WILDLIFE BIOLOGY

Exotic species

A species which does not occur naturally in an area (i.e. is not indigenous), but which has been introduced there by people, is called an alien. Sometimes people use the word "exotic" instead of alien, but this is not the best word as it has many other meanings.

Invasive and exotic species are any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem; and whose introduction does or is likely to cause economic or environmental harm or harm to human health.

The geographical ranges of many species are restricted by major environmental and climatic barriers to dispersal. The great majority of exotic species do not become establishes in the places to which they are introduced because the new environment is not suitable to their needs. However, a certain percentage of species do establish themselves in their new home and many of these increase in abundance at the expense of native species. The exotic species may displace native species through competition for limiting resources. Exotic animals may prey upon native species to the point of extinction, or they may so alter the habitat that many natives are no longer able to persist. Many areas of the world are strongly affected by exotic species.

The effects of exotic species are generally greatest on islands and in continental areas that have experienced human disturbance.

The exotic species have ability to invade because of the absence of their natural predators, pests and parasites in new habitat. So exotic easily invade-dominate new habitat-spread in size-making area unfavorable for native species-low favored area- native population low-displace natives.

Table-1: Some invasive species in Nepal

Latin name	Local name	Native	Habitat
Cassia tora	Tapare	South America	grassland, unmanaged forest
Ipomea carnea	Besaram	South America	Mist jungle, abandoned cultivated land
Mikania macrantha	Lahare Banmara	Mid/south America	Riverine forest, grassland, degraded forests
Xanthiu strumarium	Bhende kuro	Middle America	Unmaanaged land, roadside
Lantana camera	Gandhekanda	Middle America	Moist place, roadside, abandoned cultivated land
Mimosa pudica	Lajwanti	America	Grassland and forests
Eichornia crassipes	Jalkumbhi	South America	Lake, pond, water channel, wetlands
Chromolaena	Banmara	North America	Grassland, periphery of jungle

odorata			
Oxalis latifolia	Chari Amilo	America	Cultivated land

Corridors

In common usage, corridor has been defined as 1) “A gallery or passageway. . . one into which compartments or rooms open,” 2) "A gallery or passageway connecting several apartments of a building,” 3) “. . . a narrow passageway or route” (Merriam Webster and Co. 1961). The common elements of these definitions most relevant to their ecological application are the terms passageway and connecting. With “passageway” there is an implicit concept that the corridor is narrow relative to the habitats being interconnected.

In landscape ecology, Corridors are defined as “. . . narrow strips of land which differ from the matrix on either side. Corridors may be isolated strips, but are usually attached to a patch of somewhat similar vegetations” (Forman
and Godron 1986). This definition characterizes corridors in terms of their shape and spatial context, but does not explicitly ascribe a functional role.

Biological corridor is a linear landscape element that provides for survivorship and movement, but not necessarily natality, between other habitats. Thus, not all of species life-history requirements may be met in a corridor.

Areas that provide connectivity for movement of wide ranging species such as elephants. Area that provide buffers of suitable habitat types to existing PAs. It provides connectivity of suitable habitats. These are the patches of relatively unfragmented natural habitat.

The goal of corridors to preserve ecological and evolutionary process, as well as enhance connectivity between important conservation sites by effectively increasing the amount of habitat.

Habitat corridors, wildlife corridors, dispersal corridors, stepping stones, Metapopulation

TAL: Laljhadi, Basanta, Khata, Barandabhar corridors

Small sized PAs - isolation - connectedness - corridors

Negative aspects: diseases spread, fire, weeds, more cost for establishment and management, animals more vulnerable to poaching

Rare

Species that have small total numbers of individuals, often due to limited geographical ranges or low population densities. Although these species may not face any immediate danger, their small number make them likely candidates to become endangered.

Species are rare, at least 7 kinds of rarity based on the species geographic range, habitat specificity, and local population size are described by Robinowitz et. al., 1986.

Wide geographical distribution

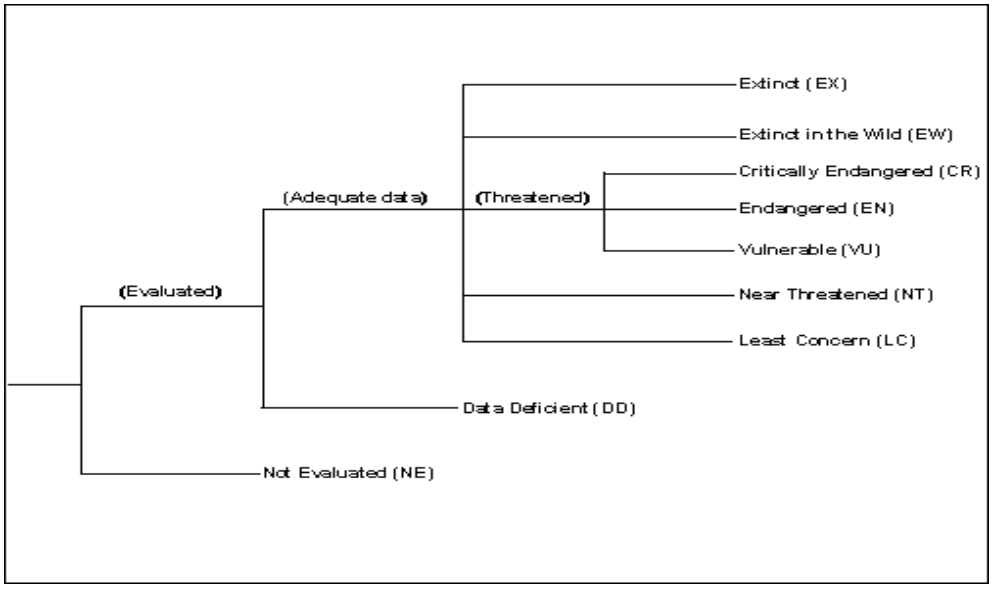
1. Broad habitat specificity, local population small everywhere
2. Restricted habitat specificity, population large somewhere
3. Restricted habitat specificity, population small everywhere

Narrow geographical distribution

4. Broad habitat specificity, population large somewhere
5. Broad habitat specificity, population small everywhere
6. Restricted habitat specificity, population large somewhere
7. Restricted habitat specificity, population small everywhere

Some species may be locally rare but globally common (eg, balckbuck in Nepal). Others may have a single or few larger populations elsewhere. A species may be rare (Adapted from Begon et. al. 1990) because;

- its habitable areas are rare
- its habitable areas remain habitable for too short a time
- competitors, predators or parasites reduce population below the level set by resources in the habitable areas
- is habitable areas are small
- Some habitable sites are beyond its range of dispersal
- its resources are present only in small amounts or in low densities
- its genetic variation narrowly limits the range of areas



Extinct

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 cycle and life form.

A species is said to be extinct when it has not been seen for over 50 years.

Examples: Pink headed duck (*Rhodonessa caryophyllacea*) Aceros nipalensis,

Extinct in the wild

A taxon is extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized 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.

In both of these situations the species would be considered globally extinct.

A species is considered locally extinct when it is no longer found in an area that it once inhabited but is still found elsewhere in the wild. It is also called as ecological extinction. Lion from Nepal, Cheetah from Indian continent, Blackbuck from Suklaphhanta etc.

Critically endangered

There is an extremely high risk of it becoming extinct in the immediate future for eg, Gharial

Out of 8 vulture species found in Nepal, 3 species (White rumped vulture, slender billed vulture, red headed vulture) are critically endangered.

Endangered

Species that have a high likelihood of going extinct in the near future. Included are sps whose numbers have been reduced to the point that the survival of the species is unlikely if present trends continue.

There is a very high risk of it becoming extinct in the near future.

Eg: Arna, Swamp deer, Tiger, Elephant, Musk deer, Cheer pheasant, Bengal florican, Bijayasal etc

Vulnerable

Species that may become endangered in the near future because their population are decreasing in size throughout their range. The long term viability of vulnerable species is not certain.

There is a high risk of it becoming extinct in the medium term future.

Category/Criteria	Critically endangered	Endangered	Vulnerable
Reduction in population size over last 10 years or 3 generations	Greater or equal 90%	Greater or equal 70%	Greater or equal 50%
Geographic range (extent of occurrence)	Less than 100 sq. km.	Less than 5,000 sq. km.	Less than 20,000 sq.

			km.
Population size (mature individuals)	Less than 50	Less than 250	Less than 1,000

Near threatened

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

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

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, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

Not evaluated

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

IUCN (2008)

Extinction crisis has been confirmed
16, 928 species in Red list of threatened species (3246 CR, 4770 EN, 8912 VU)
1 of 4 mammal species is at risk of disappearing forever,
1141 of 5487 mammal species are threatened with extinction (188 mammal CR, 450 mammals EN, 836 mammal data deficit)

Nepal
1065 animal species in Red list
74 animals threatened (mammals 32, birds 33, reptiles 7, amphibians 3)
34 plant species in red list (7 spp are threatened)

	2007	2008
Mammals CR	168	188

Mammals EN 349 448

Rhinoceros	EN (2007)	VU (2008)
Common leopard	LC (2007)	NT (2008)
Chinese Pangolin	NT/LR (2007)	EN (2008)

Out of 863 bird recorded in Nepal, ca 15% (133 spp) are threatened, 72 spp are CR.

National Red Data Book (Nepal) 1995
59 mammals, 279 birds, 35 herpetofauna, 34 fishes

See: IUCN Red List of Threatened Species: 2001 Categories and Criteria V 3.1

Mace and Lande (1991) have proposed a three level system of classification based on the probability of extinction.

1. **Critical speci**es: have a 50% or greater probability of extinction within 5 years or 2 generation.
2. **Endangered species**: have a 20-50% probability of extinction within 20 years or 10 generations
3. **Vulnerable species**: have a 10-20% probability of extinction within 100 years.

Depleted species

A depleted species is one whose numbers have dropped lower than the optimum sustainable population. The optimum sustainable population is determined by whether the animals are reproducing in a healthy number that corresponds to the carrying capacity of the environment.

Buffer Species

A plant or animal which may serve as an alternate food supply for a consumer animal, lessening the demand for a more desirable food species is called as buffer species. A buffer species is essentially an alternate species that serves to decrease predation pressure on another species. For example, an abundance population of wild pig could serve as prey for tigers that could otherwise feed on sambar and swamp deer. In general, the more complex the community, the greater the number of buffer species. In such communities, predator population sustained at a moderately high level by shifting from one type of prey to another, depending on the relative abundance and the ease of capturing each species.

Home range

The area in which an individual spends all, or most of its time is known as its home range. Home range is that area traversed by the individuals in its normal activities of food gathering, mating and caring for the young (Burt, 1943).

Total area: entire area covered by an animal in its life time

Home range: area an animal learns thoroughly and habitually perambulates

Core area: area of heaviest use within the home range

Territory: Area occupied more or less exclusively by an animal or group of animals by means of repulsion through over defence or advertisement.

The home range contains all the food, shelter, escape cover and other needs for the individuals that occupy them. Migratory species have 2 different home ranges, one for winter and one for summer. Between these they travel over a clearly defined migration trail. It can be taken as a single, elongated home range.

Herbivores have much smaller home range than did granivores, fructivores, insectivores, and carnivores.

Large animal need to eat more food and so in general, we would expect them to have larger home ranges. Specialist feeders have larger home ranges than do generalists. Gregarious species tend to have larger home ranges than do solitary ones.

Methods of home range calculation

1. **Minimum convex polygon method** (Southwood, 1966)
    - Quick and easy to calculate by hand
    - Widely used due to its simplicity
    - Sample size bias (home range size increases with sample size)
    - Shape is usually convex polygon
2. Bivariate normal method
3. Ford and Krummet
4. Grid square method
5. Fourier transform method

Territory

Elliot Howard, an English bird watcher, coined the word territoriality to describe the behaviour of the male birds. The idea of animal territories was first introduced by the ornithologist Eliot Howard in a book “Territory in Birdlife” published in 1920.

The occupancy of an area by an individual or a group to the usual exclusion of their individuals or groups of the same species, the area is known as territory, and the behaviour that leads to such exclusive or near exclusive occupancy and spacing of home areas is known as territorialism.

Territories may be held by an individual, a mated pair, or a group. Territoriality is not a fixed property of a species: for example, robins defend territories as pairs during the breeding season and as individuals during the winter. Some mammals have herd or pack territory (eg, wolves). In species that do not form pair bonds, male and female territories are often independent, in the sense that males defend territories only against other males, and females only against other females; in this case, if the species is polygynous, one male territory will probably contain several female territories, while in some polyandrous species

such as the Northern Jacana, this situation is reversed. He convinced the scientific world that, among other things, song is used by male birds to mark their territory and territoriality is typically manifested by aggression toward intruders. Territory marking by male tiger is usually by scratching, scent-urine.

Territorial behaviour is often viewed as a tactic by which individuals may increase their fitness through the defence and acquisition of resources such as food, shelter, or mates. However, because the costs of defence can outweigh the benefits of holding a territory, animals are predicted to defend territories only when there is a net benefit. Given that an individual has decided to defend a territory, a fundamental question is how large an area should be defended. Howard (1920) concluded that the territory size is often inversely related to food abundance. Territory will be larger if the energy yield from the habitat is poor. It helps to maintain pairs, regulate population density and decrease competition for young.

