodiversity and ecosystem services. Ecoagriculture landscapes are mosaics of areas in natural/native habitat and areas under agricultural production. Effective ecoagriculture systems rely on maximising the ecological, economic and social synergies among them, and minimizing the conflicts.

*Ecological footprint:* The area of productive land and aquatic ecosystems required to produce the resources used and to assimilate the wastes produced by a defined population at a specific material standard of living, wherever on Earth that land may be located.

*Ecology:* The science of the relationships between organisms and their environments.

*Ecosystem:* A dynamic complexity of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (Article 2 of the Convention on Biological Diversity).

*Ecosystem approach:* has been defined as *a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way*. Its implementation is based on 12 principles and a 5-point operational guidance (www.cbd.int/ecosystem/operational.shtml), which may be complemented with the IUCN's *Five steps to implementation of the ecosystem approach*. (www.iucn.org/dbtw-wpd/edocs/CEM-003.pdf) (Both accessed 6 May 2008).

*Ecosystem degradation:* occurs when alteration to an ecosystem degrade or destroy habitat for many of the species that constitute the ecosystem.

*Ecosystem loss:* happens when the changes to an ecosystem are so profound and when so many species, particularly those that dominate the ecosystem, are lost that the ecosystem is converted to another type (e.g. deforestation and draining of wetlands).

*Ecosystem services:* The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual and recreational benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services. Modern land use practices, while increasing the short-term supplies of material goods, may undermine many ecosystem services in the long run – even on regional and global scales (see Foley*, et al*., 2005).

*Endangered:* See *Threatened species*

*Endemic:* means native to a specific region or environment and not occurring naturally anywhere else.

*Extinct:* See *Threatened species*

*Extinct in the Wild:* See *Threatened species*

*Focal species:* A term used for the species identified as being most sensitive to a threat in the landscape.

*Folivore:* Is an animal which specialises in eating predominantly leaves. Examples include: sloths, possums, various species of monkeys and apes.

*Geomorphological:* is the study of the evolution and configuration of landforms.

*Habitat:* is the physical and biological environment used by an individual, a population, a species, or perhaps a group of species.

*Habitat degradation:* is the process by which habitat quality for a given species is diminished. When habitat quality is so low that the environment is no longer usable by a given species, then *habitat loss* has occurred.

*Keystone species:* is a species that has a disproportionate effect on its environment relative to its abundance. Such species affect many other organisms in an ecosystem and help to determine the types and numbers of various others species in a community. An organism of this kind plays a role in its ecosystem that is analogous to the role of a keystone in a Roman arch. While the keystone feels the least pressure of any of the stones in an arch, the arch still collapses without it. Similarly, an ecosystem may experience a dramatic shift if a keystone species is removed, even though that species was a small part of the ecosystem by measures of biomass or productivity.

*Landscape:* is a territory that is characterized by a particular configuration of topography, vegetation, land use, and settlement pattern that delimits some coherence of natural, historical, and cultural processes and activities. A landscape is best delineated functionally — that is, within the context of a particular issue or problem. It may also be defined as a large-scale mosaic of ecosystems often consisting of a *matrix* with *patches* (small ecosystems) imbedded within it.

*Landscape models:* In conservation biology two models have been used to conceptualise landscapes: (i) the patch-corridor-matrix (Forman, 1995); and (ii) the landscape continuum model (McIntyre and Hobbs, 1999). The two models differ in their relative emphasis. In the patch-corridor-matrix model, landscapes are viewed as varying mosaics of different types of patches and corridors. In the landscape continuum model, landscapes are characterized by having different levels of vegetation cover with a continuum or gradient of possible conditions that range from an intact cover of native vegetation through to relictual levels of cover. The focus of the patch-corridor-matrix model is on the form or structure of landscapes, whereas the landscape continuum model emphasizes the function of a landscape across varying structural gradients of vegetation cover. Simultaneous consideration of both models is useful because it can lead to greater awareness of the range of conditions that occur in real landscapes and, in turn, the diversity of responses to such varying conditions by different biota. Both models have limitations. In particular, landscapes are usually treated (intentionally or otherwise) in very simple terms as having two components – patches (habitat) and remaining land (non-habitat). Real landscapes are more complex than this. Such complexity matters – particularly when attempting to predict the response of species to landscape modification.

*Landscape matrix:* The intervening area among a set of habitat fragments. Also the spatial array of habitats across a landscape.

*Least Concern:* See *Threatened species*

*Mainstreaming:* of biodiversity refers to a process which ensures that biodiversity issues, concerns and priorities are considered during the preparation, updating and implementation of Policies, Plans and Programmes (PPPs). By mainstreaming biodiversity into PPPs we recognize the crucial role that biodiversity has for human livelihood and society in general. See further details in Chapter 6 of the Common Vision on Biodiversity (NRE, 2008a).

*Matrix:* comprises landscapes that are not designated primarily for conservation of natural ecosystems, ecological processes, and biodiversity regardless of their current condition (i.e. whether natural or developed).

*Matrix management:* The term refers to approaches to conserve biodiversity in habitat outside a Protected Areas System.

*Millennium Development Goals:* The Millennium Development Goals (MDGs) were developed out of the eight chapters of the United Nations Millennium Declaration, signed in September 2000. The eight goals and 21 targets include

1. Eradicate extreme poverty and hunger
    - Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day.
    - Achieve full and productive employment and decent work for all, including women and young people.
    - Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
2. Achieve universal primary education
    - Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.
3. Promote gender equality and empower women
    - Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015.
4. Reduce child mortality
    - Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate.
5. Improve maternal health
    - Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.
    - Achieve, by 2015, universal access to reproductive health.
6. Combat HIV/AIDS, malaria, and other diseases
    - Have halted by 2015 and begun to reverse the spread of HIV/AIDS.
    - Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it.
    - Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.
7. Ensure environmental sustainability
    - Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources.
    - Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss.
    - Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation (for more information see the entry on water supply).
    - By 2020, to have achieved a significant improvement in the lives of at least 100 million slum-dwellers.
8. Develop a global partnership for development
    - Develop further an open trading and financial system that is rule-based, predictable and non-discriminatory. Includes a commitment to good governance, development and poverty reduction - nationally and internationally.
    - Address the special needs of the least developed countries. This includes tariff and quota free access for their exports; enhanced programme of debt relief for heavily indebted poor countries; and cancellation of official bilateral debt; and more generous official development assistance for countries committed to poverty reduction.
    - Address the special needs of landlocked and small island developing

States.

- Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.
- In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries.
- In cooperation with the private sector, make available the benefits of new technologies, especially information and communications.

See further information at http://en.wikipedia.org/wiki/Development_goals (Accessed 29 Apr 09).

*Millennium Ecosystem Assessment:* (MA) is the most comprehensive survey ever into the state of the planet. It was drawn up by 1,360 researchers from 95 nations over four years from 2001 to 2005. The MA is slightly different to all previous environmental reports in that it defines ecosystems in terms of the "services", or benefits, that people get from them. The findings provide a state-of-the-art scientific appraisal of the conditions and trends of the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably.

It reports that humans have changed most ecosystems beyond recognition in a dramatically short space of time. Some 63% of the ecosystem services that support life on Earth – such as fresh water, capture fisheries, air and water regulation, and the regulation of regional climate, natural hazards and pests – are being degraded or used unsustainably. Scientists warn that the harmful consequences of this degradation could grow significantly worse in the next 50 years. The MA observed that *ecosystem approaches* provide an important framework for assessing biodiversity and ecosystem services, and for evaluating and implementing potential responses.

See further at www.millenniumassessment.org/en/index.aspx

*Near Threatened:* See *Threatened species*

*Niche:* is the particular area within a habitat occupied by an organism, or the function or position of an organism or population within an ecological community.

*Not Evaluated:* See *Threatened species*

*Paradigm:* A set of assumptions, concepts, values, and practices that constitutes a way of viewing reality.

*Patch:* Landscapes may be considered composed of a mosaic of patches which refer to habitat fragments as the basic elements or units that make up a landscape. Patches are dynamic and occur on a variety of spatial and temporal scales. Thus, a landscape does not contain a single patch mosaic.

*Patch-corridor-matrix:* See *Landscape models*.

*River basin:* is a topographical area which drains directly into the sea. It is typically identified as the main area for coordinated water management. It can be considered as consisting of *Watersheds* which again are subdivided into *Catchments*. See also *Drainage area.*

*Run-off:* Water that flows over the land surface.

*Snag:* is a dead tree that is still standing. Snags provide important food and cover for a wide variety of wildlife species.

*Stand:* Term used in forestry to denote a group of trees of sufficiently uniform species composition, age, and condition to be considered a homogeneous unit for management purposes.

*Stepping stone:* is a small patch providing part of linkage between habitat fragments. It may be considered intermediate in connectivity between a corridor and no corridor, and hence intermediate in providing for movement of interior species between patches.

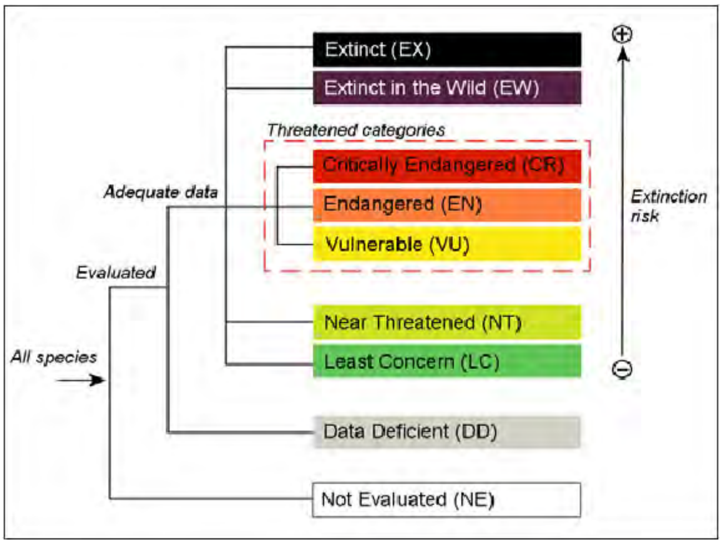
*Taxon:* A taxon (plural: taxa) is a group of (one or more) organisms, which a taxonomist adjudges to be a unit. Usually a taxon is given a name and a rank, although neither is a requirement. Defining what belongs or does not belong to such a taxonomic group is done by a taxonomist. (Wikipedia accessed 23 Apr 09).

*Taxonomic:* see Taxonomy

*Taxonomy:* is the practice and science of classification. Typically this is organised in a hierarchical structure. For example, car is a subtype of a vehicle.

*Threatened species*: For more than forty years, the World Conservation Union – IUCN – has been maintaining the *IUCN Red List of Threatened Species*. The Red List Categories are as shown in the figure to the right and detailed below (Based on IUCN 2008, *Guidelines for using the IUCN Red List Categories and Criteria, v. 7.0 Aug 2008*).

Structure of Red List Categories (Figure to the right, from the 2008 *Red List - a conservation tool* (http://cmsdata.iucn.org/downloads/the_iucn_red_list_a_key_conservation_tool.pdf, accessed 23 Apr 09).




The details of threatened species categories are:

**Extinct (EX)**

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycles and life form.

**Extinct in the wild (EW)**

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

**Critically endangered (CR)**

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.

**Endangered (EN)**

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.

**Vulnerable (VU)**

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

**Near threatened (NT)**

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically

Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

**Least concern (LC)**

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

**Data deficient (DD)**

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data

Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information

is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

**Not evaluated (NE)**

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

*Trophic:* Of or involving the feeding habits or food relationship of different organisms in a food web (or chain).

*Vulnerable:* See *Threatened species*

*Watershed:* is a topographical sub-division of a river basin and may drain to a point on a river network, river segment or to water bodies (e.g. lakes, dams, wetlands). It is subdivided into *Catchments*. See Figure 23, p. 22. See also *Drainage area.*

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# Endnotes

[1] See NRE, 2009a.

[2] See NRE, 2008a.

[3] *Time* and *space* is also often referred to as *temporal* and *multiple scale* aspects. Examples of *time* include the adaptation of coastal life forms to the changing tides; and the seasonal migration of birds. *Space* is represented in the Figure with an increased scale from the centre to (i.e. genes) to the perimeter (i.e. landscapes). In cells, genes consist of a long strand of DNA with an approximate diameter of 1 nanometre, 10,000 of which would make up the width of a human hair. At the other extreme, landscapes may be depicted in scales ranging from 1:10,000 to one to several millions (i.e. in a 1:1,000,000 map, one centimetre would correspond to 1,000,000 centimetres in real life – which is 10 kilometres).

