Biodiversity Conservation
-An Overview

What is Biodiversity?

- **Biological Diversity** or **Biodiversity** in simple words means variety in life forms in a given place at a given time.
  - *A term given to the variety of life on Earth. It is the variety within and between all species of plants, animals and micro-organisms and the ecosystems within which they live and interact.*
  - *Complete range of species and biological communities, as well as the genetic variation within and all ecosystem processes*
  - *totality of genes, species, and ecosystems of a region*

Types of Biodiversity

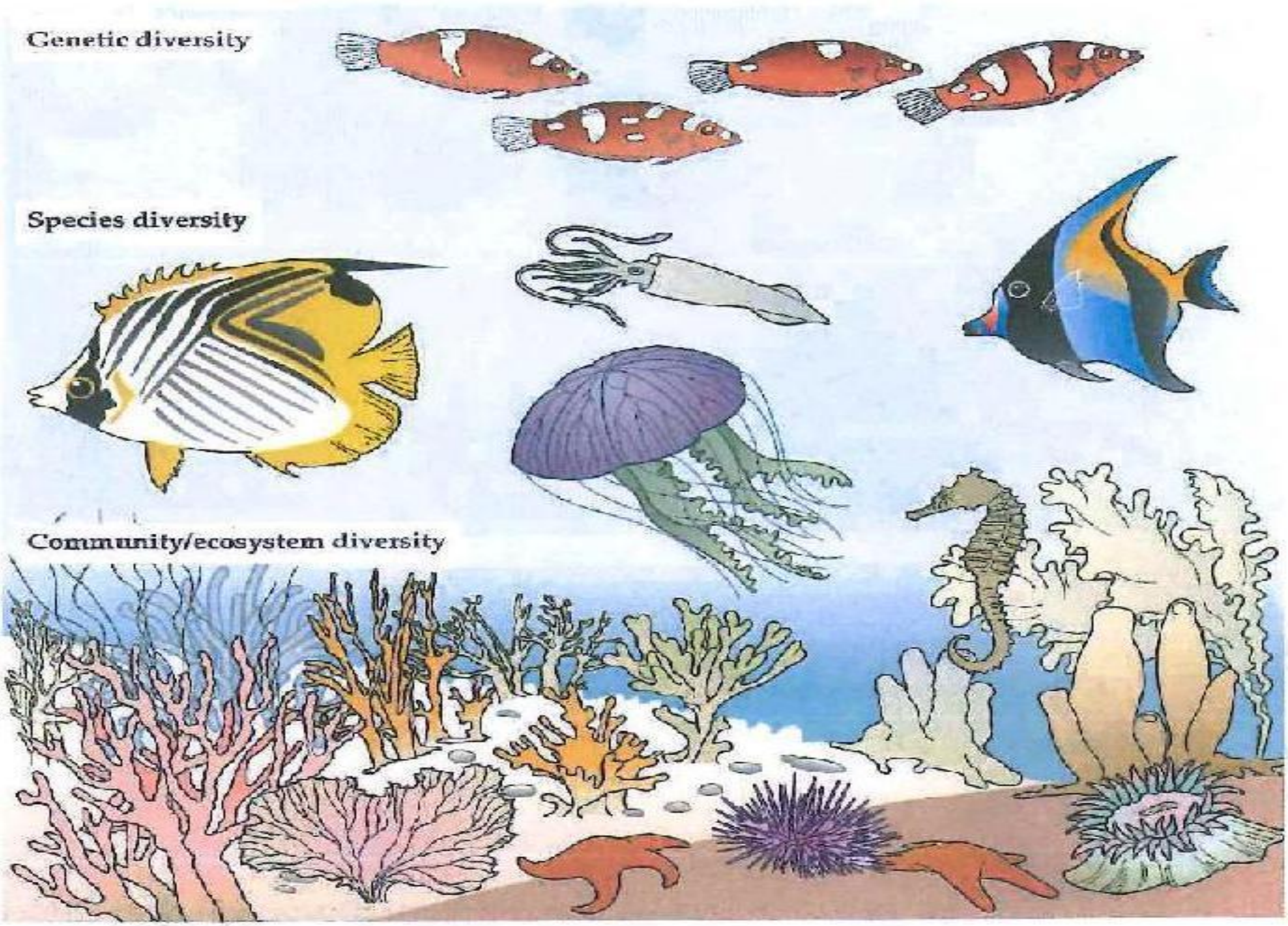
I. Species Diversity
II. Genetic Diversity
III. Ecosystem Diversity
IV. Molecular Diversity (?)

Species Diversity

- **Species Diversity**: The number or variety of species in a particular region

- *Species richness* = number of species

- *Evenness, or relative abundance* = extent to which numbers of different species are equal or skewed


Genetic diversity
Species diversity
Community/ecosystem diversity

Species Diversity contd

What is a Species?

1. **Morphological Definition**

   A group of individuals that is morphologically, physiologically or biochemically distinct from other group of individuals

2. **Biological Definition**

   A group of individuals that can potentially breed among themselves in the wild and that do not breed with the individuals of other groups

3. **Evolutionary Definition**

   A group of individuals that share unique similarities of their DNA and hence their evolutionary past

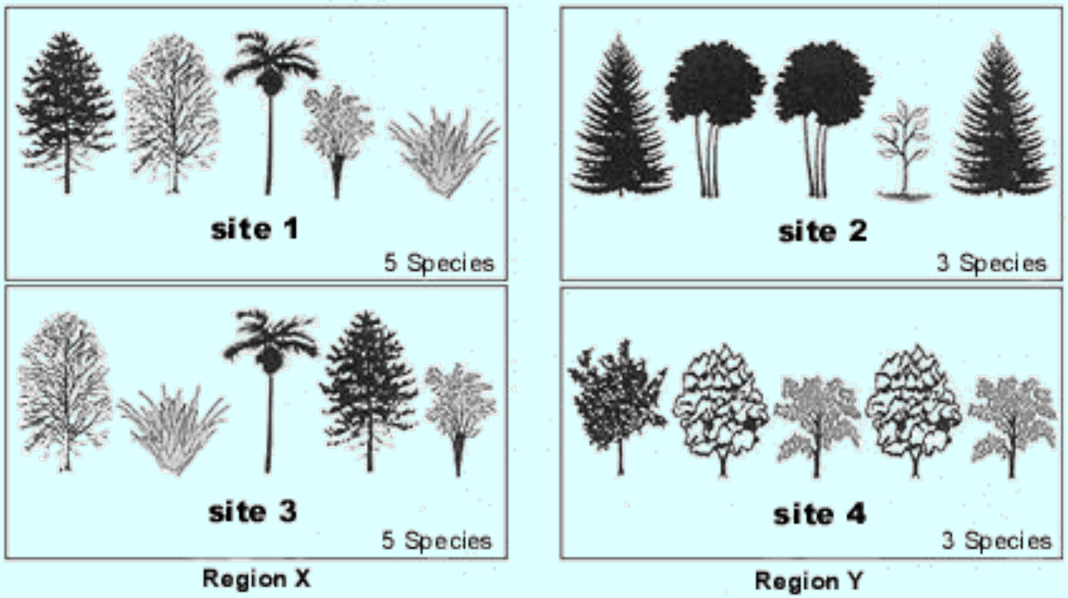
Species Diversity contd

- Origin of new species
  - Darwin-Wallace theory
  - Speciation
    - Phylectic evolution
    - Adaptive radiation
    - Polyploids
    - Hybrids