Interspecific (between species) territoriality is often less vitriolic than intraspecific. it could be due to food (eg leopard and tiger). When territory owners experimentally removed or die naturally their places taken over by new comers. According to Nice (1941) and Wilson (1975), territories are:

Type A: large defended area in which requirements for mating, rearing young and gathering at least most of the food are met.
Type B: all breeding activity occurs but not most of the food gathering
Type C: smallest, small defended area around the nest of colonial nesting birds
Type D: leks, pairing and mating area, defended by polygamous birds
Type E: quite small like C, roosting positions only.

Dispersion

- Spatial distribution of a species
- solitary or gregarious

Dispersal

Animal's movement

1. Internal to the area: it do not affect population composition, short, daily travels.
2. External to the areas: it change population composition, those travels are dispersal, which establish new populations and result in the colonization of new areas.

Dispersal: due to antagonism between young and parents and adult fighting. A single animal on one journey can be both an immigration and emigration. Immigration and emigration is not a migration. Migration is a two way movement within the area. Immigration is a movement into a new area. Emigration is a movement out of a previously occupied area.

Flag ship Species

Flagship species are charismatic species that serve as a symbol and rallying point to stimulate conservation awareness and action but are often used synonymously as de facto umbrella species. Flagship species are charismatic megafauna. These species act as ambassadors for a natural habitat, issue, campaign or environmental cause. By focusing on, and achieving conservation of that species, the status of many other species which share its habitat may also be improved. Flagship species may or may not be keystone species and may or may not be good indicators of biological process.

TAL : Rhinoceros, Elephant and TIGER

Key stone species

A species whose presence has a disproportionate effect on the community structure. For instance, a top predator that enable other species to coexist in the community, or a species that is a critical food resources to many other species (eg, ficus tree stand).

Umbrella species

A species whose preservation or management indirectly serves to preserve many other species. For instance, if it requires such a large area to persist, that most other species in the community also can persist in that area. Tiger may be umbrella species.

Endemic species

Species with an exclusively local range (at a spatial scale). Species of very small biogeography are endemic species. Centers of endemism are areas where we can find high concentration of species that are found nowhere else and probably originated therein. An endemic species is not only indigenous, but is restricted to a particular area. Some species have very small ranges but can found in two countries (Border species).

In Nepal:
342 (399?) endemic flowering plants, 14 herpetofauna, 6 fish species, 108 spiders
Annapurna CA: 56 of 3430 flowering plants are endemic
Dhorpatan HR: 36 of 1150 flowering plants are endemic
Shey Phoksundo NP: 30 of 1579 flowering plants are endemic

For example: Endemic bird: - Spiny Babbler found in ACA, MCA, KNP, SNNP, BNP
Endemic mammal: - *Apodemus gurkha* found in 2200 to 3600m in central Nepal

Indigenous species

An indigenous species is one which occurs naturally in the place in which it is currently found, and has not been assisted in its travels by people. Being indigenous does not mean that a species has always occurred where it is now found - some species shift their distribution quite quickly.

Nomadism

- a form of migration
- irregular long distance movement
- portions of range may be abandoned and not revisited for many years
- differ greatly from year to year
- the entire population will shift to a new region

Carrying capacity

Carrying capacity is an attempt to define the level of tolerance or compatibility between animal activities and demands and the ecological, social and economic support systems to meet those demands. It understands for the number of animals that an area can sustain without damaging the integrity of the natural environment and diminishing the habitat value of the species.

It is the number of conspecific animals that can be supported within a given area. In other words, it is the average number of animals that a habitat can maintain in a healthy, vigorous condition.

The idea of carrying capacity assumes that there is a level of development and a maximum number of animals that an area can tolerate without adverse effects on the environment.

Carrying capacity is a relative and dynamic concept. All natural areas are considered to have limited ecological, physical and aesthetic carrying capacity. A number of factors need to be considered in determining the various carrying capacities (CC) of an area. CC of any particular site or area may be seen as a function of a number of variables-the quantity and variety of resources, the tolerance of resources to use, the number and frequency of animals, their activity types and intensity of resource use, provision and maintenance of infrastructure facilities, monitoring and management of resource use sites, and expectations, attitudes and behavior of animals as well as managers of resources and local community.

The notion of carrying capacity presumes that there is always an upper limit beyond which sustainable use of the resource is not possible.

Edge and ecotone

The zone of contact between two or more habitat types is termed edge. Edge species are species which occur primarily or most abundantly or spend the greatest amount of time in junction between communities. Forest Edge benefits some species, but has a strong impact on other woodland flora and fauna. Animals of edge require 2 or more vegetation communities. Because of species responses, the variety and density of life are often greatest in and about edges and ecotones. This phenomenon is called edge effects or law of interspersion.

Amount of edge available (length, width, degree of contrast between adjacent communities affects the availability of animals. Very small or irregularly shaped reserves may be unable

to sustain populations of forest interior plants. Faunal effects of a forest edge would exceed floral effects.

Ecotone

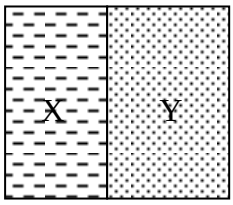
Where 2 or more communities not only meet but also intergrade. It is a junction zone or tension belt which may have considerable linear extent but is narrower than the adjacent communities. Eg, woodland-grassland, marsh area between lake and terrestrial ecosystem.

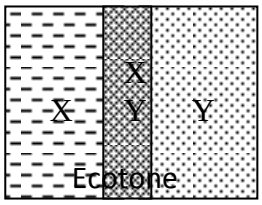
Ecotone was introduced to designate the ambiguous between two patches. Ecotone exhibits a shift in dominants of certain species of community.

Edge and ecotone are more applicable to low mobility species.

Types of edges and ecotone

1. Abrupt, narrow edge: due to changes in edaphic factors eg soil, topographic differences, micro climatic changes (also called inherent edges)- more stable and permanent type.
2. Induced edge: due to natural disturbances such as fires, storms, floods or from such human induced disturbance ass livestock grazing, timber harvesting, land clearing and agriculture. Human induced edge could be abrupt or transitional resulting in an ecotone.





Niches

The animals place in the biotic environment and its relation to food and enemies is its niche. The total expression of all ecological conditions, reactions and capacities that describe the total functioning of an organism within the habitat. Niche is the:

- Role of an organism within a community
- Functional role of a species in a community, including activities and relationships
- Profession of a species

Fundamental niche

An individual or a species free from the interference of another could occupy the full range of variables to which it is adapted. This is the idealised niche. If fundamental niche of 2 sps overlap, then 2 sps are competing.

Realised niche

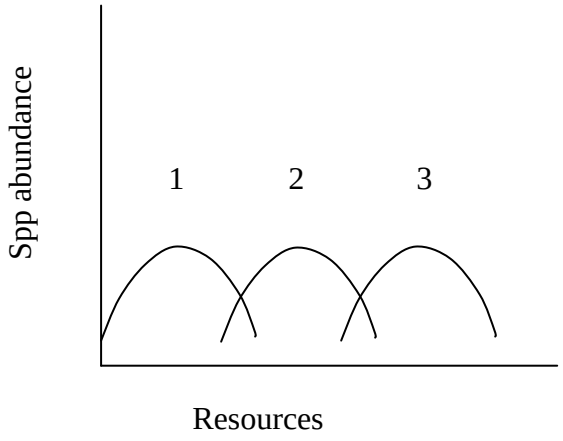
It is the range bounded by actual ranges, as found in the field of each variable. Species in one community may be more specialised (i.e., adapted to a narrow range of food, soil ort other environmental factors). They may have narrow niches.

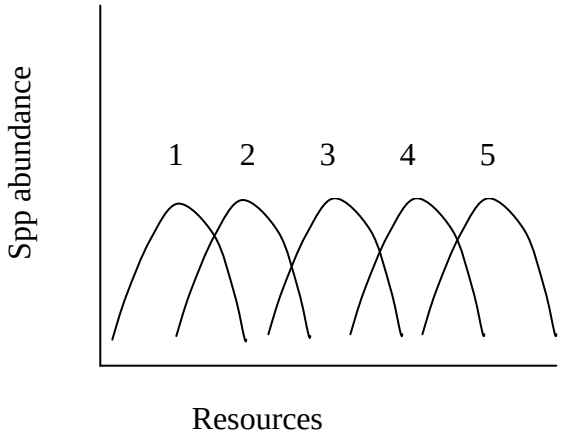
A species is adapted to certain habitat(s), it prefers certain type of cover and feeds on certain certain sizes and categories of food. No other species in the habitat prefers precisely the same food or cover. Consequently, each species has exclusive occupancy of its own niche, although portion of it may be used by other birds and mammals. If another species attempted to use the same foods, it would compete directly with another species. Either of one sps would be displaced or the competitor could not become established.

A species and its niche tend to evolve together. Deer occupying a grassland create the kind of grassland most favorable to deer, thus create deer niche.

The niche of exotic and native species may overlap lead to disappearance of native one.

The idea that each species has its own niche and no 2 spp can occupy the same niche in the same area is useful for understanding the way spp have sorted themselves out over time in well established natural community. It does not account the dynamics of spp interaction and adaptations. In disturbed and restorated habitats the niche may be different for the same species.



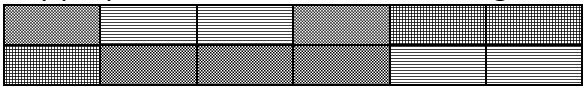


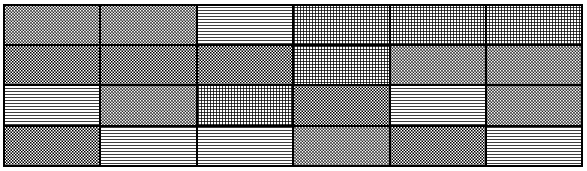
Broad niches
Low diversity
High abundance

Narrow niches
High diversity
Low abundance

1.2 Interspersion and juxtaposition

Interspersion and juxtaposition describe arrangement and proximity of habitat in the landscape, interspersing patches or stands on a landscape creates more edge. Juxtaposition is the spatial relationship/association/network of habitats. It is related to species requirements. Recognizing the complexity of habitat requirements, the edge between two or more habitat will be more favorable as wildlife habitat. Because of species responses, the variety and density of life are often greatest in and around edges and ecotones. Both the number of species and the total biomass tend to be larger in the edge areas. Aldo Leopold (1933) has stated this phenomenon as law of interspersion. According to this law, the density of wildlife is directly proportional to the amount of edge.





Different pattern denotes different habitat types

1.3 Translocation

Translocation is the deliberate movement of individuals to an existing population of conspecifics. It is a deliberate and mediated movement of wild individuals or populations from one part of the range to another.

Introduction is simply introduction of species into wild, generally, outside its range but into suitable habitat.

Conservation\Benign Introduction: An attempt to establish a species for the purpose of conservation outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool when there is no remaining area left within a species historic range. Introduction may be useful in stocking new or artificially altered habitats for example where dams or irrigation projects have created new lakes or swamps.

Reintroduction is an attempt to establish a species in an area which was once part of its historic range but from which it has been extracted or become extinct. The principle objective is to create

Reestablishment is a synonym but implies that the reintroduction has been successful. Simply it is an introduction of species back into the wild area that has been used by the species previously.

Reinforcement\ Supplementation is the addition of individuals to an existing population of conspecifics. Translocation is considered in 3 main circumstances, first, where land development is about to destroy wildlife habitat and translocation is seen as a possible way, secondly, where a wild population is not faring well and the manager wishes to boost its numbers and thirdly, where a manager decides to split a population to reduce the risk of losing the entire population.

Restocking is the movement of the number of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat.

Aims and objectives of reintroduction

The principle aim of any reintroduction should be to establish a viable free ranging population in the wild, of a species, which has become locally or globally extinct or extricated in the wild. It should be reintroduced within the species former natural habitat or range.

The objective of a reintroduction may include enhancing the long tem survival of a species to reestablish a key stone species (in an ecological or cultural sense) in an ecosystem, maintain and /or restore biodiversity, to provide long term economic benefits to the local and/ or national economy to promote conservation awareness, or a combination of these.

A detailed study that examined 198 birds and mammals reintroduction program conducted between 1973 and 1986 found a number of significant generalizations (Griffin et al 1989 in Primack, 1995). The reported success of program in establishing new populations was.

- Greater for game species (86%) than for threatened, endangered and sensitive species (44%)
- Greater for release in excellent quality habitat (84%) than in poor quality habitat (38%)
- Greater in the core of the historic range (78%) than at the periphery of and outside the historic range (48%)
- Greater with wild caught (75%) than with captive bred animals (38%)
- Greater for herbivores (77%) than for carnivores (48%)

Biological hotspots

Biological hotspots are earth's biologically richest regions that harbour a great diversity of endemic species and have been significantly impacted and altered by human activities. Plant diversity is the biological basis for hotspot designation; To qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and it has to have lost at least 70 percent of its original habitat.