[4] What is also important here is that functional traits and species interaction are at the core of what provides ecosystem functioning and resilience.

[5] Another example is the temperate succesional stages in vegetation after the last glacial period where different species moved in from grass to different forest types representing *community turnover* eventually resulting in extensive oak forests.

[6] The 2008 update of The IUCN Red List includes 44,838 species, of which (see the Glossary for the terms used):

- 869 (2%) are 'Extinct' or 'Extinct the Wild'.
- 16,928 (38%) are threatened with extinction (with 3,246 'Critically Endangered', 4,770 'Endangered' and 8,912 'Vulnerable');
- 3,513 (8%) are 'Near Threatened'
- 5,570 (12%) have insufficient information to determine their threat status ('Data Deficient').

The number of extinctions might well exceed 1,100 if the 257 Critically Endangered species tagged as Possibly Extinct are considered.

The 2008 IUCN Red List update includes:

- A complete reassessment of the world's mammals, showing that nearly one-quarter (22%) of mammal species are globally threatened or Extinct, and 836 (15%) are Data Deficient.
- The addition of 366 new amphibians, many listed as threatened, and the confirmed extinction of two additional species, reaffirming the extinction crisis faced by amphibians; nearly one-third (31%) are threatened or Extinct and 25% are Data Deficient.
- A complete reassessment of the world's birds indicates that one in seven (14%) are threatened or Extinct; birds are one of the best-known groups with less than 1% Data Deficient.
- 845 species of warm-water reef-building corals have been added to the Red List, with more than one-quarter (27%) listed as threatened and 17% as Data Deficient.
- All 161 grouper species; over 12% are threatened with extinction because of unsustainable fishing; a further 30% are Data Deficient.
- All 1,280 species of freshwater crab, 16% of which are threatened with extinction, but 49% are Data Deficient.

[7] Among other considerations:

The National Policy on Biological Diversity (NPBD) states:

- p. 14: "There is no single comprehensive legislation in Malaysia which relates to biological diversity conservation and management as a whole. Much of the legislation is sector-based."

The National Policy on the Environment states:

- §5.1, p. 29: "All policy-making mechanisms in government for addressing issues related to environment and development will be streamlined and coordinated for effective and efficient implementation,

monitoring and feedback".
- §5.2, p. 29: "Environment-related legislation and standards shall be reviewed regularly and revised where necessary to ensure the continued effectiveness and coordination of laws. Particular attention will be paid to effective enforcement.
- §5.3, p. 30: "Ministries and government agencies will be encouraged to establish mechanisms to ensure that environmental considerations are integrated into their development projects and activities".

The 3rd Outline Perspective Plan 2001-2010
- §1.80 "During the OPP3 period, emphasis will be placed on addressing environmental and resource issues in an integrated and holistic manner..."
- §1.81 "…The National Biodiversity Policy will form the basis for integrating and consolidating biodiversity programmes and projects in the country…."

8 See further details in Section 2.4, p. 5, and Annex 1 in *a Common Vision on Biodiversity* (NRE, 2008a).

9 Vision 2020: "…we must also ensure that our valuable natural resources are not wasted. Our land must remain productive and fertile, our atmosphere clear and clean, our water unpolluted, our forest resources capable of regeneration, able to yield the needs of our national development."

National Vision Policy (NVP) 2001 – 2010: It has defined seven critical thrusts, of which one is "pursuing environmentally sustainable development to reinforce long-term growth." (OPP3, Chapter 1.14).

OPP3 (2001-2010): informs to be based on NVP (i.e. "pursuing environmentally sustainable development"). The OPP3 is one of few policies clearly referring to other policies in specifically stating that: §181 "The National Biodiversity Policy will form the basis for integrating and consolidating biodiversity programmes and projects in the country."

National Policy on Biological Diversity (1998): has the policy statement: "To conserve Malaysia's biological diversity and to ensure that its components are utilised in a sustainable manner for the continued progress and socio-economic development of the nation." A number of provisions set out how to go about it.

National Policy on the Environment (2002): is based upon eight principles which are all related to environmentally sustainable development.

9th Malaysian Plan (2006-2010): Chapter 22.02, p. 453: "For the Ninth Plan, in line with the ninth principle of *Islam Hadhari* [i.e. "Safeguarding the environment"], environmental stewardship will continue to be promoted to ensure that the balance between development needs and the environment is maintained. Greater focus will be placed on preventive measures to mitigate negative environmental effects at source, intensifying conservation efforts and sustainably managing natural resources."

National Physical Plan (2005): Objective (ii): "To optimise utilisation of land and natural resources for sustainable development".

10 National Policy on Biological Diversity, p. 6, §17- §20; National Policy on the Environment, p. 5; 9th Malaysian Plan: §22.02; National Physical Plan: Objective IV, P4.

11 OPP3: §1.80 "… These approaches will, among others, be geared towards addressing the challenges of providing access to clean water, providing adequate food without excessive use of chemicals, using more organic fertilizers, providing energy services without environmental degradation, developing healthy urban environments, and conserving critical natural habitats and resources."

National Policy on Biological Diversity (1998): (§4, p. 10) "Very little of the lowland dipterocarp forests, the largest reservoir of genetic variation of terrestrial flora and fauna, remain and these require total protection, as do the remaining swamp and mangrove forests."

National Policy on the Environment (2002):

"Second Principle – Conservation of Nature's Vitality and Diversity: Conserve natural ecosystems to ensure integrity of biodiversity and life support systems"

"Green Strategy 2 – Effective Management of Natural Resources and the

Environment."

§2.1 "A national inventory and audit of environment and natural resources will be maintained and regularly updated, with particular emphasis on depletion and renewability, to serve as a guide to policy formulation and decision-making. Appropriate environmental monitoring systems shall be established to facilitate the evaluation of programmes and projects".

With §2.1 in place it will be fairly straightforward to achieve the following paragraph.