Species Diversity contd…

- Measuring Species Diversity
  - Species richness
    - Alpha Diversity
    - Beta Diversity
    - Gamma Diversity

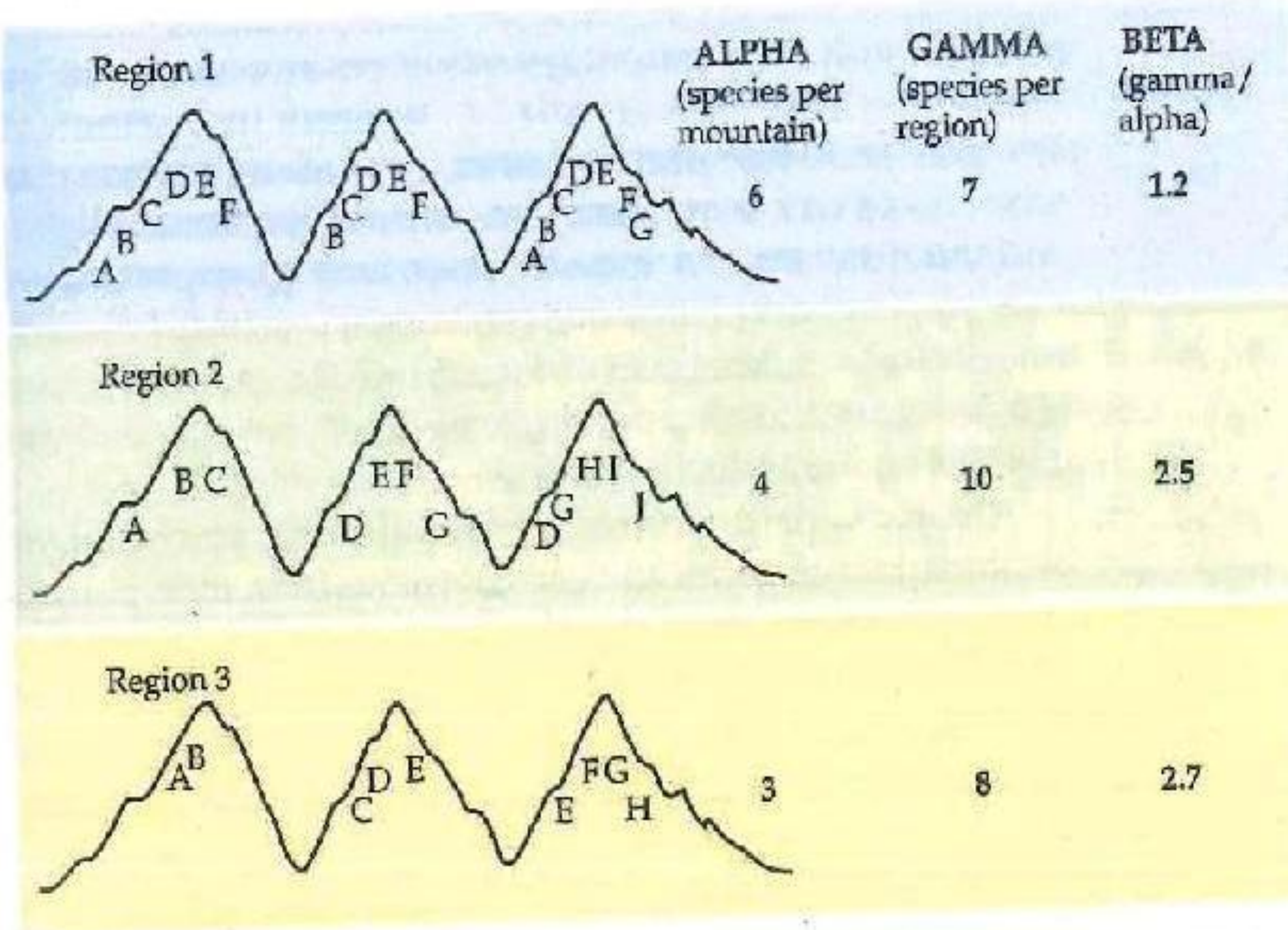
Alpha, Beta and Gamma Diversity



ALPHA-, BETA- AND GAMMA-DIVERSITY.
Alpha diversity is measured locally, at a single site, as at sites 1 and 2. Site 1 has higher alpha-diversity than site 2.

Beta-diversity measures the amount of change betwen two sites or along a gradient, as in regions X and Y. Region Y has higher beta-diversity than region X, as there is a higher turnover of species among the sites in region Y.

Gamma-diversity is similar to alpha-diversity, only measured over a large scale. Both alpha- and beta-diversity contribute to gamma-diversity. Region X has high alpha-diversity at its sites, but they are all fairly similar; the region thus has low beta-diversity and only moderate gamma-diversity. Region Y has low alpha-diversity at its sites, but the sites differ from each other; the region therefore has high beta-diversity, and higher gamma-diversity than region X.



Region 1
ALPHA (species per mountain)
GAMMA (species per region)
BETA (gamma / alpha)
A B C DE F
B C D E F
A B C DE F G
6
7
1.2
Region 2
A B C
D EF G
D G HI J
4
10
2.5
Region 3
A B
C D E
E FG H
3
8
2.7

Genetic Diversity

- Includes the differences in DNA composition among individuals within a given species
- Adaptation to particular environmental conditions may weed out genetic variants that are not successful.
- But populations benefit from some genetic diversity, so as to avoid inbreeding or disease epidemics.

Ecosystem Diversity

- Includes diversity above the species level

- Biologists have viewed diversity above the species level in various ways. Some alternative ways to categorize it include:
  - » Community diversity
  - » Habitat diversity
  - » Landscape diversity