- Norman Myers in 1988 first identified ten tropical forest "hotspots" characterized both by exceptional levels of plant endemism and by serious levels of habitat loss.
- In 1990 Myers added a further eight hotspots, including four Mediterranean-type ecosystems.
- In the 1999 analysis, published in the book *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*, and a year later in the scientific journal *Nature* (Myers, et al. 2000), 25 biodiversity hotspots were identified.
- In total, this updated analysis reveals the existence of 34 biodiversity hotspots, each holding at least 1,500 endemic plant species, and having lost at least 70 percent of its original habitat extent. Overall, the 34 hotspots once covered 15.7 percent of the Earth's land surface. In all, 86 percent of the hotspots' habitat has already been destroyed, such that the intact remnants of the hotspots now cover only 2.3 percent of the Earth's land surface.

Hotspots are not the only system devised for assessing global conservation priorities.

- BirdLife International, has identified 218 "Endemic Bird Areas" (EBAs) each of which hold two or more bird species found nowhere else.
- The World Wildlife Fund-U.S has derived a system called the "Global 200 Ecoregions", the aim of which is to select priority Ecoregions for conservation within

each of 14 terrestrial, 3 freshwater, and 4 marine habitat types. They are chosen for their species richness, endemism, taxonomic uniqueness, unusual ecological or evolutionary phenomena, and global rarity. All hotspots contain at least one Global 200 Ecoregion and all but three contain at least one EBA; 60 percent of Global 200 terrestrial Ecoregions and 78 percent of EBAs overlap with hotspots.

Examples:

'Western Ghat and Sri Lanka' and 'Eastern Arc Mountain and Coastal Forests' are two examples of biological hotspots. Western Ghat and Sri Lanka is the home to 2180 endemic plants and 355 endemic vertebrates whereas Eastern Arc Mountain and Coastal Forests supports 1500 and 121 endemic plants and endemic vertebrates respectively.

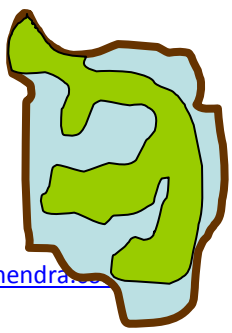
Nepal in context:
Sagarmatha National Park and Chitwan National Park with typical natural, cultural and landscape characteristics were listed as World Heritage sites in 1979 and 1984, respectively. Similarly, 7 monuments and buildings of Kathmandu and Lumbini, the birthplace of Siddhartha Gautam has been inscribed as Cultural World Heritage Sites in 1979 and 1997. Nepal presently has 9 sites designated as Wetlands of International Importance (Ramsar Sites) covering 34,455 ha, and 0.23% of Nepal's area. Six of nine Ramsar sites are inside the PA system (Poudel, 2009). There are 27 Important Bird Areas (IBAs), covering about 18% of the country's land area. Thirteen IBAs are wholly within PAs, 2 are partially protected and 12 are unprotected. About 81% of the total area of IBAs is included in PA system (Baral and Inskipp, 2005). Nepal have 7 species of plants, 32 species of mammals, 32 species of birds, 7 species of reptiles and 3 species of amphibians are globally threatened (IUCN, 2008). A total of 54 Important Plant Areas (IPAs) complex for medicinal plants have been provisionally identified which comprise altogether 230 IPAs or rich diversity of the priority medicinal plants (Hamilton and Radford, 2007).

Fragmentation

Fragmentation occurs when a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original.
When the landscape surrounding the fragments is in hospitable to species of the original habitat and when dispersal is low, remnant patches can be considered true "habitat islands" and local communities will be "isolates".

Effects:
Reduction in total habitat area (affects Population & Extinction rates)
Redistribution of remaining area into disjunct fragments (affects dispersal & immigration rates)
Extinctions: Due to Habitat degradation & Insularization

Process of fragmentation



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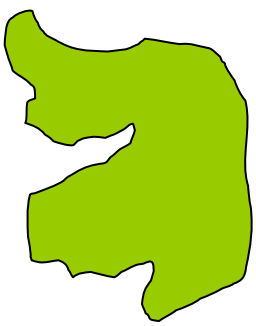
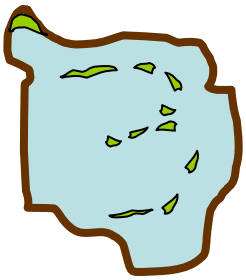




83000 forest patches in TAl.

Special habitats: riparian zone

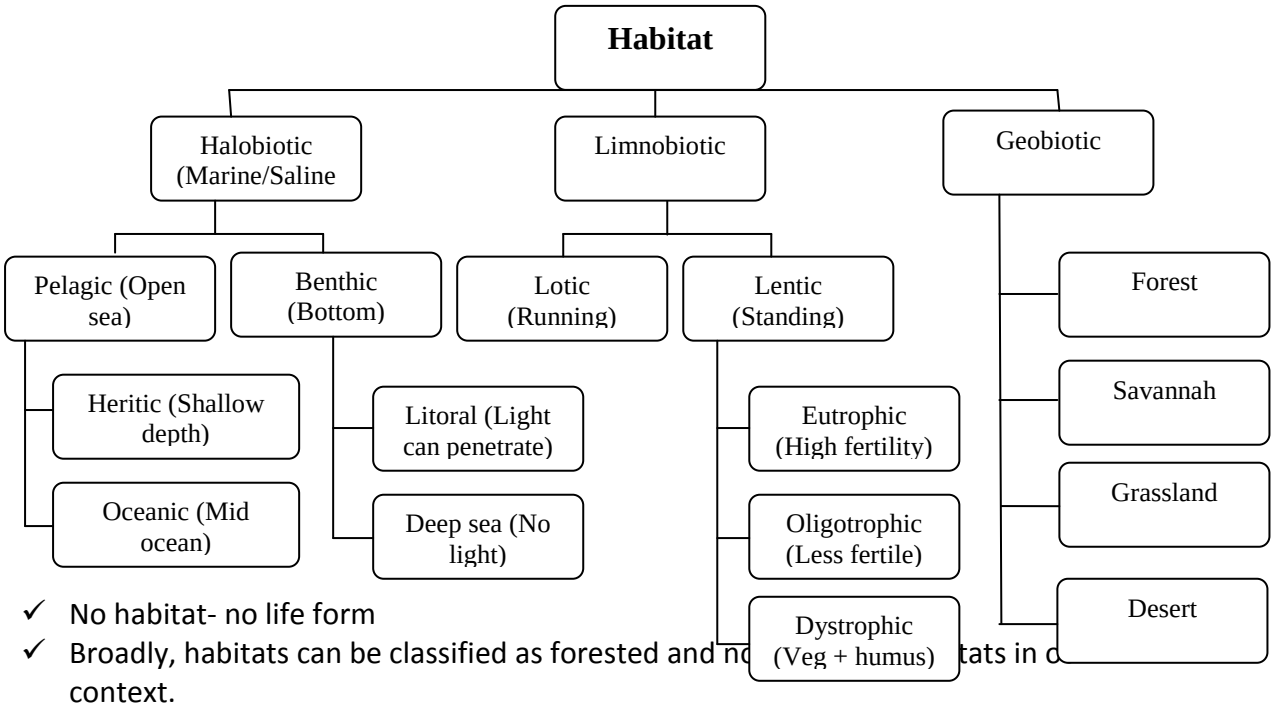
Unique habitats: snag, cave, den

2: Wildlife Habitat

2.1 Habitat Components: Food, Cover, Space and Water

Habitat is the place where a plant or animal lives (Smith). Habitat is the specific set of environmental conditions under which an individual species exists and meets its requirements. It is the address of the species. Protected areas are the better habitat of wildlife. Species vary in their habitat requirements, so that any given are may provide excellent habitat for one species but may be completely unsuitable for others.

Habitat classification (global level)



- ✓ No habitat- no life form
- ✓ Broadly, habitats can be classified as forested and no tats in c context.
- ✓ Agricultural fields serves as important habitat for many insects, small mammals, birds etc

- ✓ Habitat factors: biotic (such as plant, animal, human use etc) and abiotic (such as soil, water, climate, geomorphology etc)
- ✓ Unique habitats: Snags, logs, cliff, caves etc
- ✓ Special habitat: Riparian zone, secondary forests, scrubs land etc.
- ✓ Habitat components: Food, cover, space and water

2.1 Habitat components

Food

Food is the most important critical component of any wildlife habitat. The availability of food changes with seasons. Food may be plentiful in one season and critically short in another. For carnivores or predators, food availability simply means prey availability. Carnivores expend energy searching for, chasing, capturing, and killing prey, but these extra expenditures are offset by the higher concentration of the energy contained in the animal matter of their food. Because animal matter is nutritionally complete and easy to digest, predators seldom experience qualitative food deficiencies from natural diets.

Herbivores, on the other hand, depend upon foods that require no active pursuit but that are lower in energy and more variables in protein and nutrient composition. Thus, they must spend more time actually eating than do carnivores. For herbivores, food can become critical in 2 ways: an overall shortage (quantitative food stress) or an unbalanced diet (qualitative food stress) such as one deficient in proteins.

Animals do not feed randomly but instead show clear and predictable preferences for certain plants over others. This selective behavior leads to preferences from digestibility, palatability or taste. The usual classifications are **preferred** –first choice and always taken more frequently, **staple** – second choice but still providing all nutritional needs, **emergency** – able to furnish only short term nutritional needs and **staffers** – useless nutritionally and ingested apparently to relieve hunger pangs.

Cover

Any variation in the habitat that provides protection from weather or predators or that offers a vantage point is termed cover. In a terrestrial habitat vegetation provides food and cover for different species inhabiting it. The different layers of vegetation and their structure act as a resource for cover which is crucial for species to survive and perform various activities.

Types of cover

Escape cover: required for most of the prey species to hide or escape during predators attacks. For example, many ungulates rush from open areas to dense vegetation and/or remain motionless in dense shrubs or ground layer vegetation to avoid detection by predators. Escape terrain- cliff in mountain to escape from predators.
Ambush cover: Stalking predators use dense shrubs and ground layer vegetation to ambush their prey. For example, Tiger, Leopard, Snow leopard etc.

Resting /Thermal cover: Protection against severe weather, high temperature (during day, relief from wind and precipitation). Foe example, use of high tree and canopy cover or high shrub cover areas by elephant, deer to escape from heat.

Escape and resting cover for fawn: Most of the deer are hiders. Mothers conceal their new born fawns in dense grass/shrub cover sites and nurse them regularly while feeding nearby. Sometimes also called as fawning cover.

Nesting/Roosting cover: can be critical for many kinds of birds.

Water

Water is the most critical component of a habitat. Animals fulfill the water need by;

- ✓ Drinking
- ✓ Ingesting the water contained in succulent plants
- ✓ Metabolism

Some are purely aquatic and some are dependant on water. For aquatic animals, water is the habitat, and the water is must while all other organisms depends on water.

Water systems are mainly lotic and lentic. Lotic system includes rivers and streams (flowing water) and lentic means stagnant water for e.g., ponds, lakes etc.

Water is mostly available everywhere in rainy season and can be scarce in dry season. Waterhole constructed or remained in a habitat act as a hub of many wild animals during pinch period. Source (temporary or permanent) and area (size: small or large) of waterhole are important.

Wetlands are considered as:

- the kidney of nature
- biological hotspot
- most productive ecosystem (tropical wetlands)

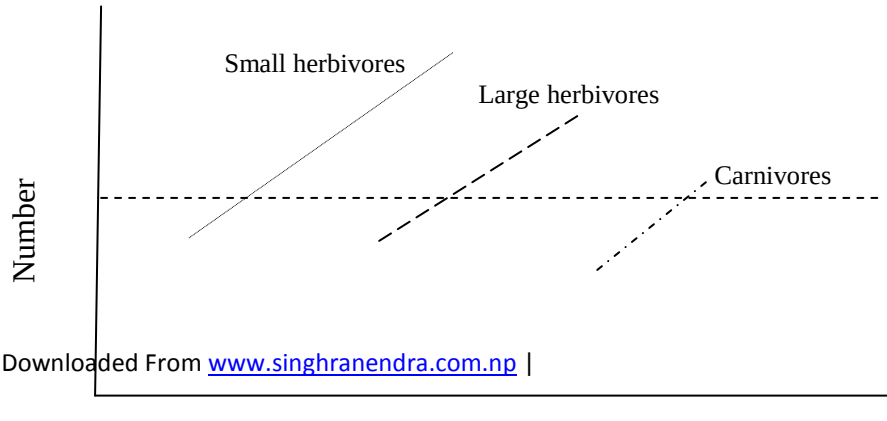
Waterholes are vulnerable and sensitive habitat because the poacher or people can poison the waterhole for retaliation and for many other purposes.

Water needs differs with species and with individuals. For example, deer take water twice a day, tiger once in a day. Rhino spends about 10-20% day time in water - Rhino wallowing.

Riparian habitats occur naturally along rivers and streams. Vegetation changes with changes in rainfall pattern and affects obviously the faunal distribution.