§2.2 "Natural resource areas, particularly those containing biologically rich habitats and ecosystems will be established and maintained as zones for the conservation and protection of indigenous flora and fauna and genetic resources"

9th Malaysian Plan (2006-2010):

§22.20 "…The strategic thrusts for addressing environmental and natural resources issues will focus on [here only referring to two out of six thrusts]:

- Promoting a healthy living environment
- Utilising resources sustainably and conserving critical habitats"

§22.30 "*Biodiversity*. Efforts will be intensified to protect critical habitats. Towards this end, existing management plans will be reviewed to further strengthen the protection of threatened flora and fauna…"

National Physical Plan (2005): Chapter 5.6: "Although these PA already comprise various habitats/ecosystems, the distribution of reserves reveals that some habitats/ecosystems are seriously under-represented, namely wetlands and lowland dipterocarp forests. Moreover, despite these PA being gazetted, there are provisions that allow degazettement for short-term economic uses".

NPP20: "Sensitive coastal ecosystems shall be protected and used in a sustainable manner".

12 National Policy on Biological Diversity (1998):

Strategy 5, Action 1: "Expand the network of in-situ conservation areas to ensure full representation of ecosystems and all ecological processes therein."

National Policy on the Environment (2002): See comments under Endnote 11 which (paraphrased) state that "conservation and protection" should include "rich habitats and ecosystems".

National Physical Plan (2005): NPP18, IP8: Environmental Sensitive Areas (measures): (v) "The Protected Areas (PA) network shall be enlarged to include a full representation of the diversity of natural ecosystems, particularly the lowland dipterocarp forests and wetlands…."

13 OPP3: §1.81 "…Steps will be taken to formulate integrated river basin management plans to improve water quality and supply as well as manage water resources. To ensure sustainability of coastal resources, integrated coastal management plans will be introduced in all states."

National Policy on Biological Diversity (1998):

Strategy 10, Action 1: "Identify major sources of biological diversity loss such as forest damage or degradation, overfishing, pollution of marine resources, development that disrupts primary forest or catchment areas, destruction of mangrove areas and coral reefs, and act to minimise these sources."

National Policy on the Environment (2002): §2.7 "For river basin management and related development projects, specific procedures for planning, including beneficial-use classification, coordination, and monitoring measures, shall be incorporated to ensure sustainability."

9th Malaysian Plan (2006-2010):

§22.22 "*Water Quality*. The utilisation of the integrated river basin management (IRBM) approach will be intensified to improve river and groundwater quality…"

National Physical Plan (2005):

NPP30, IP14: Water Resources and Water-Stressed Areas (Measures): (iii) "Integrated Water Resource Management (IWRM) and Integrated River Basin Management (IRBM) are to be adopted as input of land use planning".

Chapter 2.3 Principles, P8 Avoid disrupting ecological stability: "…. Water resource management based on the concept of Integrated River Basin Management (IRBM) should be exercised".

[14] OPP3:

§1.80 "During the OPP3 period, emphasis will be placed on addressing environmental and resource issues in an integrated and holistic manner. …"

§1.81 "…The National Biodiversity Policy will form the basis for integrating and consolidating biodiversity programmes and projects in the country…"

National Policy on Biological Diversity (1998):

§22, p.15. "Having ratified the Convention on Biological Diversity on 24th June 1994, Malaysia must incorporate into the national policy the set of commitments under the treaty. The Convention reaffirms the sovereign rights of States over their biological resources and their responsibility for conserving their biological diversity and utilizing the biological resources in a sustainable manner. To achieve the above, they must develop national strategies, plans or programmes. As far as possible and where appropriate, these must be integrated into sectoral or cross-sectoral plans, programmes and policies."

Strategy 6: Integrate Biological Diversity Considerations Into Sectoral Planning Strategies: "Ensure that all major sectoral planning and development activities incorporate considerations of biological diversity management."

Strategy 2, Action 3: "Ensure the development of sectoral and cross-sectoral policies, plans and programmes which integrate considerations of biological diversity conservation and sustainable use".

Strategy 6, Actions 1 to 7: Include extensive provisions for cross-sectoral integration; analysis of plan/strategy on biodiversity; review of sector PPPs; incorporation of biodiversity into long-term and medium-term plans; efficient dissemination of relevant information; etc.

National Policy on the Environment (2002):

"Green Strategy 3 – Integrated Development Planning and Implementation: Environmental considerations will be integrated into all stages of development, programme planning and implementation and all aspects of policy making."

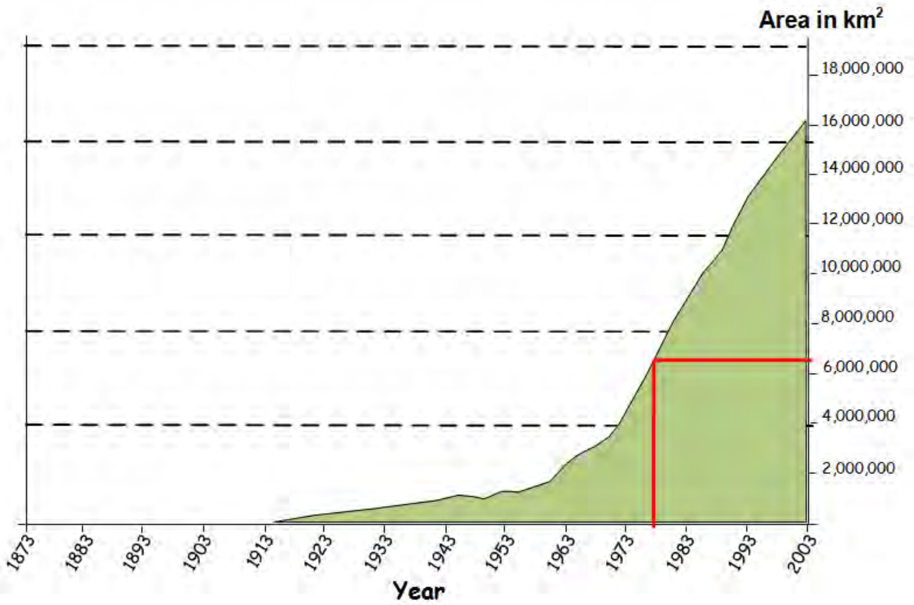
§3.1 to §3.5: Include extensive provisions for integrated development planning by mainstreaming of biodiversity and environment into plans at all levels. It also states that "a national natural resource accounting system will be devised and implemented to ensure a balanced perspective of the role of environment and natural resources in relation to overall development plans and strategies". Moreover, "environmental considerations will be integrated into policies, programmes, plans and project formulation as well as implementation, through a comprehensive assessment process, taking into account social, ecological and health effects." Finally, it establishes the also important need to make linkages to different spatial scales to ensure that both economic as well as environmental protection objectives are met.