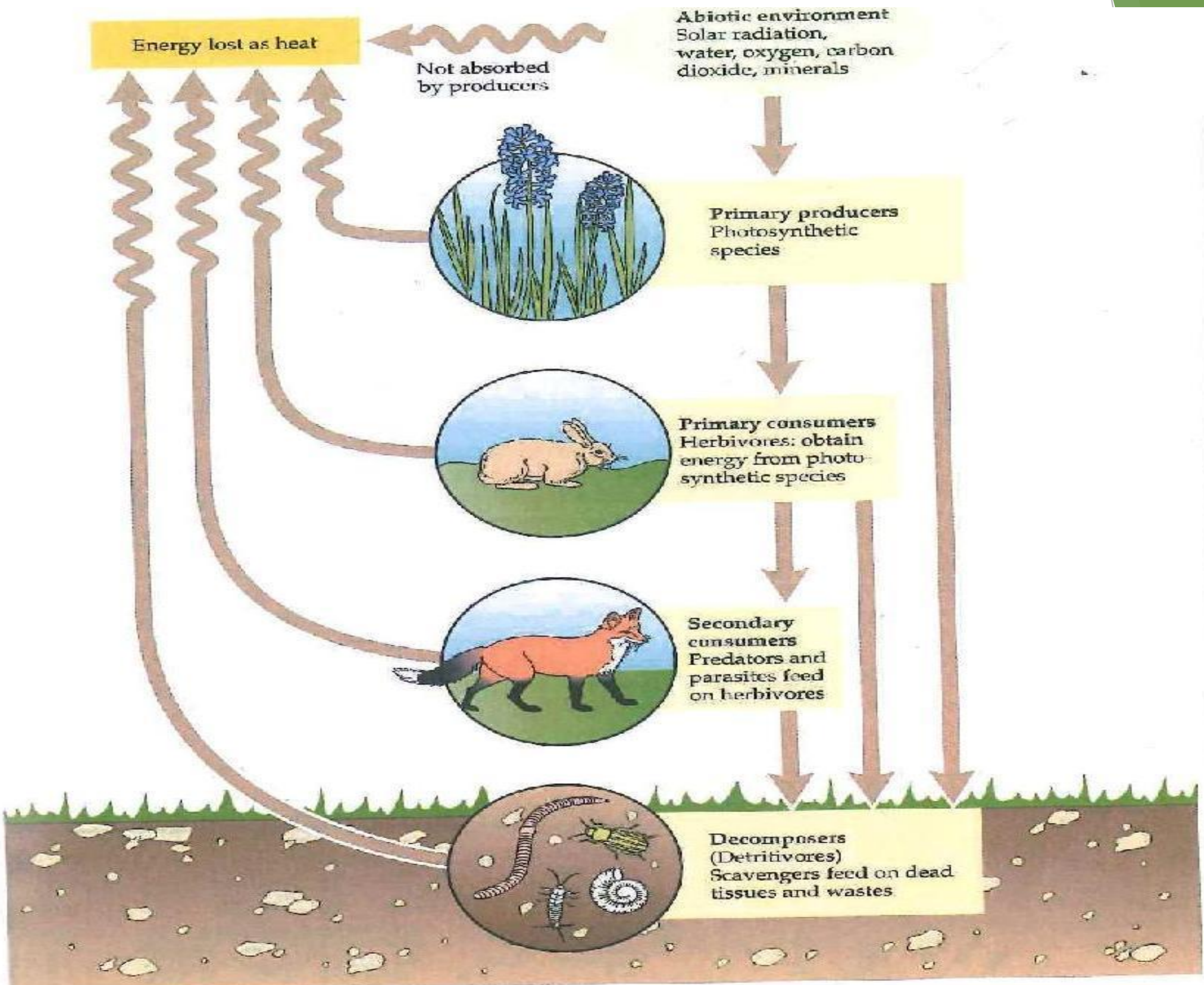
Ecosystem Diversity contd……

- Biological Community: Species that occupy a particular locality and interactions among these species
- Ecosystem: A biological community together with its associated physical and chemical environment
- Habitat: A place where a living thing lives, a place where it can find food, shelter, protection and mates for reproduction. It is the natural environment in which an organism lives, or the physical environment that surrounds a species population.

  A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators.

Ecosystem Diversity contd......

- Ecosystem components
  - Abiotic
  - Biotic
    - Primary producers
    - Primary consumers
    - Secondary consumers
    - Decomposers
  - Food chain, food web and energy flow
  - Umbrella Species
  - Keystone species
  - Indicator species
  - Flagship species



Energy lost as heat
Not absorbed by producers
Abiotic environment
Solar radiation, water, oxygen, carbon dioxide, minerals
Primary producers
Photosynthetic species
Primary consumers
Herbivores: obtain energy from photosynthetic species
Secondary consumers
Predators and parasites feed on herbivores
Decomposers
(Detritivores)
Scavengers feed on dead tissues and wastes

Ecosystem Diversity contd……

- **Umbrella Species:** one whose minimum area requirements are at least as comprehensive of the rest of the community for which protection is sought though the establishment and management of a protected area.
- **Keystone species:** a species whose presence contributes to ecosystem function and whose elimination would lead to the disappearance of other species in the ecosystem. (Keystone Resources)
- **Indicator species:** a single species (or more often, a suite of species) is identified as an indicator species because (their) presence, absence or abundance reflects a specific environmental condition
- **Flagship species:** a species that has become a symbol and leading element of an entire conservation campaign, often a large charismatic mammal.

Why Biodiversity is important?

- Preserving biodiversity preserves ecosystem services, and directly provides things of pragmatic value to us.
  - • *Food, fuel, and fiber*
  - • *Shelter and building materials*
  - • *Air and water purification*
  - • *Waste decomposition*
  - • *Climate stabilization and moderation*
  - • *Nutrient cycling*
  - • *Soil fertility*
  - • *Pollination*
  - • *Pest control*
  - • *Genetic resources*

Ecosystem Services

Provisioning services

- foods (including seafood and game) and spices
- precursors to pharmaceutical and industrial products
- energy (hydropower, biomass fuels)

Regulating services

- carbon sequestration and climate regulation
- waste decomposition and detoxification
- nutrient dispersal and cycling

Supporting services

- purification of water and air
- crop pollination and seed dispersal
- pest and disease control

Ecosystem Services contd.

Cultural services

- cultural, intellectual and spiritual inspiration
- recreational experiences (including ecotourism)
- scientific discovery