Space

Space is the habitat where an animal or group of animals find food, cover, and water and locate mates. The space largely determines the population size of a species. Generally larger the animal the larger the space required. Space depends on productivity and diversity of the habitat in relation to habitat requirements. One habitat may be shared by many individuals and even by many species. Protected area is the better space for many wild animals.



Conservation biology theories support the following consideration in protected areas design, while talking to wildlife space.

Better space (Better areas)	Worse
Large	Small
One large	Several small
Close together	Far apart
Shared habitat	Linear- less shared habitat
Corridors	No corridors
Round	Not round

2.2 Concepts related to wildlife habitat trophic levels

2.2.1 Energy transfer

Wild animal lives in natural habitat. Species obtaining food in same way are on the same trophic level/energy level. Generally, green plants/primary producers are at the first trophic level, herbivore at second and carnivores are at the third trophic level. In terrestrial ecosystem, there are 3 or 4 energy levels whereas in aquatic habitat it may be upto 10 levels.

Species in adjacent trophic level linked together, is called food chain. The pathways over which energy move through an ecosystem are called food chain. The complex link between levels is called food web. The ecological systems are dynamic and changing over time.

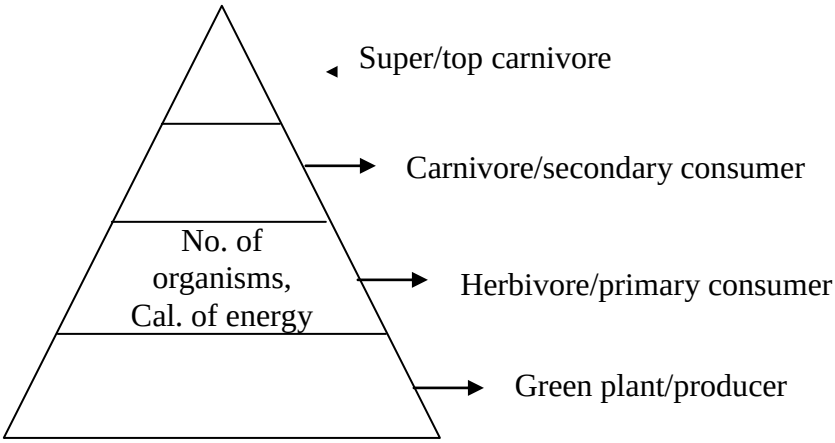
Energy pours down from sunlight and captured by green plants and transformed and stored in plant tissues. The energy is used by green plants for growth and development and for metabolism. Plants stores energy in the form of starches, proteins etc. The functioning of ecosystem depends on inflow of energy.

The energy in sunlight is large in relation to amount actually captured and used by a biotic community. Most of it is lost to the ecosystem. The efficiency of green plant to transfer and store the energy available to them is low (around 1%). However plants are the most efficient converters of solar energy into forms useful to animals and humans.

Direct capture of solar energy and its use in heat, electricity is also prevalent. In each energy transfer (plants-herbivore-carnivore) some energy is lost. No energy transfer is 100% efficient. A great deal of energy is lost at each step up the food chain or web. Thus productivity of carnivore within a community is much less than that of herbivore. If the consumers are birds or mammals (Homeothermic) the energy transfer rates are low as they pay high energetic cost to maintain more or less constant body temperature. The energy is lost during digestion and metabolism in the form of heat.

The second law of thermodynamics states that energy can not be transformed from one form to another without enormous loss. This principle applies to transfer of energy between trophic level. Many says that the average energy transfer is 10%, 90% lost.

Because of energy relationship, this concept is useful to animal distribution within an ecosystem. The species of different energy level are found in the form of biotic pyramid (broad at the base and tapering towards the top). Relationship between trophic level in a community can be expressed in terms of relative number, biomass, or energy transfer (productivity).



Therefore the statement 'prey determine the predator level" is always true and "predators determine the level of prey population" is sometimes true.

2.2.2 Carrying capacity

It is an important concept in wildlife management. Carrying capacity (CC) is the functions of habitat rather than of factors intrinsic to the population

Carrying capacity is an attempt to define the level of tolerance or compatibility between animals requirements and the ecological, social and economic setting of environment. It is the number of conspecific animals that can be supported within a given area. In other words, it is the average number of animals that a habitat can maintain in a healthy, vigorous condition.

Three ways to define carrying capacity:

1. The upper limit of population growth in a habitat, beyond which no further population increase can be sustained by the habitat (Population ecologist's view). It is sometimes denoted by 'K'. The climax of the sigmoid curve of population growth.
2. The number of animals of a given species that are actually supported by a habitat over a period of years. It requires several years' census data. Useful for waterfowl and birds.
3. The average number of animals that a habitat can maintain in a healthy, vigorous condition. This concept is more useful in range management. This is not K but more closely resembles the maximum sustained yield (MSY) pint on the logistic growth curve. Below CC, the greater amount of food, cover, space per animal leaves animals generally heavier, in better nutritional condition and with fewer signs of parasites and diseases than animals from population at CC.

Therefore, CC is number per area. CC for any species can vary between different habitats. Usual definition of CC implies that CC is static or fixed for a given species in a particular habitat. Actually habitat conditions are always changing therefore CC also changing. Carrying capacity is a relative and dynamic concept. All natural areas are considered to have limited ecological, physical and aesthetic carrying capacity. It changes between seasons. Lower CC in colder/drier season (Crunch/pinch period). A number of factors need to be considered in determining the various carrying capacities (CC) of an area. CC of any particular site or area may be seen as a function of a number of variables-the quantity and variety of resources, the tolerance of resources to use, the number and frequency of animals, their activity types and intensity of resource use, provision and maintenance of infrastructure facilities, monitoring and management of resource use sites, and expectations, attitudes and behavior of animals as well as managers of resources and local community.

The notion of carrying capacity presumes that there is always an upper limit beyond which sustainable use of the resource is not possible. The idea of carrying capacity assumes that there is a level of development and a maximum number of animals that an area can tolerate without adverse effects on the environment. It understands for the number of animals that an area can sustain without damaging the integrity of the natural environment and diminishing the habitat value of the species. The focused question is “how much use is too much?" This question has been based on the assumption that it is possible to identify specific level of use where if exceeded would lead to changes in the environmental setting.

2.2.3 Succession and habitat change

Plant succession, biotic succession and ecological succession are interchangeably used in practice. The succession is the predicatable change in the species composition of a community through time. The gradual changes in overlapping phases are termed seral stages.

Primary Succession

Primary succession is occurring for the first time in new sites which is previouslt inhabitated in forest sand dunes, in bare rocks etc.

Secondary succession

It’s a common form of succession which follows disturbances such as storms or fires. It is generally advances faster than primary succession.

Early successional stages: Pioneer species are those which occur on early successional stages. Mostly non woody and most prefers open area and direct sun light.

Mid successional stages: shade tolerant. Live longer than pioneer species.
Late successional stages: more stable plant community establishes.

Succession varies with climate, habitat type and frequency of disturbance. Similarly no animal species is equally well adapted to all successional stages. Species best adapted to late successional stages may remain at higher densities.

Habitat management includes advancing succession and setting back succession.
Setting back succession: fire, grazing, logging, mechanical treatments, use of herbicide etc
Advancing succession: planting, construction of cover etc.

Habitat change: different degree, mode, forms of habitat change

1. Habitat modification: change in form/quality of habitat. Factors may be legion such as fire, reservoir, grazing etc. Shrub land into forest, riverine forest into grasslands, grasslands into savanna type. May modify rapidly or slowly.
2. Habitat fragmentation: Linear projects such as canal, roads, bridge, railway, electricity transmission line, dam etc. Single habitat becomes fragmented into several patchy.
3. Habitat destruction: Destruction lessens the area. Flooding, agricultural expansion, commercial farming, encroachment cause habitat destruction.
4. Habitat degradation: Area may be same but the quality of the habitat will be degraded. Cutting of trees, grazing, repeated fire etc. Degradation makes an area less favorable/suitable to any species.
5. Habitat restoration: Restoration is very difficult. It means restoring to an original state. But should try to restore as original as possible.
6. Habitat improvement: Making area favorable/suitable for any purpose is improvement. It may be due to burning, through plantation or cutting etc.

2.2.4 The edge effect

The zone of contact between two or more habitat types is termed edge. Edge species are species which occur primarily or most abundantly or spend the greatest amount of time in junction between communities.

Forest Edge: benefits some species, but has a strong impact on other woodland flora and fauna. ‘Seed rain’ in small forested areas is dominated by seeds of the edge species – changes in species composition (shade tolerant replaced by shade intolerants)

Nesting success of ‘song birds’ is lower near forest edges than in the interior (higher densities of nest predators near edges). Major vegetation changes caused by the edge extended only 10-30 m inside the forest. Very small or irregularly shaped Reserves may be unable to sustain populations of forest interior plants.

Leopold (1933) explained that more edge per unit area have effects of higher production of game. This is the edge effect or law of interspersion. Density of wildlife is directly proportional to amount of edge available. Animals of edge require 2 or more vegetation communities. Because of species responses, the variety and density of life are often greatest in and about edges and ecotones. Width and quality of edge are more important than amount. Later the corollary “greater the edge-greater the overall species diversity and total abundance of wildlife” established. This edge effects phenomenon. The edge concept is

more applicable to animals which have limited mobility and varied habitat requirements. Simply the edge boost species diversity by increasing the habitat diversity. Faunal effects of a forest edge would exceed floral effects.

Amount of edge available (length, width, degree of contrast between adjacent communities affects the availability of animals. Very small or irregularly shaped reserves may be unable to sustain populations of forest interior plants.

See chapter 1 for types of edge.

Pattons (1975) technique

Circle has the least amount of edge per unit area of any geometric figure; it serves as a convenient standard. Amount of edge (d)=[total perimeter/{2*√(Area*π)}]. Shape changes the amount of edge.

a. Circle: Radius=112.8m, Area=1 ha, amount of edge = 1
b. Square: Length =100m, area= 1 ha, amount of edge=1.12
c. Rectangular: length=200m, breadth=50m, Area=1 ha, amount of edge=1,41

Baxtor and Wolfe, 1972

The number of changes between cover types along both lines furnishes an index of edge.

3. Wildlife populations

3.1 Population dynamics

Population

A population is a group of organisms of the same species occupying a particular space at a particular time (Krebs, 1992). A population is comprised of all members of a particular species within a definable area.

Population dynamics

Population dynamics is the numerical, distributional and structural changes in populations over time, and the processes which both proximately and ultimately cause such changes (Keith, 1978).

3.1.1 Population growth models

A mathematically simple way of looking at the relationship between the size of a population and the rate at which it grows is through the logistic equation. Take an example:

Year	Population	Growth			
1	100	-	-	-	
2	105	5%	105 = 100+100*0.05	100(1+0.05)	100*1.05
3	110	5%	110 = 105+105*0.05	105(1+0.05)	105*1.05
4	116	5%	116 = 110+110*0.05	110(1+0.05)	110*1.05

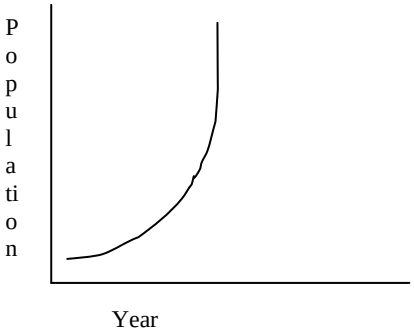
The calculation can be simplified by multiplying the population of each year by 1.05. In this case the 1.05 is the lambda (λ).

Population tends to grow exponentially and because of this biologists have found it convenient to substitute for lambda an exponential value to depict population growing at a constant rate. They use the base of natural logarithms (2,71828) with the value r representing the power to which the base is raised.

The positive value of r shows population growth, a negative means a decreasing population and r of 0 indicates a stable population. r is the maximum rate at which a population can grow with a stable age distribution with no resource is limiting. It is described as intrinsic rate of increase at biotic potential.

So the **exponential growth** equation is;
Change in population size/change in time interval (usually 1 year) = rN, where r is the intrinsic rate of increase and N is the population size at the start of the time period.

Exponential population growth
(J-shaped curve)



It represents biotic potential growth without the modifying effect of environmental resistance, a process known as exponential growth. The resulting growth curve is J-shaped and exponential growth equation.

The carrying capacity slows and halts the population growth. This biological inevitably can be approximated mathematically by adding the expression (K-N)/K to exponential equation.