9th Malaysian Plan (2006-2010): §22.02 "…Emphasis will be given to the fostering of closer cooperation between stakeholders in addressing environmental concerns. Environmental planning tools such as environmental impact assessments (EIA), strategic environmental assessments (SEA), cost-benefit analysis, market-based instruments and environmental auditing will be increasingly applied in evaluating and mitigating environmental impacts of development activities."

National Physical Plan (2005): implicit measure to take for Environmental Sensitive Areas.

[15] Costanza *et al.*, 1997.

[16] During the last quarter of a century both the number and the extent of Protected Areas (PAs) have increased significantly. Thus, the area of PAs in 1978 was almost 7 million km$^2$ but had grown to more than 16 million km$^2$ in 2003 – some 2.3 times 25 years later (see Figure below).




Growth of global Protected Areas over time (Note: 38 427 PAs covering approximately 4 million km2 have no date and are not included in the cumulative graph.) Redrawn from Chape *et al*., 2005.

However, based on a comprehensive global gap analysis undertaken by Conservation International in 2003, it was concluded that "the degree to which biodiversity is represented within the existing network of protected areas is unknown" (reported in Chape *et al*., 2005). In order to assess if biodiversity objectives are achieved the location, design and effectiveness of an overall PA System, as well as individual PAs, will have to be reviewed.

17 By comparing the altitudinal distribution of 171 forest plant species between 1905 and 1985 and 1986 and 2005 along the entire elevation range (0 to 2600 meters above sea level) in west Europe, researchers have found that climate warming has resulted in a significant upward shift in species optimum elevation averaging 29 meters per decade. The shift is larger for species restricted to mountain habitats and for grassy species, which are characterized by faster population turnover. The study shows that climate change affects the spatial core of the distributional range of plant species, in addition to their distributional margins, as previously reported.
www.sciencemag.org/cgi/content/abstract/320/5884/1768?hits=10&RESULTFORMAT=&FIRSTINDEX=0&maxtoshow=&HITS=10&fulltext=lenoir&searchid=1&resourcetype=HWCIT (Accessed 28 Apr 09).

18 An assessment of trends in land use changes for states in Peninsular Malaysia has been done in the so-called "Master Plan" for the period 1974 to 1990 (see Table below).

| **Land use - Peninsular Malaysia** (in %) | | | | **% Change** |
|---|---|---|---|---|
| | **1974** | **1982** | **1990** | **1974-1990** |
| Forest | 55 | 50.3 | 47.4 | **-7.6** |
| Rubber | 14.5 | 15.2 | 14.8 | 0.3 |
| Oil palm | 3.7 | 8.3 | 12.1 | **8.4** |
| Swamps | 8.1 | 7.6 | 6.8 | **-1.3** |
| Scrub | 3.8 | 3.3 | 3.6 | -0.2 |
| Urban areas | 0.6 | 1 | 1.3 | 0.7 |
| Cleared land | 2.6 | 1.9 | 1.2 | **-1.4** |
| Mixed horticulture | 1.7 | 1.9 | 2.1 | 0.4 |
| Coconut | 1.4 | 1.5 | 1.5 | 0.1 |
| Padi | 3.1 | 3.2 | 3.2 | 0.1 |
| Unimproved pasture, scrub, grass | 1.7 | 1.5 | 1.3 | -0.4 |
| Roads, rivers, canals, etc. | 1.1 | 1.3 | 1.7 | 0.6 |
| Other uses | 2.5 | 3 | 3.1 | 0.6 |
| **Total** | **100** | **100** | **100** | 0 |

Based on data from the Department of Agriculture Malaysia (DWNP, 1996).

Ignoring only minor changes, it is clear from the Table that for the 16-year period in question oil palm plantations is the only land use system which shows a

significant increase of 8.4% while forests have been reduced with an almost equal extent. In the period covered also swamps were reduced with 1.3%. Land cleared for urban, industry and infrastructure were reduced 1.4%.
A new assessment of status and trends since 1990 is urgently required.

[19] The *Biodiversity Assessment and Mapping Methodology* from the Australian Environmental Protection Agency, Queensland, provides an excellent and consistent approach for assessing landscape level biodiversity values – even when limited data is available (see EPA, 2002). For similar excellent methodology for aquatic biodiversity assessment, see Clayton *et al*., 2006.

[20] There is an estimated nearly 300,000 plant species of which roughly 85% have been described. Of the known plants only 4% have had their conservation status assessed. Producing conservation assessments for the remaining 96% within a reasonable timeframe is not possible. However, the need for a broader view of the status of biodiversity is urgent (Collen *et al*., 2008, The 2008 Review of The IUCN Red List of Threatened Species).

[21] Collen *et al.*, 2008.

[22] From www.iucnredlist.org/documents/2008RL_stats_table_5_v1223294385.pdf, accessed 23 Apr 2009.

[23] Importantly, biodiversity planning for decision-support should not be confused with the exercise of biodiversity inventory – as typically carried out by some sector agencies (e.g. PERHILITAN), research institutions (e.g. FRIM), and universities. The main differences are shown in the table below.

| | Biodiversity Planning | BioD Inventory |
|---|---|---|
| Primary audience | Decision-makers, planners, inter-agency | Scientific community |
| Focus | High-level, strategic (PPP), decision-centred | Detailed, descriptive |
| Level | Ecosystem, landscape | Site specific |
| Scales | Fed/Reg/State/Local | Small |
| Time horizon | Short, medium, long | Present |
| Features | Quantitative, qualitative | Quantitative |
| Assessment framework | Strategic Environmental Assessment - SEA | Environmental Impact Assessment - EIA |

[24] MOSTE, 1997.

[25] MOSTE, 1998.

[26] Landscapes can be classified using: *structural attributes* (i.e. the amount and configuration of vegetation); *habitat for a particular species* (e.g. in an effort to reverse the status of threatened species and/or ensure the permanence of keystone species); and *functional attributes or landscape processes* (i.e. flow of energy, water and nutrients). Applying the patch-corridor-matrix model to classify landscapes obviously represents a simplification which may not capture many important aspects of landscapes.