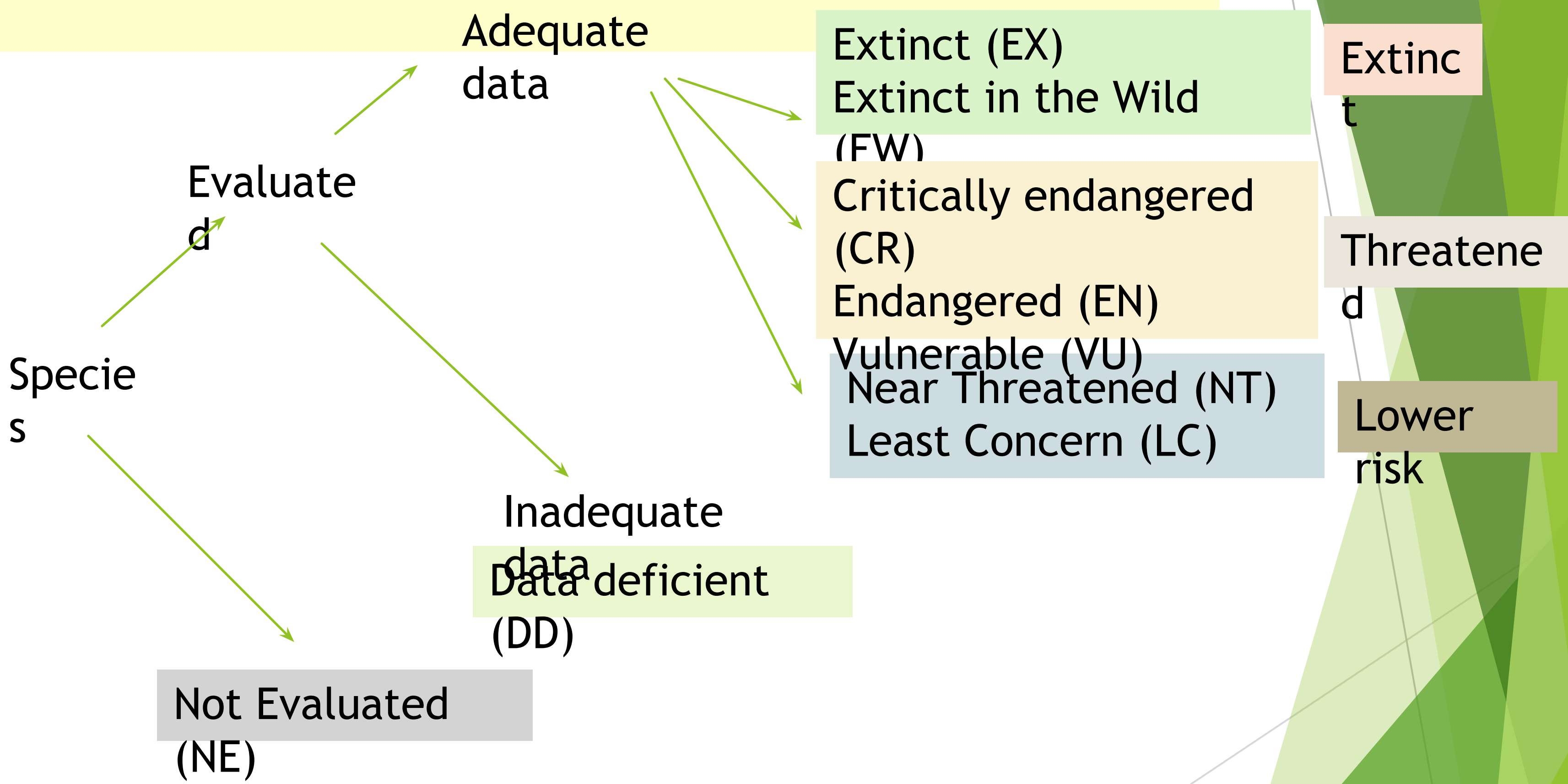
Preserving services

- genetic and species diversity for future use
- accounting for uncertainty
- protection of options

Loss of Biodiversity and Extinction of Species

- **Extinction** = last member of a species dies and the species vanishes forever from Earth
- **Extirpation** = disappearance of a particular population, but not the entire species globally
- These are natural processes.
  *On average one species goes extinct naturally every 500-1,000 years—this is the **background rate of extinction**.*
- Endemism

IUCN Conservation Categories



IUCN Conservation Categories

- **Extinct (EX):** the species (or subspecies/variety) no longer known to exist
- **Extinct in the Wild (EW):** exists only in cultivation, captivity or in naturalized population well outside its original range
- **Critically Endangered (CR):** having extremely high risk of extinction in wild as per prescribed criteria
- **Endangered (EN):** with very high risk of extinction in the wild as per prescribed criteria
- **Vulnerable (VU):** with high risk of extinction in the wild as per prescribed criteria
- **Near threatened (NT):** is close to qualifying for a threatened category but currently not considered threatened
- **Least concern (LC):** currently neither considered threatened or near threatened
- **Data deficient (DD):** with inadequate data to determine the risk
- **Not Evaluated (NE):** not yet evaluated for inclusion in Red Data book

Two Additional Red List Categories:

- **Regionally Extinct (RE):** does not exists in a region but exists in other parts of the world.
- **Not Applicable (NA):** Not eligible for inclusion in Regional Red Data Book

IUCN Red List Criteria

Red List Criteria A-E	Quantification of criteria for Red List 'Critically Endangered' category
A. Observable reduction in number of individuals	The population has declined by 80 % or more over the last 10 years or 3 generations whichever is longer
B. Total geographical Area occupied by the species	The species has a restricted range (<100 km^2 at a single location) and there is observed or predictable habitat loss, fragmentation, ecological imbalance or heavy commercial exploitation
C. Predicted decline in number of individuals	The total population size is less than 250 mature, breeding individuals and expected to decline by 25 % or more within 3 years or 1 generation
D. Number of mature individuals currently alive	The population size is less than 50 mature individuals
E. Probability that the species will go extinct within a certain number of years or generations	Extinction probability is greater than 50% within 10 years or 3 generations

VULNERABILITY TO EXTINCTION

- Species with a very narrow geographical range
- Species with only one or a few populations
- Species in which population size is small
- Species with low population density
- Species that need a large home range
- Species that have large body size
- Species with low rates of population increase
- Species that are not effective dispersers
- Species that migrate

Threats to Biodiversity

- HIPPO (by E. O. Wilson)
  - Habitat
  - Invasive species
  - Population
  - Pollution
  - Overexploitation
- Climate Change
- Diseases

Threats to Biodiversity contd

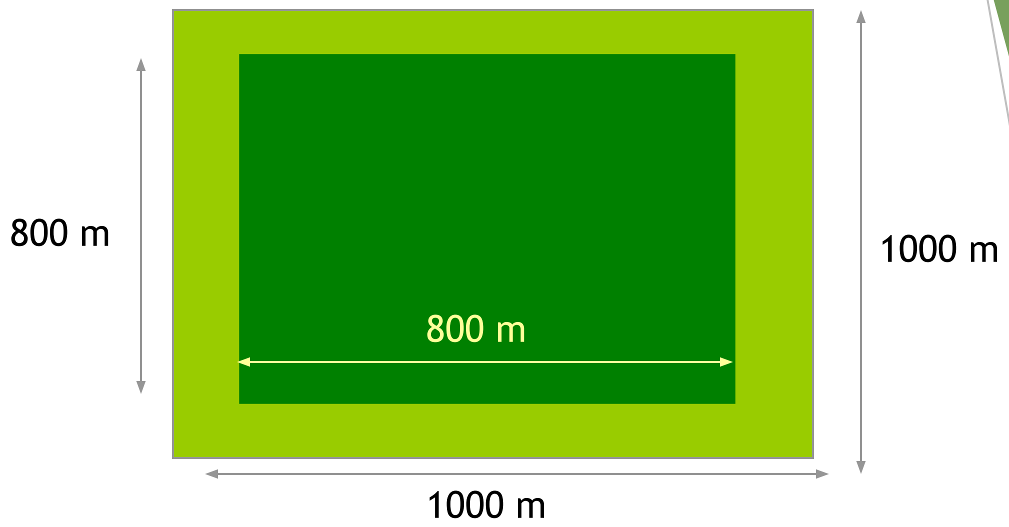
- Habitat Destruction
  - Clear felling, encroachment, land use change, fire etc
- Habitat Degradation
  - Overexploitation, illegal collection, Pollution etc
- Habitat Fragmentation

Habitat Fragmentation

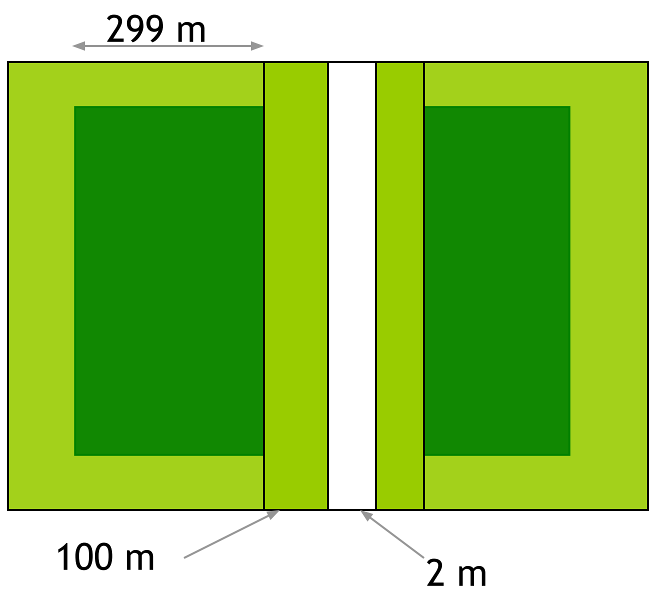
The term habitat fragmentation includes six discrete phenomena:

- Reduction in the total area of the habitat
- Increase in the amount of edge
- Decrease in the amount of interior habitat
- Isolation of one habitat fragment from other areas of habitat
- Breaking up of one patch of habitat into several smaller patches
- Decrease in the average size of each patch of habitat