Change in population size /Change in time = rN [(K-N)/K]

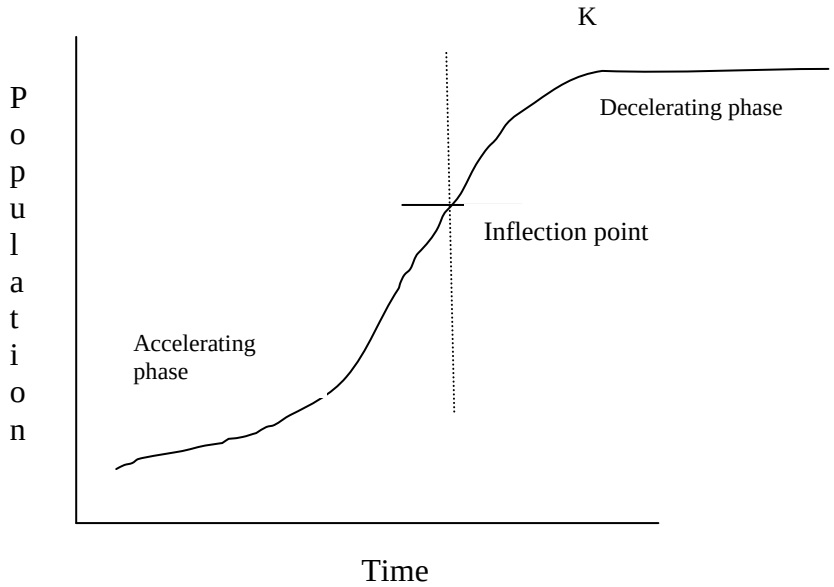
[(K-N)/K], the experimental resistance is near unity if population low. It approaches 0, nearer to K and reaches ultimately to K, then rate of growth at K is zero.

Closer the population is to the K, the greater the effect of the added expression which, when multiplied times rN, will diminish its value.

Addition of K changes the shape of the population growth curve from J shaped to S shapes and converts the exponential equation to logistic equation.

The logistic equation is a mathematical model in which growth of a population is determined by its biotic potential proportionally reduced by the environmental resistance.

- Number of animals annually added is highest at K/2.
- Beyond K/2, growth slows.
- Growth stops when K is reached.



Both are very basic model. Logistic model is very simple model of population dynamics. So more precise analysis requires more specific and complex models. (discuss: open and closed models for tiger population estimation/Software use).

3.1.2 Natality and mortality

Natality

Change in population is brought about by birth, death and movements. If birth and death balanced the population will be stable. If it goes out of balance, then population grows or declines. The production of new individuals by a population is termed natality. Natality rate is the number of new individuals born, hatched or otherwise produced per unit time. Specific nat ality rate is the individuals produced per unit of time per breeding individual. The actual birth rate, measured as the number of live births per female over a given period of time is called fecundity. In egg- laying species, the number of eggs produced per female. With game species, natality rate is expressed as number of youngs produced per 100 breeding females per year. For e.g., 80 fawns per 100 does.

Factors affecting population's birth rate;

1. Quantity and quality of food: abundance of food and nutritional level
2. Size of clutch or litter produced: genetically determined (e.g., human 1, deer 1, tiger 2, elephant 1, wild pig 8 etc)
3. Length of breeding season: birth interval (gestation period: tiger 105 days, elephant 22 months, Rhino 16 months etc.). Generally Rhino give birth once in three years in an average. Tiger one in 2 years etc. The mother with calf/cub does not breed for longer time than the female with no calf/cub.
4. Breeding age: Minimum and maximum age. Age at maturity affects. E.g., Elephant reach at maturity at 14 years, Rhino at 6 years, tiger at 4 years, deer at 2 years etc.
5. Sex ratio and mating habit: Monogamous/polygamous/polyandrous
6. Population density: In sparse population, difficulty in finding mate and natality-low, more abundant population, higher chances of natality.

Mortality

In healthy wildlife population, old age is the main cause of death. If population reach near carrying capacity, population growth slows and once K is reached, population grows no more. Because there is reduction in birth rate and increase in death rate. The causes of death that increase along with population size are termed density dependant mortality.

There is fairly consistent positive relationship between death rate and population size. Death rate rarely constant between different age classes.

In mammals: mortality rate higher in very old age class, lowest in middle years and moderate in juvenile stage (Convex survivorship curves).

In birds and reptiles: fairly constant rate of mortality. Mortality is independent of age. It is because the mortality of bird is little known because they are mobile, smaller and carcass not found. Probably it may be due to difficulty in estimating age.

In insects and fishes: High mortality at young and then low afterwards. (Concave survivorship curve).

The factor that caused death is termed deciminating factor by Leopold 1933. These includes;

1. Predation: Prey-predator relationship, buffer species, usually feeding on certain size range and class of prey.
2. Diseases and parasites: Many bacterial and viral diseases (e.g., FMD, Rinderpest, canine distemper, Bird Flu, Anthrax etc.).
3. Poisoning: Plants produce poisons/toxic alkaloids that protect them from excessive attack and animal neutralize by metabolism. Waterhole poisoning-mass prey base killing technique. Pesticides.
4. Accidents: Fire, highway collision, high tension line, landslide, drowning etc
5. Weather: A sudden hail storm, temperature fluctuation mostly affected the migratory populations.
6. Starvation: If no other factors as deciminating habitat exerts a final control. Death resulting from lack of fuel to maintain the metabolism process.
7. Stress: Social/antropogenic stress may cause reduced fecundity and abnormalities.
8. Hunting: predation by man. Poaching main cause.

3.1.3 Age structure and sex ratio

Age structure

Natality and mortality rates changes with age. Age has profound effects on population dynamics. Age at first breeding affects population growth. See example 1: suppose 50:50 sex ratio, fecundity rate 2 per female per year and no mortality.

Example 1: Effects of age at first breeding on population

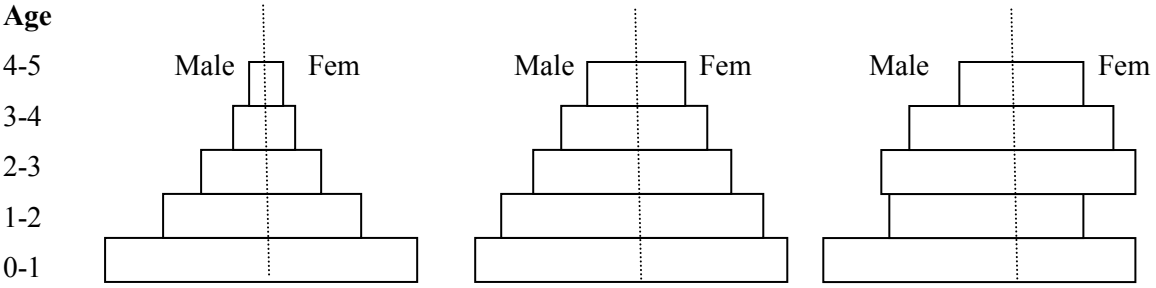
Age at 1st breeding	Population in Years					
	0	1	2	3	4	5

1	2	4	8	16	32	64
2	2	4	6	10	16	26
3	2	4	6	8	12	18
4	2	4	6	8	10	14
5	2	4	6	8	10	12

Age composition has little effect on population growth for species that reproduce during their first year but greater the age at first breeding, greater the effect that age composition can have upon population growth.

Precise ageing technique is difficult in determining age structure. For birds it is extremely difficult. For mammals, it is a bit easier because tooth wear, tooth eruption, growth rings in horn, weight of eye lens etc can be taken as indicators of age.

Some population have balanced sex ratio (male =female at birth) and some have distorted ratio (female>male at birth). If we have complete information on age, then we can prepare age and sex pyramid. Age pyramid is a popular means of estimating population rate of increase. It is often estimates by 3 age classes: juveniles, sub-adults and adults.



(a) Pop. A (b) Pop. B (c) Pop. C

Pop. A	**Pop. B**	**Pop. C**
Expanding population	Stable population	Declining population
Rapid growth rate	Slower growth rate	Irregular shape
Broad at the base because of high number of youngs.	Narrower base and taper less sharply	Small production of youngs, greater number of older individuals

Sex ratio

A sex ration of about 50:50 at birth is the general rue among most species of vertebrate. Departure from this even sex ratio influence population dynamics. It largely depends on mating habits.

1. Monogamous species (A pair bond): growth decline with a departure from an even ratio.

2. Polygamous species (Each male mates with more than one female): change in sex ratio can have major effect on population growth. (See example 2 and above figure for sex pyramid).

Suppose: Population =1000, fecundity rate is 2 young per female. No mortality, all female breeds

Sex ratio	Number of female	Number of young produced
1:5	833	1666
1:4	800	1600
1:3	750	1500
1:2	667	1334
1:1	500	1000
2:1	333	666
3:1	250	500
4:1	200	400
5:1	167	334

Case 1 (1 male: 4 female) – can produce 1.6 times as many young as could the same sized population with a 50:50 sex ratio.

Case 2 (4 male: 1female) – could produced only about 40% as many young as could the same population with a 50:50 sex ratio.

3.1.4 Dispersal, population fluctuations

Dispersal

Wild animals are free ranging animals. The population of a species is not just depend on rate of births and deaths but also the movement into or out of population. Population on islands or areas restricted by impassable barriers are relatively unaffected by movements. All other are influenced by such movements. Frequency and distance of travel vary with species and the kind of environment in which it occurs. Travels of animals can be considered under two categories:

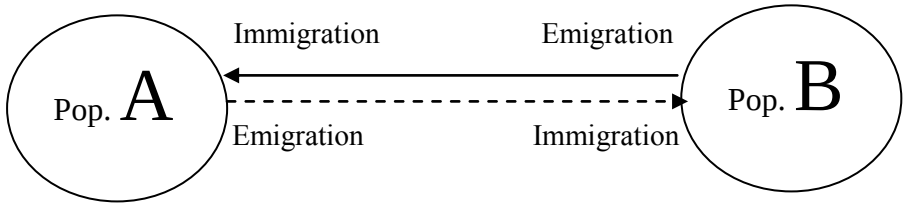
1. Internal to the area occupied by the population, which do not affect the composition of population, where the travels are short and daily, and mass movement from one place to another place of its range.
2. External to the population area that takes individuals out of or bring them into the population and thus change the composition. It establishes new population.

Migration is different than dispersal, which are two way movements within the area normally occupied by a species population. It commonly represents travel from one seasonably suitable habitat to another with a subsequent return to the first.

Dispersal is the movement of an animal from its birth or release site to the place where it reproduces or would have reproduced or it survived (Howard, 1960). Dispersal movement falls into two categories (two forms f dispersal):

1. Immigration: movement into a new area
2. Emigration: movement out of a previously occupied area.

A single species on one journey can be both an immigrant and emigrant. Dispersal permits a species to spread to new areas and is essential for long term survival of species. Habitat conditions change through time, so may sometimes unsuitable for a population of a particular species, so dispersal occurs.



Usually sub-adults/young individuals not settled in a home range disperse. E.g., Elephants, Tiger etc. Dispersal is important in ecology and wildlife management. Tigers may turn into man-eater, bull elephant may become crop raider. Dispersal animal may sometimes cause human-wildlife conflict.

Documenting the rate at which a species expand its geographic range gives a rough index of dispersal.

The factors that cause d dispersal can be many. Such as antagonism between parents and young when young reach at maturity, fighting between adult individuals force one animal to leave the group.

Population fluctuations

All wild animals fluctuate. Major population fluctuations are of two types: cycles and irruptions. Aldo Leopold has classified population fluctuation into three categories.

1. Population that remains relatively stable in number, from year to year.
2. Population that are normally stable but occasionally exhibit an increase to a high peak in number of irruptive population, and
3. Population that fluctuate at regular intervals, from high peak to a low trough in number, the cyclic populations

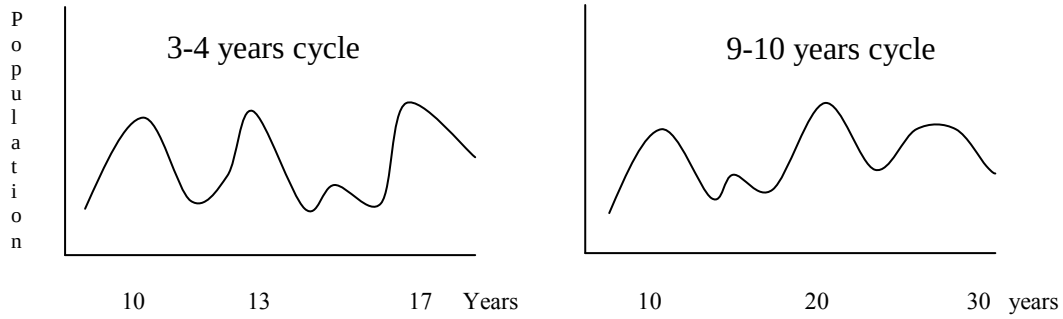
1. Cyclic fluctuations

A pattern of numerical change in which time intervals between successive highs and successive lows are significantly less variable and hence more predictable than in auto-correlated random fluctuation (Keith, 1978).

Cycles are major population changes that occur at regular intervals, usually either 3-4 years cycle characteristics of rodents in arctic region or 9-10 years found in population of hare, lynx in boreal forests.

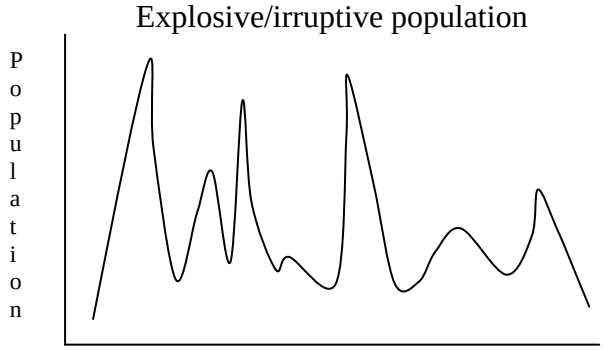
The larger cycles are typically occurring in boreal forests. Causes of cycles are two types.