Landscape classification is challenging because:

1. Landscapes are dynamic and characterized by compositional (structural) attributes and process (functional) attributes, such as flows of energy, water and nutrients.
2. Maps are the usual translation of a landscape into a classification and while they capture compositional attributes reasonably well, they have rarely been used to represent processes or flow paths, particularly those that are continuous entities or gradients.
3. in general are today rarely used to support policy formulation and
4. There are many ways of perceiving the same landscape and – undoubtedly – organisms perceive it differently from humans. In this Guideline we emphasise simplicity over complexity.
5. Different problems and objectives may require different classifications, even in the same landscape. A classification to guide an organism-

specific research programme will likely differ from one needed by a Town & Country Planning Department.

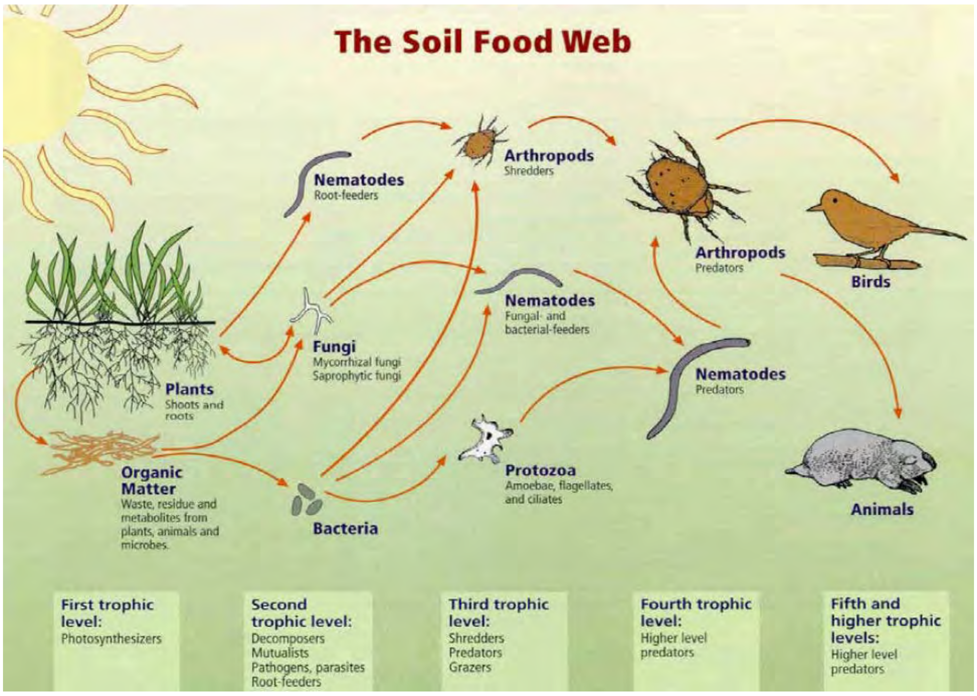
The importance of classification and conceptual models is overlooked by many researchers, planners and decision-makers, and practitioners who seem unaware of interrelationships among themes such as fragmentation, increased isolation of habitat elements, patch size and shape in relation to edge effect, and connectivity. A further complication is the need to consider such aspects at various scales and over time to illuminate the linkages between the status of ecosystems, their resilience and the supply of ecosystem services.

Maps and their analytical products are essential for data driven policy formulation which will lead to enhanced physical planning while safeguarding ecosystem processes and services.

[27] For further information on Protected Areas and a Protected Areas System see the *Common Vision on Biodiversity* (Reference Document) Chapter 4, p. 15. (NRE, 2008a).

[28] The Conference of the Parties to the Convention on Biological Diversity (CBD) identified soil biodiversity as an area requiring particular attention. See www.cbd.int/doc/meetings/sbstta/sbstta-10/official/sbstta-10-14-en.pdf (Accessed 2 May 2008).
The European Commission adopted in September 2006 a Thematic Strategy for Protection of Soil (http://ec.europa.eu/environment/soil/index.htm) with the objective of preventing further soil degradation, preserving soil functions and restoring degraded soils to a level of functionality consistent at least with current and intended use. The strategy identifies a certain number of soil degradation processes, including the loss of soil biodiversity that should be prevented and minimised to the extent possible. It also underlines that there is little public awareness of the importance of soil protection.

(Continued on the following page)




Simplified soil food web. Energy and nutrients are transferred from one 'trophic' level to the next. There is a continuous movement of material from all levels back to the pool of organic matter (from http://eusoils.jrc.ec.europa.eu/library/themes/biodiversity).

[29] This is a simplification. High species diversity does not necessarily entail high ecosystem resilience or vice versa, and species-rich areas may still be highly vulnerable to environmental change. Furthermore, equating resilience with species richness also ignores the reality that species loss if often non-random. See further details in Elmqvist *et al.*, 2003. However, changes in abundance of species –

especially those that influence water and nutrient dynamics, trophic interactions, or disturbance regime – affect the structure and functioning of ecosystems. Thus, diversity is important, both because it increases the probability of including species that have strong ecosystem effects and because it can increase the efficiency of resource use. Differences in environmental sensitivity among functionally similar species give stability to ecosystem processes, whereas differences in sensitivity among functionally different species make ecosystems more vulnerable to change. Current global environmental changes that affect species composition and diversity are therefore profoundly altering the functioning of the biosphere. From Chapin *et al.* 1997.

30 Main sources for the remainder of this Chapter are: Lindenmayer & Franklin, 2002; Lindenmayer & Fischer, 2006; Lindenmayer *et al.*, 2006. The source material is extensively referenced to the scientific literature and should be consulted for further information on subject matter dealt with.

31 See Tewksbury *et al.*, 2002.

32 With the 4th Assessment Report from the Intergovernmental Panel on Climate Change released on 17 November 2007 there is now an international consensus that triggered human activities is taking place (See Summary for Policymakers at www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf, accessed 29 May 2008).
For a revealing example of a country's synthesis and assessment of climate change see the report from the US Climate Change Science Program's (2008): *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States* (www.climatescience.gov/Library/sap/sap4-3/final-report/sap4-3-final-all.pdf, accessed 28 May 2008).

33 This has been documented for important pollinators such as butterflies in Europe and the United States; for the Brown Kiwi in New Zealand; and fruit pigeons and bats in Australia. It is also considered that stepping stones may assist connectivity in plant populations as part of range shift s in response to climate change. See Table 3.1, p. 45, in Lindenmayer & Franklin, 2002.