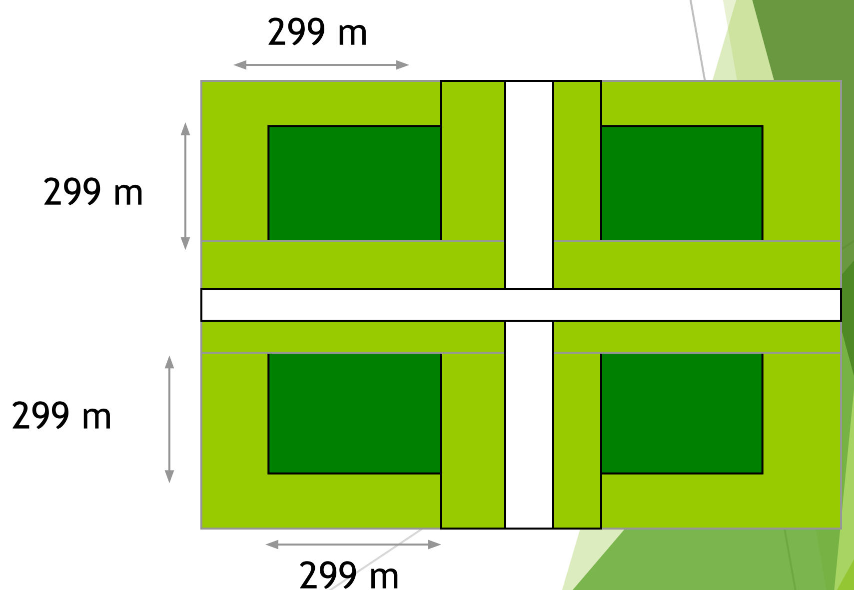
Habitat Fragmentation



Green Area= 640000 m^2 = 64 ha

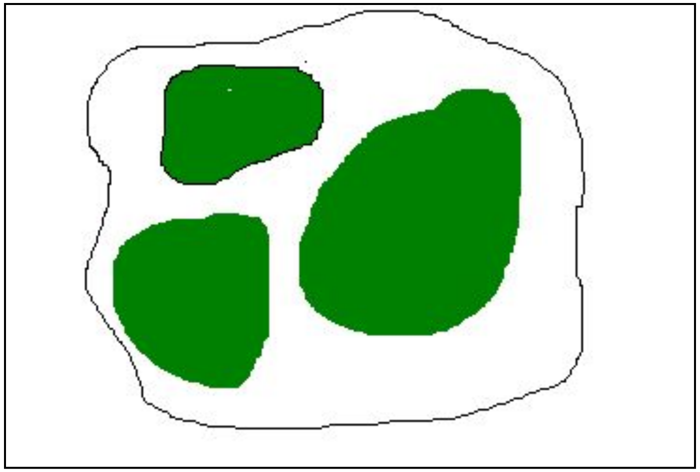


Green Area= 2x(299 x 800)=478400m^2 =47.8 ha



Green Area= 4x(299 x 299) = 357604 m^2 =35.8 ha

Habitat Fragmentation



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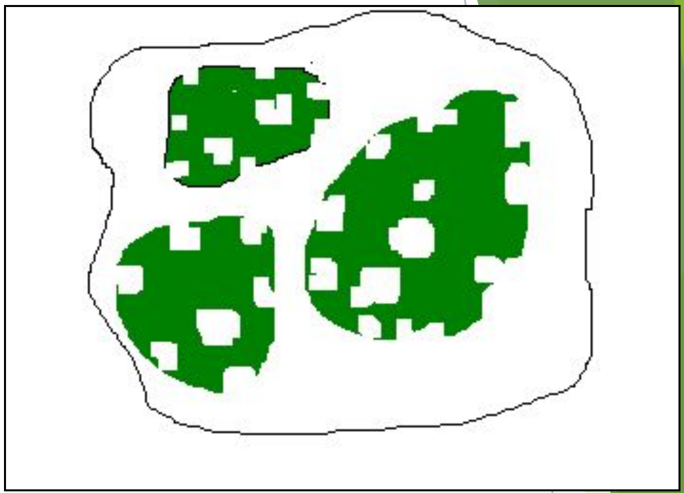

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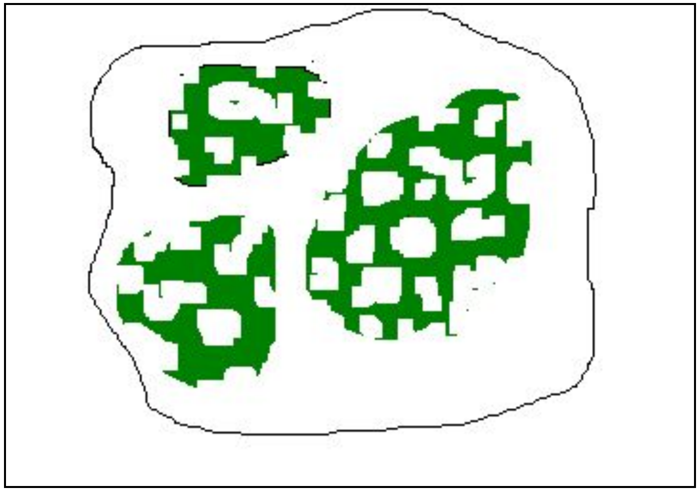