1. Extrinsic factors: those caused by forces outside the population themselves and includes long-term climatic cycles, infectious diseases, decline in quality and quantity of foods and predation.
2. Intrinsic factors: those forces from inside the population. It consists of physiological stresses brought on by crowding, changes in social systems.



2. Irruptions

Sometimes also called as explosive populations. Irruptions occurs at irregular intervals and seem to occur more in temperate and perhaps even tropical regions than do cycles. An irruption differs from a cycle in its lack of regular periodicity. A population will increase to a high peak and then crash, only to a condition of relative stability. Irruptions in deserts and semi arid steppe can usual to obvious changes in climate. A high rainfall year brings an abundance of vegetation and animals can increase. A series of good years brings great abundance.



Years

3. Stable population

In more humid ecosystems where temperature and rainfall do not change much from year to year, habitat will remain relatively stable. In such habitats one would expect to find relatively stable population, with number going up and down in an annual cycle, but returning each year to the same base level. Where there is a seasonal fluctuation in plant growth, animals have adapted to these seasonal changes in vegetation. The young of most species born during a period when food is most abundant.

3.1.5 Population patterns (r-selected and k-selected)

Species have evolutionary strategies that contribute to their survival in the particular kind of habitat to which they are adapted. According to island biogeography theory (MacArthur and Wilson,1967) the first animal reaching unclonized island encounter abundant resources and their population expand rapidly. Natural selection favours rapid reproduction, an strategy is called r-selection. When island become crowded, resources decline, competition starts and dwindling resources. This is called k-selection.

Such species that are considered to live near the K of their environment have been termed K-selected species. The r and k concept applies to species that dwell on continents as well as those on islands. This is not absolute only relative concept. The species falls on a continuum between strongly r-selected and strongly k-selected species.

Pest animals	Game species	Endangered species
Rat, mouse	Rabbit, deer	Elephant, rhino

r-selected K selected

r-strategies	**k-strategies**
Uncrowded/empty environments	Stable/Predictable environments
Rapid population growth	Food and resource competition
High rate of increase	Low rate of increase
More energy for reproduction	More energy for non-reproductive activities
Short lived	Long lived
Small bodied	Large bodied

High reproductive rate	Low reproductive rate
Large no. of offspring with low survival	Few young, parental care
Wide dispersal	Not widely dispersed
Early to mid successional stage	Mid to late successional stage
Early maturity (age at 1st breeding-younger)	Late maturity (older age)
High juvenile mortality	Low juvenile mortality
Rapid population turn over	Slow population turn over
Abundant	Less number
Weed/pest animals	Endangered animals
e.g., Rat, mouse, pig etc	Rhino, elephants, bison, tiger etc

3.2 Population genetics related problems

Most wildlife management is the numbers, the success of which is measured by population changes. Recently long term genetic changes evolved. For long term conservationfocus should be on preservation of gene pool not only on numbers.

A gene pool is sum total of the genetic diversity contained within a population or even within an entire species. Gene pool can increased only through outbreeding or through mutation. More common genetic problem are;

1. Severe reduction in the size of the gene pool and
2. occurs when one wild species intrebreeds with another.

Severe reduction in the gene pool

It is the most common problem. This is irreversible process usually results from reduction in number, combined with limited geographic range of species. As the range diminishes, the unique genes carried by locally adapted variants are lost. When this process is allowed to continue, the species eventually becomes confined to small isolated patches of its former range. The isolation accelerates genetic losses further by preventing genetic exchange or gene flow between populations. The smaller the population is in each patch, the greater the loss of genetic diversity through chance, and process known as genetic drift.

Genetic drift

The long term effect of genetic drift include randon changes phenotypes and depletion of genetic variance. Drift weakens the population ability to recolonize former portions of its geographic range. The number of different alleles at a locus in the population as a whole will tend to decrease in the absence of immigration and mutation. Heterogeneity thus decreases. Rate of decline = f(population size, proportion of heterogeneous loci)

= 1/2N per generation

Over one generation mean heterozygosity (H) changes according to

$H_1 = H_0(1-(1/2N)]$

The most serious short term effect of inbreeding and drift is a decline fecundity, survival of young, or both, a problem called inbreeding depression.

Inbreeding

Inbreeding is mating between close relatives. Smaller the population, more frequent such matings are. Inbreeding reduces the heterozygocity of the offspring below that of the population. It is measured by inbreeding coeficients. It ranges from 0 to 1. 0 indicates complete outbreeding and 1 indicates the complete inbreeding, all individuals are homozygous, H = 0.

Inbreeding depression

Inbreeding decreases fitness. Decline in heterozygocity tends to lead to a decline in fitness. The rate of loss accelerates with declining number. The consequences are manifold;

- The frequency of matings between close relatives rises,
- Which leads to reduce heterozygocity in the offsprings,
- Which exposes the effect of semi lethal recessive alleles,
- which reduces fecundity and increases mortality,
- Which causes population to become smaller, and that trend may continue to extinction.

Discus effective population = [4NmNf/(Nm+nf)] and minimum viable population [50/500 rule].

Genetic Swamping

Contamination of the gene pool is genetic swamping. It occurs through hybridization with a closely related species.

Unit 4: Habitat Selection

- Behavioral response/process that may result in the disproportionate use of habitats
- Principle aim is to influence the fitness and survival
- Heterogenous habitats-some good while others bad- better fitness in good whereas give lower fitness in bad habitats
- Habitat selection is due to;
    - Differences in food availability
    - Differences in predator occurrence
    - Differences in ease of defense
    - Differences in likelihood of offspring survival
    - Microclimatic variations
    - Disturbance level etc
- For example: rhino (swampy areas), kingfisher (near river on tree branch), woodpecker (tall old tree with fungus), Bengal florican (tall grasslands), tiger (dense forest/undisturbed)
- Some group of animals are much more habitat specific than others
- The extent to which a habitat can fulfill the requirements of an animal determine habitat selection
- Habitat selection is affected by factors like abundance and quality of food, suitability of weather, shelter against extremes of weathers, escape cover for predators etc
- Habitat use is the way an animal uses (or consumes) a collection of physical and biological components in a habitat

Territorial behavior

- The occupancy of an area by an individual or a group to the usual exclusion of their individual or group of same species, the area is known as terrotiry and the behavior that leads to such exclusive or near exclusive occupancy is territorial behavior.
- It may be hold by an individual, a mated pair or a group
- Terrotiriality is not a fixed property of a species (e.g., robin bird (maintained by pair in breeding season and individual during winter)
- Male and female territories are often independent in case of species that do not form pair bond, male defend terotory only against other male and female…
- Song is used by male bird to make their territory, or territory is manifested by aggression towards intruders
- Tiger: scratching, scent stations etc
- Territorial behavior is a tactic to increase their fitness through the defence and acquisition of resources (food, shelter or mate)
- Cost of defence should be less than the benefits of holding a territory
- Terotory size is also affected by food abundance
- It is intraspecific than interspecific
- Nice (1941) and Wilson (1975): a, b, c, d e

Mate and courtship behavior

- Courtship behavior is a behavior in which males and females of the same species prepare for mating.

- Courtship behavior ensures that the males and females of the same species recognize one another, so that mating can take place.
- It is the animal activity that results in mating and reproduction.
- Species/individuals have differently attract the females such as visual, sound/calls/songs, smell/pheromones, touch, stag fight, playing/dancing etc.
- A means of communication given by the male (usually sometimes by females) animals during period of rut to attract opposite sexed animals
- Objective is to convey emotional state
- If vocalization, it is louder, longer and repeated

Lek: restricted territories occupied and intensively used by breeding mates for display and mating
Display ground for females
Female make a selection
Older and fitter male has access to prime location in lek

Sexual selection

- … as a special subset of natural selection or as a type of natural selection in which reproductive success among individuals is determined by the way in which mating occurs
- It is the selection of males (females) for trials which are solely concerned with increasing mating success
- All sexually reproducing animals seek reproductive partners, or mates, who will enable them to enhance their reproductive success.
- Sexual selection results in morphological distinction of the sexes, or sexual dimorphism.
- Reproductive behavior can favor the evolution of traits that the attractiveness of individuals to members of other sex
- Anderson (1982) explained that females of many species exhibits strong preferences for particular male characteristics. Experiment on effects of tail length of widow-birds, female choose male with long tail and found that success of mating was higher in birds that had elongated tails.
- Zohari (1975) postulated good genes hypothesis. He suggested that male display indicates some components of male fitness. E.g., bright coloring or long tail in mail bird indicates a lack of parasites. Display characters serve as a signal to females that this particular male has good genes.
- Long tail of peacock is a handicap for day to day survival and it acts as an advertisement of the quality of male for the female. Longer tails are preferred by females. (Handicapped principle)

Reproductive physiology and behavior

- Sexual maturity
- Gestation period (short for small mammals whereas long for larger ones)
- Female with calf/cub vs female without calf/cub
- Group formation (bachelor group, before and after breeding season)
- Male and female mixed group during breeding season
- Deer are hiders

- Territoriality
- Infanticide in Tiger, Lion
- Polygynous and polyandrous (eg, jacana)

Why do male chimpanzees much smaller than male gorillas have larger testes than gorillas.

Chimpanzees	**Gorillas**
Size: much smaller, closest relatives of gorillas	Largest living primates
Several male copulate with each oestrus females	One male mating with several females
Multi-male system	Single male system
Testes 120 gram	Testes 30 gram
A male's sperm has to compete with sperm from other males	Each male need ejaculate only enough sperm to ensure fertilization
Selection should therefore favor increased production of sperm, so larger testes	
For greater chances of producing offspring by male, it has to produce more sperm and testes are larger	

Due to difference in breeding system

Aggressive behavior

- It is the behavioural strategy of individual recognition and differential treatment of neighbours and strangers.
- Neighbor already has territory and know the ability of neighbor and knows that neighbor is not likely to try to take over his/her territory (dear enemy phenomenon)
- Level of aggression is indirectly proportional to degree of familiarity
- Territoriality is typically manifested by aggression towards intruders.
- Attacks on persons or animals which come close to the nest site
- Why bull elephant kill more people and raid crops more often? (High risk, high gain strategy)
- Tusker elephant more aggressive during musth.

Parental care

- Usually male have no/less share in parental care
- Wild pig strategy (defend easy, threats of predation is low)
- Deer are hiders
- Aggressive behavior for parental care
- Parental care is expensive, there is a cost of reproduction that forms some sort of limit on how much an animal can do to provide care to its offspring
- Without offspring or offspring that have been killed or died in early periods, the mother comes little early in estrus condition.

Imprinting

- Phenomenon in which an early experience of the animal determined their social behavior is imprinting.

- Imprinting appear to occur at a critical period early in the life of an animals
- Early experience of an animal have a profound effect on their adult behavior
- The effects of early experience upon adult behavior is inversely correlated with age
- Early habits are very persistence and may prevent the formation of new ones
- Early perceptions deeply affect all future learning
- Early social contact determine adult social behavior
- When youngs are born, the first moving object they see is usually their mother. They proceed to follow her. If they see another moving object, they follow it instead.
- Imprinting is related to psychology and ethology to describe any kind of phase-sensitive learning that is rapid and apparently independent of the consequences of the behavior.

Circadian and circannual rhythms

- Circadian (Daily) and cirannual (Annual)
- Serves as biological clocks that provide the major basis for their temporal orientation
- Cirannual rhythms are responsible for annual migration
- Male cock give call at every morning (circadian)
- Embedded in daily/yearly activity patterns

Migration

- Movement which is regular, periodic and away from and back to their place of birth
- Seasonal migration occurs in many species of birds, insects and fishes
- The migration provide the animals with more favorable condition of temperature, food or water
- Chief function of seasonal migration is to provide a suitable place for reproduction
- Many fishes migrate to freshwater (towards source) to lay eggs, spawning grounds
- Dolphin migration: sighted during rainy seasons in streams in Nepal
- Many amphibians and reptiles gather near water source during breeding seasons
- Hybernation strategy of many reptiles vs migration strategy
- Domessile crane: Russia, Mongolia, South China to Nepal to India
- Birds form Srilanka to Nepal Himalaya
- Causes of migration: most common reason is to take advantage of food, shelter and water that vary with seasons. Another; to cope with difficult time of year. Next; to escape from external pressures such as temp, drought, food shortage

Types

- Seasonal: migration that corresponds with the change in season.
- Latitudinal: movement of animals north and south.
- Altitudinal: movement of animals up and down in mountains like land features.
- Reproductive: movement of animals to bear youngs. The area may be safer for the youngs.
- Removal: movement of animals that don't come back. The environment can have changed due to fire, flooding, biological invasion, and the animals need to leave the areas for their survival.

- Complete/partial migration: some/all members of a population move away from their breeding grounds during non-breeding seasons.

5. Food and cover

Food and nutrients

Food and nutrients are the substances required by the plants and animals from the surrounding environment. The essentiality of food and nutrients are;

- can not complete the life cycle without these
- could not be replaced by any other
- actions of the nutrients are direct.