34 The use of the term "river reserves" should not be understood as being the result of a gazettement.

35 The National Physical Plan states that "Studies shall be undertaken to determine the possibility of re-establishing the integrity and connectivity of forests and wetlands through the implementation of the linkages between […] four major forest complexes" (in connection with the Central Forest Spine). However, it also states that: "Rivers shall be used as connecting corridors to maintain the integrity and connectivity of forest ecosystems. Structure Plans and Local Plans shall incorporate the concept of using the rivers and forests as the backbone for developing the country's network of linear recreational areas and for maintaining ecological balance." "Wildlife corridors" are considered as Environmentally Sensitive Area category 2.
Finally, it is a specific element of Principle 7 of the Ecosystem Approach under the Convention on Biological Diversity.

36 Laurance *et al.*, 2002.

37 Lees & Peres, 2008. The study investigated the effects of corridor width and degradation status of 37 riparian forest sites (including 24 corridors connected to large source-forest patches, 8 unconnected forest corridors, and 5 control riparian zones embedded within continuous forest patches) on bird and mammal species richness in a hyper-fragmented forest landscape surrounding Alta Floresta, Mato Grosso, Brazil.

38 Laurance & Laurance, 1999.

39 Beier & Noss, 1998; Damschen *et al.*, 2006; Gillies & Clair, 2008; Haddad *et al.*, 2003; Levey *et al.*, 2005; Lindenmayer & Fischer, 2006; Lindenmayer & Franklin, 2002; Lindenmayer *et al.*, 2006; Sekercioglu, 2009; Stokstad, 2005; Tewksbury *et al.*, 2002.

40 For choices in procedures for designing corridors, see Beier *et al.*, 2008; and for guidance in designing corridors using GIS see www.corridordesign.org.

[41] Indeed, the patch-corridor-matrix model for understanding and characterising a landscape may be applied to a given forest complex where *patch* and *corridor* vegetation types are constituted by virgin forest (i.e. the goal within a production forest is to retain an infrastructure of virgin forest elements). That undisturbed forest is important for many organisms was – for instance – highlighted in a study on the effects of habitat disturbance on mammals in Peninsular Malaysia (see Laidlaw, 2000).

[42] The slopes of Munduk in northern Bali, Indonesia, were probably deforested more than 100 years ago. However, today the landscape is extensively rehabilitated by mixed home gardens in a small-holder farming system. The upper layer of the vegetation is constituted by widespread planting of clove trees with occasional clusters of coco and durian, followed by papaya, coffee, cacao, citrus and banana. At ground level important subsistence (and commercial) crops include tapioca, sugar cane, corn, beans – among others. At places, the vegetation opens up to terraced rice fields. All together, these mixed home gardens provide a high level of protection of biodiversity and ecosystem processes, which represent a balancing of environmental, social and economic needs of local communities.

[43] In Sweden, a century of intensive management in a 123,000 hectare area of boreal forest transformed stand structure from one dominated by widely spaced, large-diameter trees to young, densely stocked forests. The number and volume of large trees and snags were reduced by 90% and the extent of old stands by 99%. Recently it was recognized that large, dead trees are particularly valuable for biodiversity in Scandinavian forests. It has been calculated that almost 50% of the threatened (or red-listed) species in Sweden were dependent on snags or logs. (Reported in Lindenmayer & Franklin, 2002).

[44] Lindenmayer & Franklin, 2002.

[45] Many species will remain in logged areas if some of the original structures are retained or microclimatic conditions are maintained within tolerance levels. From here they may also facilitate recolonization and regeneration to the logged areas. Some of these are important to ecosystem functioning (e.g. fungi and other soil organisms), successful regeneration, growth of subsequent generations of trees, and thus sustained productivity on logged sites.

[46] Several studies have shown that retained trees can promote the recolonization by birds of logged and regenerated forests.

[47] May be particularly useful for animals that deploy random dispersal strategies and do not use corridors.

[48] Structural complexity can provide optimum habitat for a range of forest species, including some habitat specialists.

[49] In addition to the geographic variation in environmental conditions within a forest, spatial and temporal variations in forest management regimes also create a form of heterogeneity (e.g. thinning, selective logging, enrichment planting, and clear felling operations). See also Endnote 41.

[50] Lindenmayer & Fischer, 2006.

[51] This should be seen as an example of the importance of continued communication between practitioners, researchers and planners embarking on a process of adaptive management which allow stakeholders shaping the landscape to learn as they go along.

[52] Reports of apparent pollinator declines around the world over the past decade led to a brewing international “pollinator crisis”. The status of pollinators is or should be a matter of great concern given that more than 200,000 plant species worldwide depend on animal pollination to produce seeds. Pollinators include in their ranks about 1,200 species of vertebrates across three classes and at least 200,000 species of insects in six orders. Despite the utter centrality of pollination to terrestrial life, there is an extraordinary dearth of dependable data on pollinator populations in general. In the US the most compelling evidence for pollinator decline is available for *Apis mellifera*, the imported European honeybee, a semi-domesticated species whose pollination services are actively managed and available for purchase. Although the estimated value of honeybee pollination ranges in the billions of dollars, record-keeping practices are problematical even for this species.

In those cases in which declines could be documented, the causes of decline could be identified definitively only rarely. For many groups of pollinators, however, many interacting ecological and environmental challenges appear to be leading to a death by a thousand cuts. Declines are associated with habitat loss, fragmentation, and deterioration, non-target pesticide exposure, and invasive species. Changes in ranges and distributions of pollinators and the plant species they visit that lead to loss of synchrony (possibly because of global climate change) and to disruption of migratory routes by urbanization and other forms of development have been implicated in reductions in numbers of hummingbirds, nectar-feeding bats, and some butterflies and moths.
The economic consequences of pollinator decline are most easily estimated in the context of agriculture. The contributions of one species alone – the honeybee – facilitate production of over 90 crops in the U.S. and amount to more than $15 billion per year.
*From*: Berenbaum MR, 2007. *The Birds and the Bees"—How Pollinators Help Maintain Healthy Ecosystems*. Testimony before the US House of Representatives, 26 June 2007 (www7.nationalacademies.org/ocga/testimony/How_Pollinators_Help_Maintain_Healthy_Ecosystems.asp, accessed 4 July 2008).

53 Findings of a study published 25 October 2006 in the Proceedings of the Royal Society B: Biological Sciences (www.berkeley.edu/news/media/releases/2006/10/25_pollinator.shtml, accessed 4 July 2008), which includes this illustration on the importance of insect-pollinators as opposed to self-pollination and wind-pollination (Figure below).