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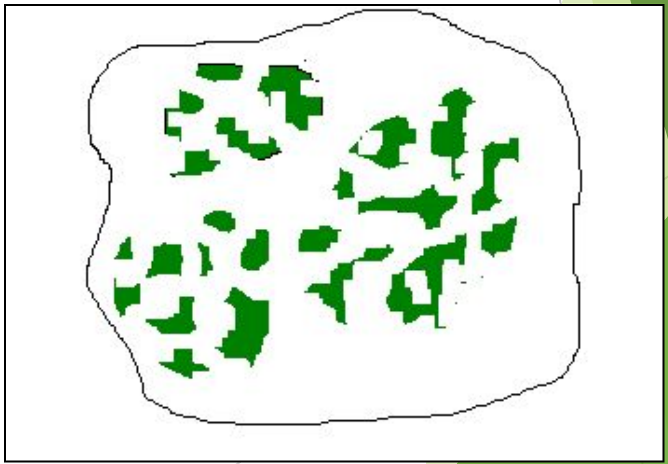
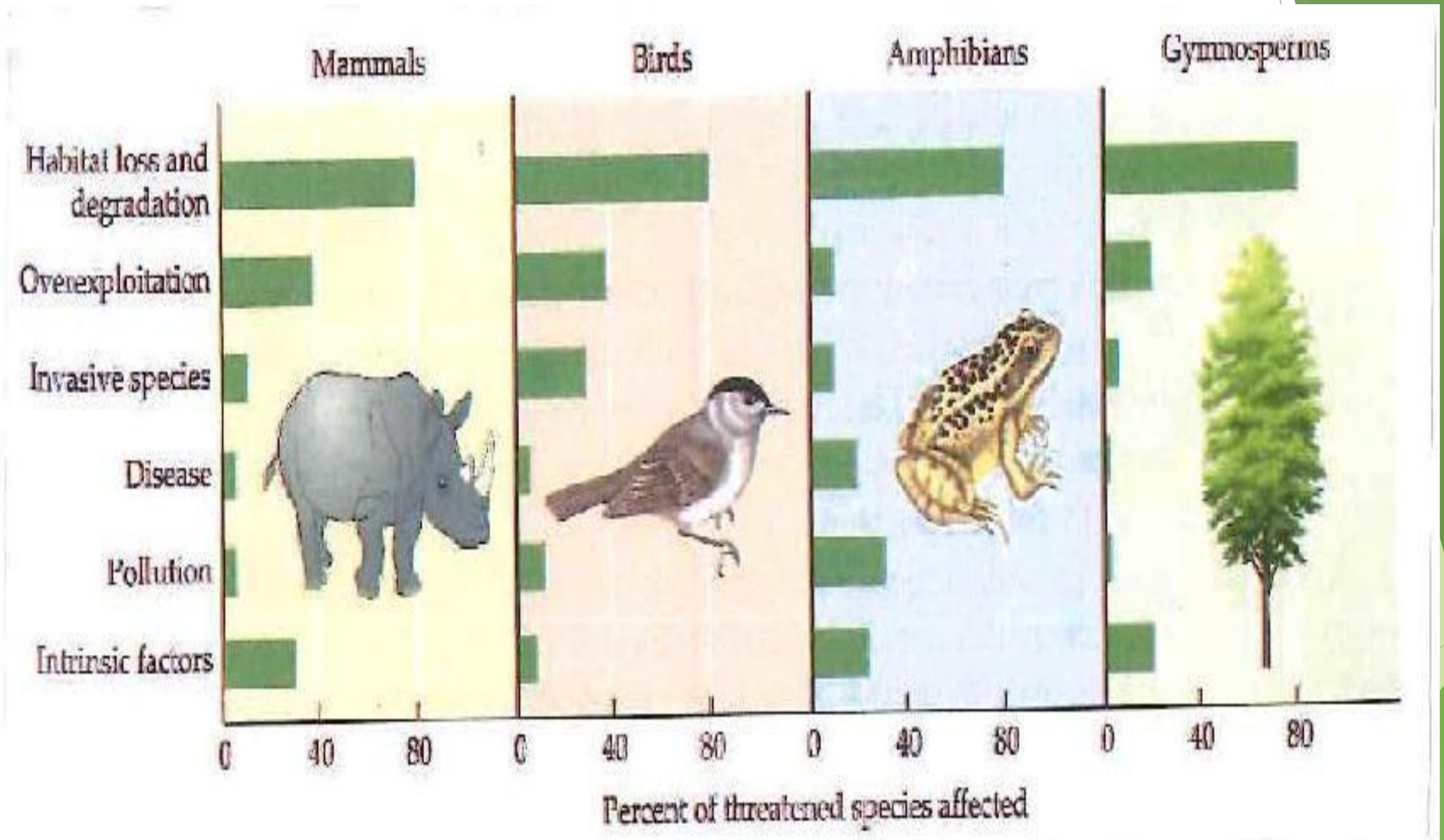


IV

Fragmentation


Mammals
Birds
Amphibians
Gymnosperms
Habitat loss and degradation
Overexploitation
Invasive species
Disease
Pollution
Intrinsic factors
0
40
80
0
40
80
0
40
80
0
40
80
Percent of threatened species affected

Landscape-scale or metapopulation models

- amount of habitat
- quality of habitat
- distribution or configuration of habitat
- connectivity of habitat

Landscape-scale or metapopulation models

Patch size matters

populations in smaller habitat patches (‘islands”) are more likely to go extinct than populations in larger habitat patches

Patch isolation matters

the more isolated an unoccupied habitat patch is from occupied habitat patches, the less likely that it will be colonized

The Theory of Island Biogeography (MacArthur and Wilson 1967)
Metapopulation Theory (Levins 1969 and others)

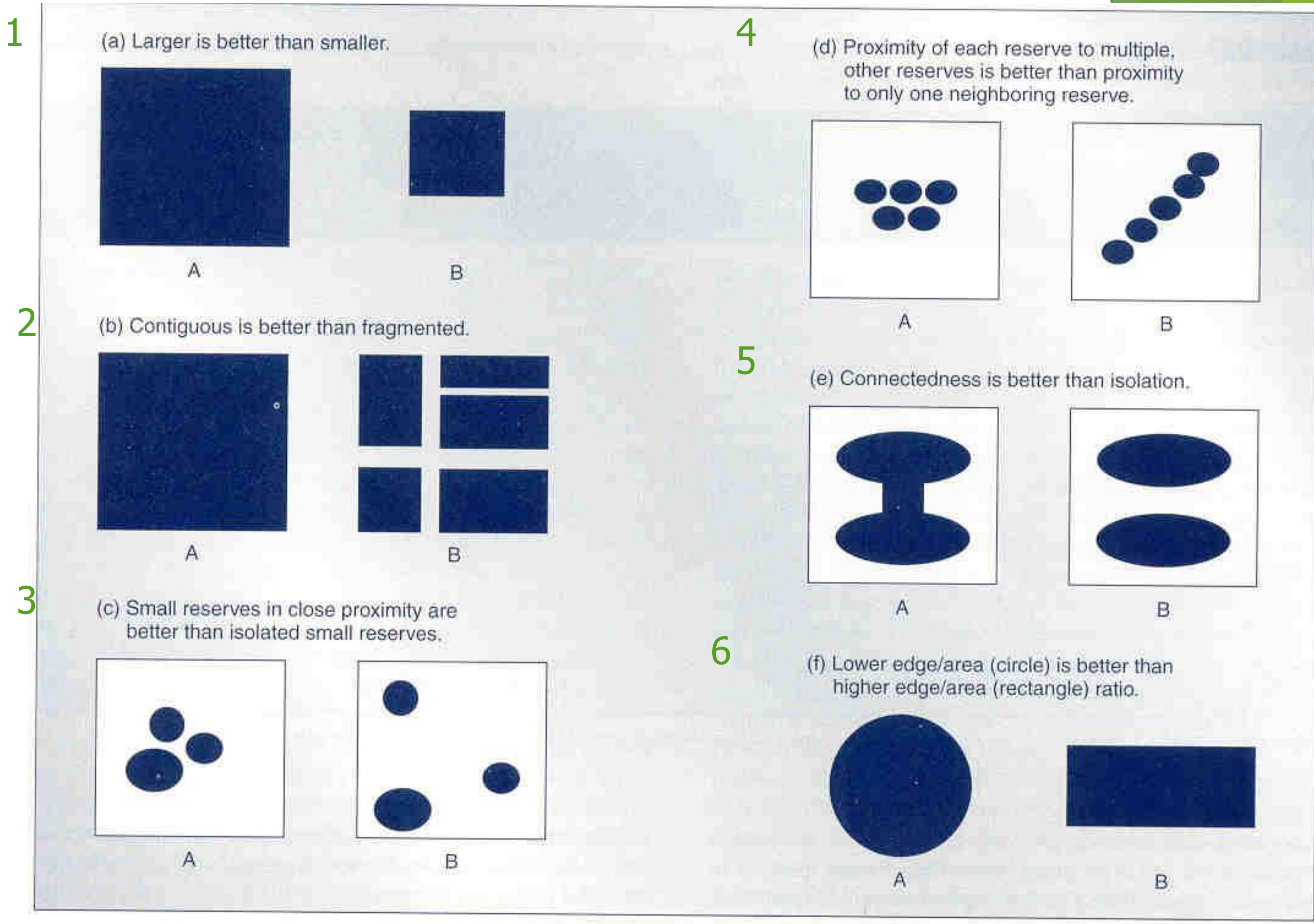


Figure 5.10
A graphical representation of the "rules" of island biogeography applied to nature reserves. In each case, design A is considered superior to design B.