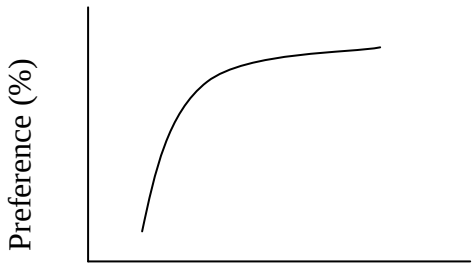
If an element is found a part of any essential compound, without which a plant/animal could not complete the life cycle of it, it is an essential nutrient. For example, proteins.

Energy

Energy is a basic need for all living beings. The energy is required to keep warm, to move, to circulate food, to transform chemicals from one form to another, and to carry out all the works that is done inside the animal body. Energy flows through an animal's body in a one-way direction. It can be stored temporarily.

Carbohydrate

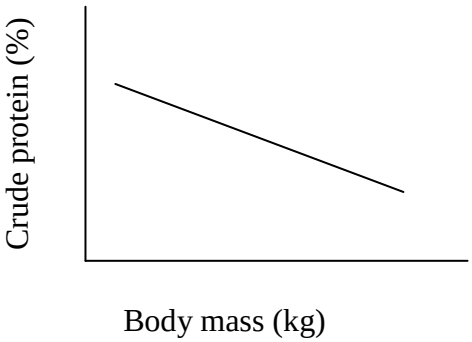
Carbohydrate content differs with species, individuals, and different parts of the individual plant, and also with season. The stages of maturity of the plant also affect the carbohydrate content. The carbohydrate content is determining factor in preference ranking by wild animals.



Protein

Protein is g[illegible] of crude protein. Crude protein is calculated by nitrogen times 6.25. Protein varies by plant parts.

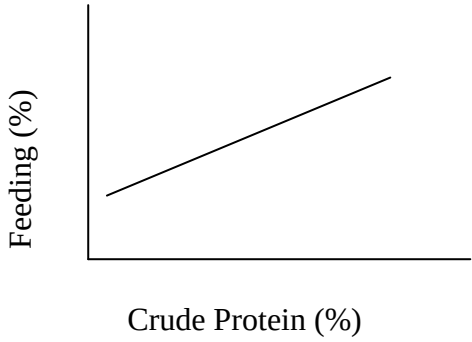
For example,
Leaf - more crude protein
Sheath - lesser crude protein
Stem - least crude protein
Fruit – more crude protein
Pod – more crude protein



In green and dead leaves it differs. Green part has more protein than dry ones. The crude fibre percentage is higher in stem than in sheath and leaf. There is a seasonal variation in protein content. Crude protein is more in winter than in monsoon and summer, so mostly trees are lopped in winter in Nepalese farming system. Growth phase (early growing, late

growing, and early dormant, late dormant phase/period) also affects the protein. Protein decreases when grass becomes mature. So young leaves and grasses or sprouts are more favored by wildlife. Research has shown that the requirement of protein decreases with body weight of the animals.

Feeding percentage is determined largely by availability of the nutrients in plants. There is a strong correlation between protein content and the feeding percentage in winter (see figure).



Ecological separation through food

Species which coexist without competition are said to be ecologically separated. Separation is achieved in one or more of six ways.

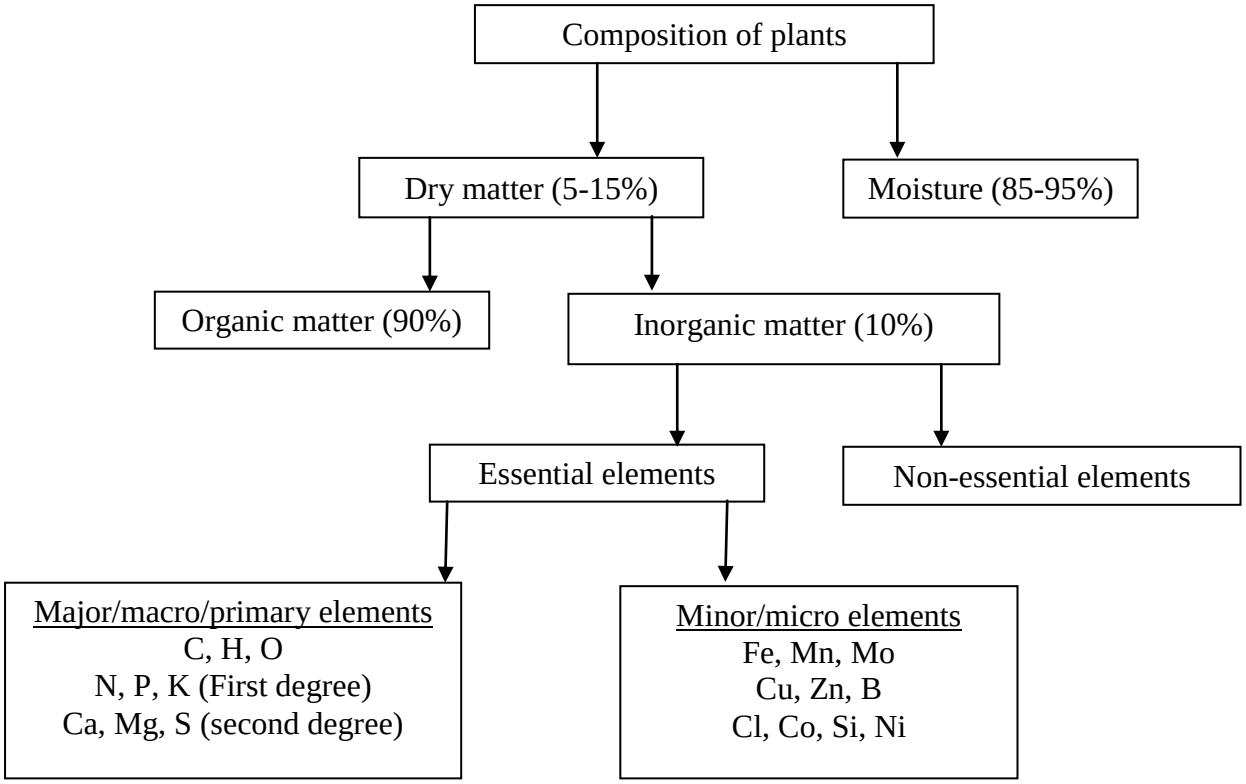
1. Through the occupation of different habitat types,
2. Through the selection of different types of food,
3. Through the occupation of different areas in same season,
4. Through the occupation of same area in different season,
5. Through the feeding at different levels in the vegetation,
6. Through the occupation of different dry season refugees.

Feeding height

In summer, less food resources, then all animals try to feed at different height but in monsoon, there are abundant resources and can get from one height level.

Macro and micro nutrients

Living being whether plant or animal is composed of water and dry matter, both inorganic and organic.



The concentration of macro elements is more than 500 mg/kg of dry matter and those of micro nutrients is less than 100 mg/kg of dry matter.

Nitrogen: constituent of DNA and RNA, requires in cell division and multiplication
Phosphorus: requires for respiration process and metabolic reactions
Potassium: involves in translocation of food within plant, require controlling stomatal activities
Calcium: cell wall material, activates several enzymes
Magnesium: key element in cholorophyll, activates many enzymes in photosynthesis & respn.
Sulfur: Important in amino acids.

Fat and vitamin

Fats can be substituted for carbohydrates. In adition to energy needs, vertebrates have specific nutritional requirements. Some fatty acids are essential to the diet and are supplied by fats or oils. A number of vitamins arerequired to provide the enzymes needed for metabolic processes.

Feeding behavior

Categories of animals according to feeding behavior

Specialists (narrow niche) vs generalists (wide niche)
Herbivore (feed vegetation) vs carnivore (eat animal)
Grazers (Chital) vs browsers (Nilgai)
Course grazers vs fine grazers
Frugovores (Langur)
Omnivores (Bear)
Solitary hunter vs pack hunters
Stalking vs coursing predators
Seed eaters/insectivores etc

Classification of ungulates according to their feeding behavior

1. Primarily grazers (ex- Rhino, swamp deer, black buck, ghoral, hog deer, Himalayan thar, wild buffalo)
2. Selective herbivores (ex- Chowsingha, musk deer, barking deer etc.)
3. Generalists (ex- Cheetal, Sambar, elephant, Gaur)
4. Browsers (ex- Nilgai, Sambar etc.)

Classification of herbivores in terms of nutrients

1. Bulk and roughage eater: need more food and fibreous food. Ex- elephant, rhino, buffalo
2. Concentrate selectors: Highly nutritive food, fruits, seeds etc
3. Intermediate feeders: in between of above two.

Carnivores

- May face quantitative food deficiency but seldom face qualitative food deficiency. Because their food is highly nutritive.

Seed eaters

- Closely resembles with carnivores. A plant stores sufficient food in its seed at the expense of parent plant. Thus obtain most of the dietary needs from seed. May face quantitative food deficiency.

Grazers

- May changed the habitat to unpalatable from palatable from heavy grazing,

Browsers

- Browse line, mostly harmful

Ruminants

- Rumen bacteria in one of four chamber of the stomach synthesize amino acid from nitrogenous products. They synthesize digestive sugars from carbohydrates. They are equipped to survive on foods lacking in many compounds.

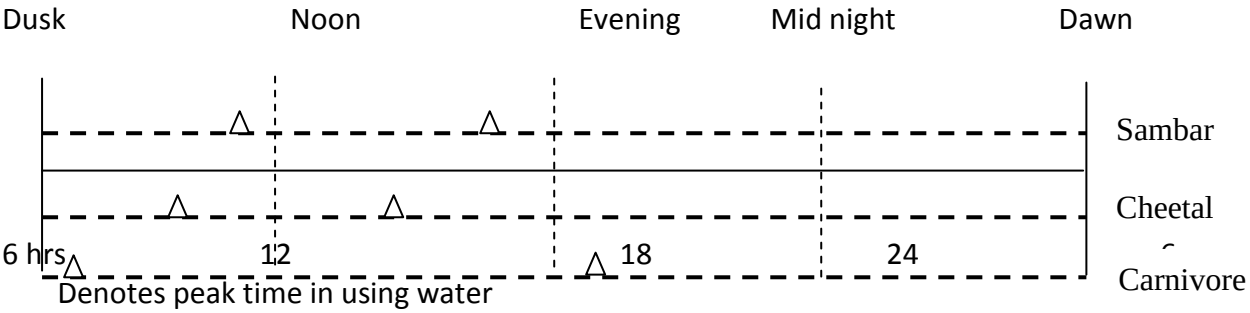
Scavenging

- Scavengers depend mostly o food killed by others. Ex- Wolf, Jackal, vulture

Some animal kill their prey and repeatedly come and eat (for e.g., tigers) when tiger kill the prey they drag and pull and eat at some distance from the killing site. In few cases, female make kill and preference is given to males while eating. (e.g., African lion).

Infanticide is the behavior of some animals (e.g., tiger, lion) which is the killing of youngs/cubs fathered by other males.

Animals activity pattern is useful. Spotted deer requires water at 10/11 hrs and 16/17 pm in a day (peak time) whereas sambar need water little after than spotted deer (12/13 hrs and 17/18 pm)



Feeding behavior also depends upon quality of food. Some plants produce secondary compounds/allele chemicals as a coping strategy to continue their existence in long term. Such as tannin, lignin reduces digestibility. Similarly toxic substances like alkaloids affect liver functions and also affects central nervous systems.

Feeding behavior

	Carnivore	**Herbivore**
Time and energy	Spend much time and energy searching for and capturing their food	Spend less time and energy finding and capturing vegetation
Food source	Animals Mobile (hide, fight) Rare	Plants Stationary Abundant
Capturing food source	Low capture rate Low dry matter content	High capture rate High dry matter intake
Quality of food source	High protein High digestible energy No cell wall/fibre Quality uniform among prey	Low protein Low digestible energy High fibre in cell wall Quality varies among plants and plant parts
Digesting food sources	Little chewing required Simple digestive tract Energy and protein derived from breakdown of proteins, fats and carbohydrate in stomach and intestine Plant fibre not digested Rapid passage through system	Much chewing required Complex digestive tract Energy derived from microbial fermentation of plant fibre and cdell contents in foregut and hindgut Protein derived from digesting rumen microbes Slow passage through system

Feeding behavior of grazers and browsers

	Grazers	**Browsers**
	Bulk and rouphage feeder that select diets containing <25% browse	Concentrate sectors that select diets containing at least 75%fruits,dicot foliage &tree &shrubs stem & foliage.
Digestive anatomy (foregut)	Large subdivided	Small Simple
True stomach	smaller	Larger
Hindgut	Smaller cecum and intestines	Large cecum and intestines
Salivary glands	Smaller parotid salivary glands	Large parotid salivary glands
Liver	smaller	Larger
Mouth	Smaller mouth opening And stiffer lips	Wider mouth opening with longer tounge
Teeth	Higher crowns in some species	Lower crowns in some species

Difference between grass (monocot) and browse (herbaceous and woody dicots)

	Grass	**Browse**
Cell wall	Thick Greater proportion is cellulose/hemi cellulose	Thin Greater proportion is lignin
Plant defense compounds	silica	Phenolics, tannins, tarpenes, alkaloids and other toxins
Dispersion	Uniform	Dispersed/discrete
Plant architecture	Low growth form New growth added at base Fine scale heterogeinity in nutritional quality within a plant	Low to high growth form New growth added at tips Course scaled heteroginity in nutritional quality within a plant

Association in feeding

1. Langur and cheetal/sambar/barking deer association
   Langur drops fruits and leaves of trees such as terminalia, Emblica. The fresh smell attracts deer and feed on those. This association is prominent in October to June. Because this period is dry and there is no abundant food resources, afterwards no association because monsoon starts and food available everywhere.
2. People and sambar association
   People lopped trees and the leaves fallen at that time will be eaten by sambar and other deer. Next day, we can see large number of pallets in areas of lopped trees.