Strawberries, *Fragaria x annanasa Duch.*, after open insect-pollination (left), passive self-pollination (middle) and passive self-pollination and wind-pollination (right). *(Photo by Kristine Krewenka, Agroecology, Göttingen, Germany.)*

54 Several studies have shown that when certain important species were lost, uncommon and non-keystone species may to some extent compensate for the loss of dominant groups. See Walker B, Kinzig A & Langridge J. 1999. Plant attribute diversity, resilience, and ecosystem function: the nature and significance of dominant and minor species. Ecosystems, 2, 95-111. (Quoted in Lindenmayer & Fischer, 2006).

55 Captive breeding, reintroduction and translocation should focus on threatened species only. PERHILITAN has already proven that several species can be bred in captivity including the Malayan Gaur (*Bos gaurus*).

56 General drivers of change were referred to in Section 2.6, p. 6.

57 NRE is presently in the process of adopting the IUCN Red List guidelines (see IUCN, 2007). See also *Threatened species*.

58 Ecosystem Approach, Secretariat to CBD (www.cbd.int/ecosystem/, accessed 27 Apr 09).

59 COP 2 Decision II/8 (Jakarta 6-17 Nov 1995) recognized that the ecosystem approach should be the primary framework of action to be taken under the Convention. The ecosystem approach has been considered by the fifth meeting of the Conference of the Parties in May 2000. www.cbd.int/programmes/areas/forest/cs.aspx (Accessed 6 May 2008).

60 See further details in NRE, 2008a (Chapter 2.4, p. 5, and Annex 1, p. 69).

61 See further details in SCBD, 2004; and Shepherd, 2004.

62 The Star published on 8 June 2008 articles reporting that for the five-year period

2001 to 2005 the gazettes show that 40,500 ha (i.e. 405 $km^2$) were excised from the Permanent Forest Reserve (PFR) in Peninsular Malaysia (www.nst.com.my/Current_News/NST/Sunday/Frontpage/2261835/Article, accessed 2 July 2008).

This extent, which was disputed by the Forestry Department Peninsular Malaysia, represents 81 $km^2$ per year. The article also stated that: *Under the purview of the National Forestry Act 1984, the state authority can: Excise a reserve or any part of a reserve "under very special circumstances". This is when the reason for its reservation no longer applies, or it is required for economic use higher than the present forest value*".

At least four issues would appear immediately relevant and they are:

i) If the "present forest value" is determined by only considering the value of commercial timber alone and not highly valuable provisioning of ecosystem services then it is grossly insufficient as discussed in Chapter 2.7, p. 9, of the Common Vision (NRE, 2008a).

ii) General replacement of mixed forest habitat with a monoculture of plantation species will not ensure the full support of ecosystem services (see also Figure 6, p. 9, and Figure 34, p. 34).

iii) Even a smaller extent regularly converted from the Permanent Forest Reserve may significantly disrupt any strategic measures resulting from the National Biodiversity Planning process (e.g. overall network of connectivity). In particular, it would affect compliance with national objectives of sustainability by potential negative impacts on: (i) a consolidated Protected Areas System; and (ii) land/seascape management of biodiversity – both in support of securing highly valuable ecosystem services (see further in Chapters 4 and 5 of the Common Vision – NRE, 2008a).

iv) Communication and information sharing needs strengthening and will be assisted by the National Biodiversity Planning process, as discussed in Section 2.11, p. 14.

63 See the Ecosystem *Approach Sourcebook* at www.cbd.int/ecosystem/sourcebook/ which has links to: (i) Beginners Guide; (ii) Advanced User Guide; and (iii) Tools and approaches. It also has links to search the *Ecosystem Approach Sourcebook Database* (Accessed 6 May 2008).
A separate publication on key issues and case studies may be acquired by downloading Smith & Maltby, 2003.

64 Among disadvantages are: results cannot be compared between agencies since multiple datasets exists (i.e. impossible to standardise work routines and products); manual overlays are difficult – if not impossible – with multiple maps; re-digitising features (which the government has already paid to turn digital) add unnecessary costs and create incompatible datasets.

65 Scherr & McNeely, 2008; Buck *et al*., 2004; Buck *et al*., 2006.

66 As far as (terrestrial) crop production is concerned, this would include extensive oil palm and rubber plantations together with monocultures of forest tree species – all of which are essentially long-term rotational crops which offer only a minimum of diversity and long-term support of ecosystem services. This necessitates coordination between at least three natural resource ministries: NRE, KPPK and MOA; as well as the Ministry of Housing and Local Government (i.e. charged with National Physical Planning).

67 See further in SCBD, 2008.

68 See further details in *A Common Vision on Biodiversity* (Chapter 6, p. 36, in NRE 2008a).

Acknowledgement

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The Component has three Sub-Components which are located at NRE, EPU and MENGO. The Component took off in November 2006 and runs until December 2009.

This Guideline is about planning and management of biodiversity in the landscape. It provides an overview of what biodiversity is, how it supports valuable ecosystem services, and what is happening to it. The Guide then proceeds by explaining how to understand a given landscape, the importance of managing habitat throughout landscapes, and suitable principles and management interventions. How complementary stakeholder actions may safeguard ecosystem services across the landscape is subsequently dealt with. Finally, checklists have been prepared to assist planners in their day-to-day undertakings supporting national goals for holistic and integrated management leading to environmentally sustainable development.

The *Best Practice Series* is in support of implementation of *A Common Vision on Biodiversity in Government and the Development Process* (NRE, 2008).

The *Common Vision on Biodiversity* targets planners, decision-makers and practitioners at all levels of federal, state and local government. It explains what biodiversity is, why it is important, how to maintain it and what measures are required to ensure a constant provision of ecosystem services that are essential for human livelihood.

Based on the different undertakings of NRE, its line agencies and the latest guidelines and experiences with respect to biodiversity planning and management, the *Common Vision* promotes a three-pronged implementation approach and outreach strategy that consists in:

i) Strengthening the Protected Areas System
ii) Land/Seascape management for biodiversity
iii) Mainstreaming of biodiversity.

To a very large extent, the Common Vision on Biodiversity responds to provisions and priorities contained in existing policies, plans and programmes, but it focuses on their implementation and the operational aspects of the pursuit of sustainable development. The Common Vision is also important because it helps to rally support within government and civil society for a shared perception of issues, priorities and required inter-agency actions.

ISBN