Landscape-scale or metapopulation models

Patch quality matters

populations in habitat patches of higher quality are less likely to go extinct than populations in patches of lower quality

A “**source**” is an area with excess individuals. Excess individuals may emigrate from a “source” patch.

A “**sink**” is an area with very limited population. Populations in sink patches are certain to go extinct. Sink populations may be “rescued” by immigration from source populations (the **rescue effect**).

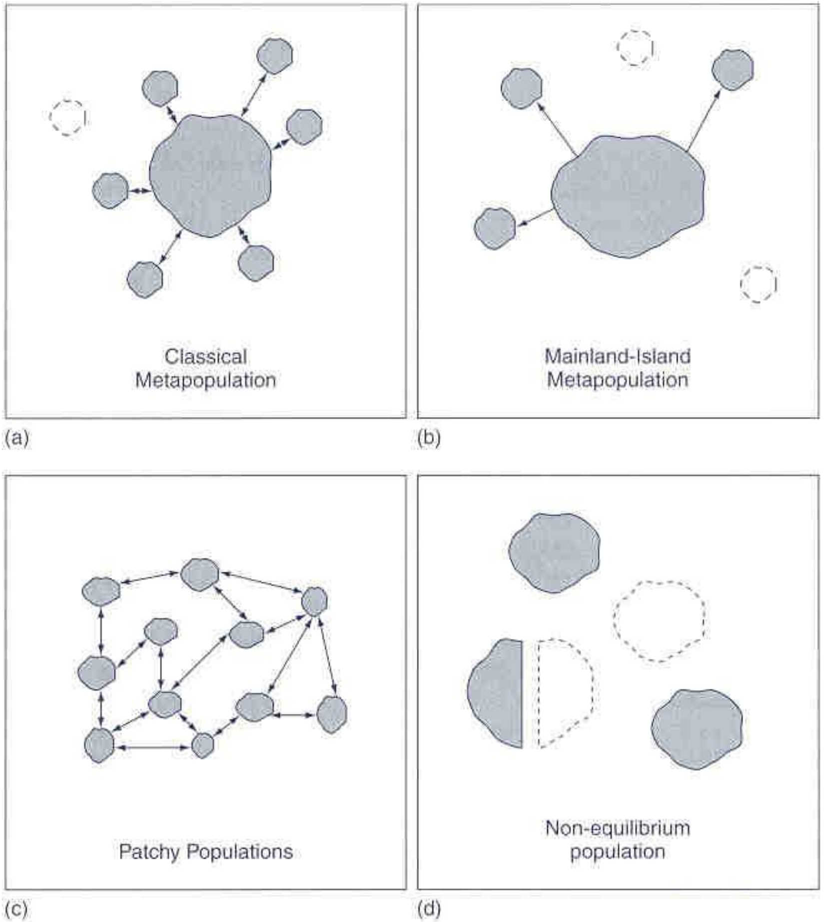


Figure 5.16

Types of metapopulation models. In a *classical metapopulation,* (a) some colonies may not exhibit high rates of movement for long periods of time. Also, colonization may unite several patches within a larger patch as a single entity that contributes to other sinks. Colonies farthest from the source are most prone to extinction. The *mainland-island metapopulation* (b) depicts local extinctions occurring mainly among a subset of populations. The mainland/source, resistant to extinction, functions as the major provider of colonists. The island and sink metapopulations have little effect upon regional persistence. In *patchy populations* (c), because of the high levels of emigration and immigration, the patches function as a single unit. It is rare that discrete local populations become extinct. The absence or insufficiency of recolonization to balance extinction distinguishes *nonequilibrium populations* (d). Extinction of metapopulations occurs as part of an overall regional decline (i.e., a product of the reduction, fragmentation, or deterioration of a habitat).

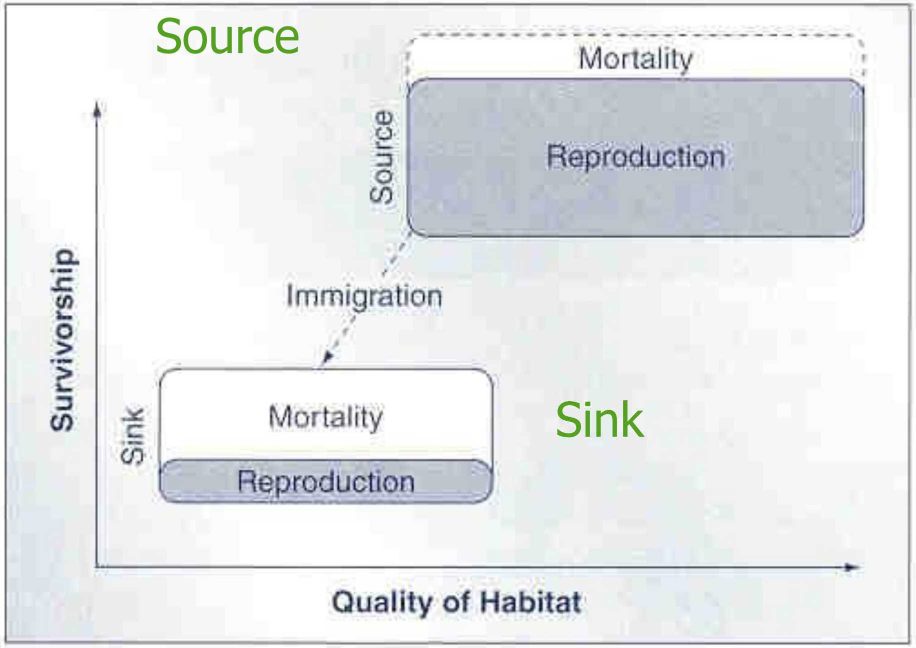
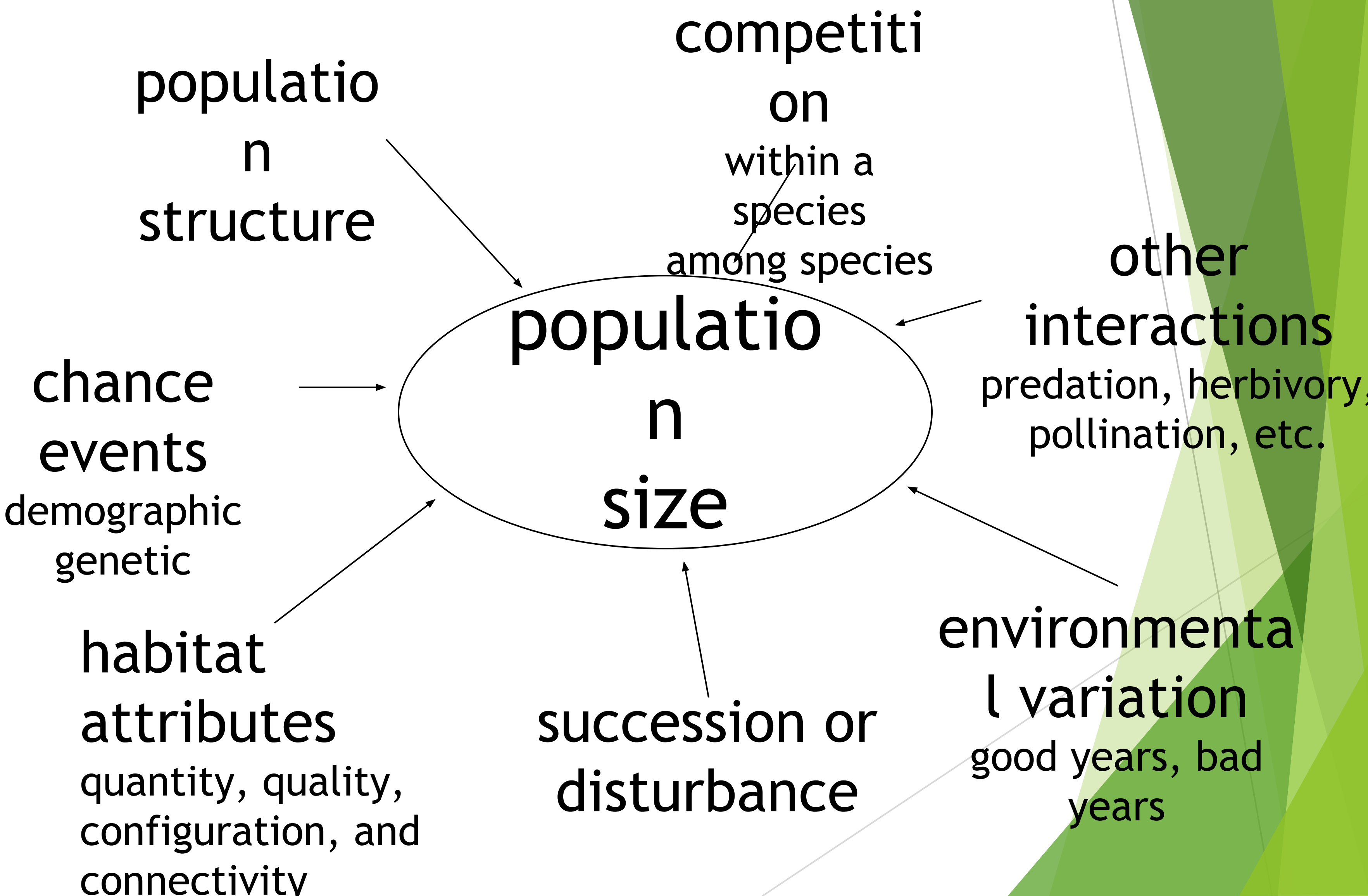


Figure 5.17

A visual representation of the source-sink model of habitat distribution. In source habitats, reproduction produces a population surplus (i.e., mortality does not decrease the number of individuals because of overcompensation through reproduction). Surplus individuals move to sink habitats where mortality exceeds survivorship. Sink habitats cannot be maintained by reproduction, but depend on immigration to maintain a population.

Many things affect population size

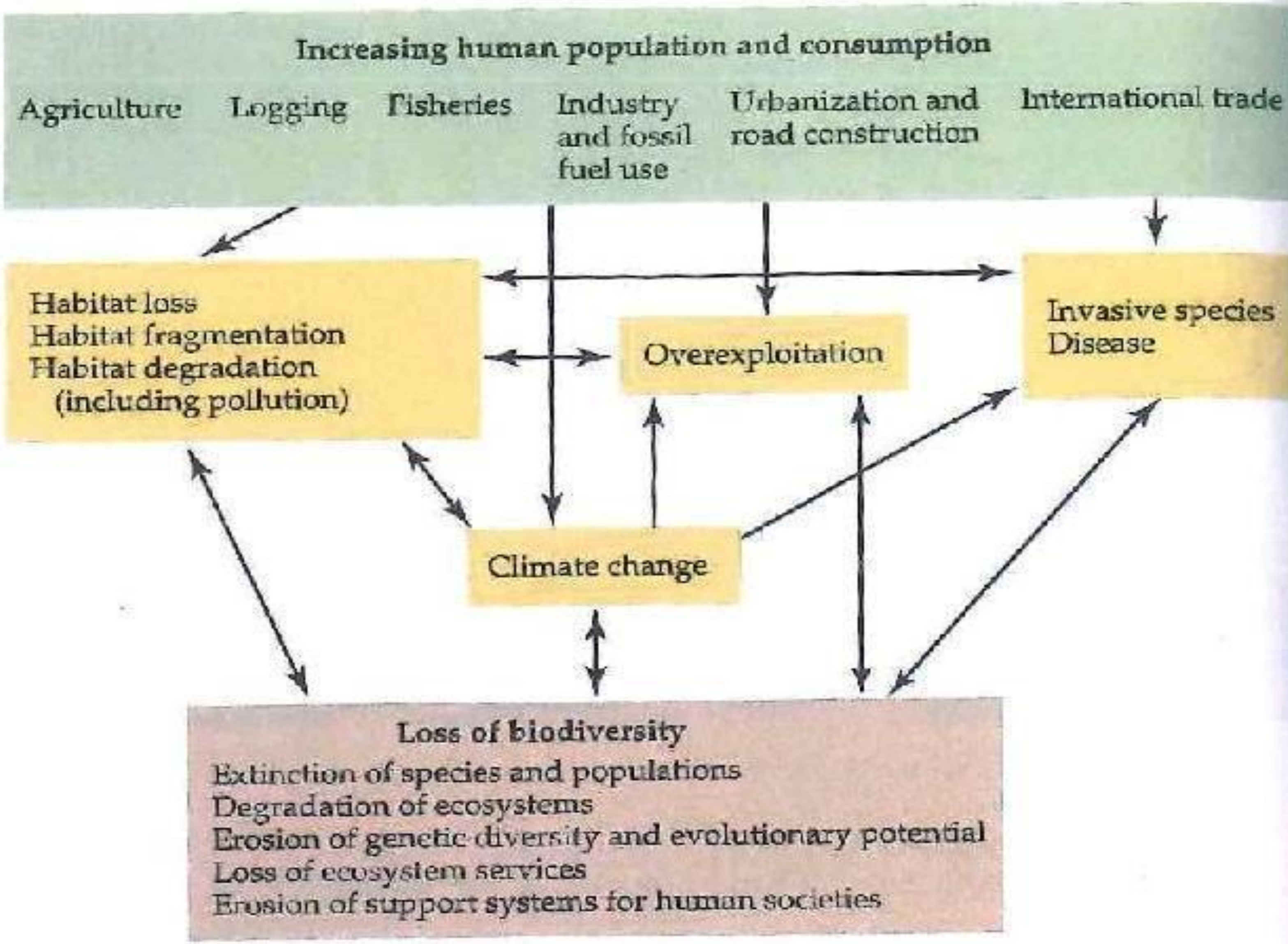


What can be done?

- In-situ conservation efforts
  - Establishment and effective management of Protected Areas
  - Managing Biodiversity outside PAs
  - Awareness generation
  - Eco-development and people's involvement
  - Promoting sustainable development
- Ex-situ approaches
  - Cloning, maintaining gene bank etc
  - Captive breeding
  - Plantations
- Enactment and enforcement of legal provisions

A lot more can be done

THANK YOU



Increasing human population and consumption
Agriculture
Logging
Fisheries
Industry and fossil fuel use
Urbanization and road construction
International trade
Habitat loss
Habitat fragmentation
Habitat degradation (including pollution)
Overexploitation
Invasive species
Disease
Climate change
Loss of biodiversity
Extinction of species and populations
Degradation of ecosystems
Erosion of genetic diversity and evolutionary potential
Loss of ecosystem services
Erosion of support systems for human societies