3. Elephant and sambar/cheetal/blue bull association
   Elephant damages a number of plant species e.g., Mallotus, Terminalia, Dalbergia and fallen leaves are eaten by sambar/cheetal/blue bull etc.

Prey predator relationship

Three thoughts

1. Predator eradicate prey if unchecked,
2. Predation has no effect on prey that would have died of other causes,
3. Predation has good effect as predator kill less fit individuals.

Population characteristics of prey

1. **Functional response**
   If prey population irruptions in the presence of predator. Irruptive population increases, predation intensified because most predators take more than one prey, then they are likely to shift their hunting pattern to take advantage of the greater abundance of irruptive population. This shift is called functional response.

2. **Numerical response**
   If irruption is localized, additional predators may attracted to the area and predation increases. If the irruption persists for a long enough time, predator population may grow in response to greater food supply. Either increase in predators population is called numerical response to increasing prey population.

It is always true that the prey determined the predators population and it is sometimes true that the predator determined the level of prey.

Size of prey

Larger predator prefers large to medium sized prey whereas smaller predators prefers smaller prey. Tiger prey upon sambar, wild buffalo, blue bull and leopard prey cheetal, wild pig, langur etc.

Age of prey

Mostly predator kills younger and older aged individuals. Cheetal with large antler length are easy to catch because they face difficulty in escaping.

Frequency

The frequency of killing by tigresses without young is one in 8 days. So one needs 40-45 kills per year.

Buffer species

Generally predator feed more than one prey. If not sambar then cheetal by tiger.

Killing technique

Tiger: if prey is less than half of the weight of tiger-neck bite
If prey is more than the half of the weight of tiger-throat bite

Therefore, prey-predator relationship not only affected by the relative size of the animals but the feeding habits of the predators. Generalised predator may feed on many kinds of prey population not affected by one prey species. Specialized predators feed only on one kind of prey. The balance between energy output and amount of food obtained is highly important to predators.

Prey-predator relationship is common phenomenon in nature.

Food management

It is always advisable to focus on improving natural food supplies rather than provisioning or artificial supply. Some tools used are;

- Fire to reduce/curb successional growth
- Reseeding or transplanting useful food plants
- Planting of ficus and fruit trees, if possible plant trees of different species which gives food for wild animals throughout the year.
- Keep seed bearing plants
- Burning grassland for sprouts and to stop succession
- Girdling to give ventage point for birds

Some examples:

Plantation of mustard, wheat etc for Black buck in Bardia
Waterhole construction and maintenance in terai protected areas
Patch burning for swamp deer in Suklaphanta wildlife reserve
Grass cutting in terai PAs
Uprooting/tree cutting to halt succession in terai PAs
Vulture restaurant in Nawalparasi to provide healthy food for vultures
Food examination in zoo

Types of cover:

1. Shelter cover/thermal cover/resting cover: to keep safe from extreme weather. A place to get out of sun and wind. May be a place to lie in sun or wind. Provided by vegetation.
2. Escape cover: to escape from predators/enemies. Dense vegetation, steep ground, cliff, rocks, cave etc.
3. Ambush cover: for prey catch, stalking predators, tiger, leopard, snow leopard etc
4. Fawning cover: for deer, to live and escape from predators in fawning period.
5. Nesting/roosting cover: A place where birds rest at night (roosting).Vegetation.

6. The biosphere and animal distribution

6.1 The biosphere

The term 'Biosphere' was coined by Russian Scientist Vladimir Vernadsky in 1929. Biosphere is the life zone of the earth and includes all living organisms including man, and all organic matter that has not yet decomposed. All animals are intrinsically linked to their physical environment and the relationship between an organism and its environment is the study of the ecology. The biosphere can be divided into distinct ecosystems that represent the interaction between a group of organisms and the environment.

Atmosphere: life processes e.g., photosynthesis, respiration emit gases to the atmosphere.

Hydrosphere: water is essential for all living organisms on earth.

Geosphere: the geosphere and biosphere are intimately connected through soils which consist of air, mineral matter, organic matter and water.

Anthrosphere: Human population poses a threat to the biosphere by habitat destruction.

Biosphere are the natural regions of the earth. Sclatter (1858) classified the natural regins of the world on the basis of their bird faunas. Wallace (1876) developed classification system on the basis of other animal species.

In the global classification of habitat types, the higher taxon is the realm. Animal distribution is characteristics by marked differences between regions. Boundary of faunal regions sometimes well defined and more often blended gradually between adjoining regions.

Wallace region represented a centre of origin for many species. Similarity between regions from interchange of species between them. Major differences between regions reflected long period of isolation. Neotropical and Neacrtic have many differences. Oriental and African have many similarities- both have lion, elephant, rhino but different species.

Udvardy (1975) modified the Wallace's classification on the basis of animals as well as distribution of plant species.

Udvardy's Realms	**Province**	**Wallace's class**	**Area/region**
1. Palearctic	44	Palearctic	Northern Asia, Europe and Mediterranean Africa
2. Nearctic	22	Nearctic	Northern America
3. Africotropical	29	Ethiopean	Sub-Saharan Africa
4. Indomalayan	27	Oriental	Indian Sub continent and SE Asia
5. Oceanian	7	-	Island of South Pacific
6. Australian	13	Australian	Australia
7. Antractic	4	-	Antarctica, Newzealand
8. Neotropical	47	Neotropical	Latin America
Total	**193**		

Realms are divided into biogeographical provinces which corresponds roughly to floral and faunal regions. The third and final taxon of Udvardy's classification system is Biomes. Similar climate have similar animal association. There are 14 principle biomes types.

1. Tropical humid forests
2. Sub-tropical and temperate rain forests
3. Tropical dry or deciduous forests
4. Temperate broad leaved forests
5. Evergreen sclerophyllous forests, scrubs or woodlands
6. Temperate needle-leaved forests
7. Warm deserts and semi deserts
8. Cold winter deserts and semi deserts
9. Tundra communities and barren arctic desert
10. Tropical grassland and savanna
11. Temperate grasslands
12. Mixed mountain and highland forests
13. Mixed island systems
14. Lake systems

Biomes are defined as 'the world's major communities, classified according to the predominate vegetation and characterized by adaptations of organisms to that particular environemnt' (Campbell, 1996). Each biome houses many unique forms of life.

Six major biomes of the world are;

1. Forest biome
2. Marine biome
3. Desert biome
4. Forest biome
5. Grassland biome
6. Tundra biome

Aquatic biome

It makes up the largest part of the biospehere, covering nearly 75% of the earth surface. It houses numerous species of plants and animals, both large and small. Aquatic biome can be broken down into two basic regions.

1. Freshwater biome

Fresh water is defines as having a low salt concentration usually <1%. Different types of fresh water regions are;

a. Ponds and lakes

Many ponds are seasonal, lasting just a couple of months while lakes may exist for hundreds of years of more. Lakes and ponds may have limited species diversity since they are often isolated from one another. They are divided into three different zones.

Littoral zone: top most layer, warmest, shallow, absorb more sun light, sustains fairly diverse community.

Limnetic zone: well lighted, plankton, small organisms found.

Profoundal zone: deep water part, colder zone, little light

b. Streams and rivers

These are bodies of flowing water moving in one direction. They starts at headwater which may be springs, snow melt or even lakes and travel all the way to mouths, usually another water channel or the ocean. The characteristics change during the journey from source to mouth. Water is cleared, has higher oxygen level and freshwater fish in source. Towards the middle, width increases. Numerous aquatic green pants and algae can be found. Towards the mouth, water become musky, decreasing the light amount that can penetrate through the water. Since less light less diversity of flora.

c. Wetlands

Wetlands are areas of standing water that support aquatic plants. Plant species adapted to very moist and humid condition are called hydrophytes.

2. Marine biomes

Marine regions cover one three forth of the earth surface and include oceans, coral reef, and estuaries. Marine algae supply much of the world's oxygen supply and take in a huge amount of atmospheric carbon dioxide.

a. Ocean

Ocean is the largest of all the ecosystems. It has separate zones. It has intertidal, pelagic, benthic zone and abyssal zone. Intertidal is the zone where ocean meets the land, sometimes it is submerged and sometimes exposed, waves and tides come in and out. Pelagic zone is generally cold. The flora includes surface sea weeds. The fauna includes many species of fish and some mammals such as whales and dolphins. Benthic layer is deeper part and bacteria, fungi, sea weeds, fishes found. Abyssal zone is the deep ocean, very cold and low in nutritional content.

b. Coral reef

Coral reefs are widely distributed in warm, shallow water. They can be found as barriers along continents.

c. Estuaries

d. Estuaries are the areas where fresh water stream or river merges with the ocean. The mixing of waters with such different salt concentrations creates a very interesting or unique ecosystem.

3. **Grassland biome**

These are the areas of land where grass is the dominant plant life. Grassland are areas with little or no tree. (tall and short grassland).

4. Desert Biome

Desert biome cover about one fifth of our planet. It is characterized by extremely low rainfall. Arid desert generally occur at low altitude e.g., South USA, Southern Asia. Semi arid desert are found in north USA, Europe, Russia and northern Asia. Cold desert receives snow and rainfall in winter but soil is very alkaline. The animals are burrowers in cold desert.

5. Forest biome

It represents largest and most ecologically complex systems. Major attributes of forest is its trees.

- Boreal biome is found in areas with shorter, warm summer long winter. The boreal biomes are found in Europe, Asia, Siberia and north America.
- Temperate deciduous forests, Oak, Cedar etc.
- Moist.dry evergreen forests,
- Temperate evergreen/broad leaved forests.

6. Tundra biome

Tundra are ice deserts and generally tree less land. It is the coldest of all terrestrial ecosystems.

- Arctic tundra: it occupies earth's northern hemisphere, circling the north pole, soil is poor in nutrients. Animals are polar bear, rabbit, squirrel etc.
- Alpine tundra: Pika, Elk, Marmot etc.

Biogeography of Nepal

Stern (1960) proposed to divide Nepal into 3 units

- Western Nepal (West of 83^0 East Longitudes),
- Central Nepal (83^0 East Longitudes to 86^0 30' East Longitudes) and
- Eastern Nepal (East of 86^0 30' East Longitudes).

WWF US (1998) covered Nepal's territory with 12 eco-regions.

SN	Eco-region	Elevation (m)
1	Trans himalayan shrub/meadow	
2	West Himalayan alpine shrub/meadow	3700-4400
3	East Himalayan alpine shrub/meadow	4000-4500
4	North west Himalayan alpine shrub/meadow	Above 4000
5	Trans Himalayan sub alpine conifer forests	
6	West Himalayan sub alpine conifer forests	3000-4000
7	East Himalayan sub alpine conifer forests	3000-4000
8	West Himalayan broad leaved forests	1500-3000
9	East Himalayan broad leaved forests	1500-3000
10	Himalayan sub tropical pine forests	1000-2000
11	Himalayan sub tropical broad leaved forests	500-1000
12	Terai duar savannas and grasslands	<500

Bio-geographical divisions of Nepal

1. Eastern region: east of mount Makalu, western boundary is Milke Jaljale mountain ridge, watershed of Tamur, Arun and Sunkoshi river

2. Central region: watersheds of Sun Koshi, Bagmati and Narayani rivers. It has north central region. Western boundary is Kali Gandaki river.
3. Western region: West of Kali Gandaki river, it has north west sub-region.
4. Trans Himalayan region: Dolpo and Mustang areas, North of Annapurna and Dhaulagiri mountain, north drier part.

Dispersal

- Travels of animal external to the population area
- Change the composition
- Establish new population
- Results colonization of new areas
- Seed dispersal-invasion
- Immigration and emigration
- Caused by antagonism, fighting etc
- Spread to new areas
- Essential for survival of species
- No dispersal in island and areas which are isolated by great impassable barriers
- Smaller sized PAs can not hold viable population of mega animals
- Metapopulation-corridors and connectivity important

7. Diseases

Any departure from normal health
Any impairment that interferes with or modifies the performance of narmal functions
Any abnormal condition of the body or mind that causes discomfort, dysfunction, or distress to the person affected.
An **infectious disease** is a disease caused by bacterial, viral, fungal, or protozoan infection. Pathogenic microorganisms cause infectious diseases. The diseases can be spread, directly or indirectly, from one person to another. Zoonotic diseases are infectious diseases of animals that can cause disease when to transmitted humans. Though some infectious diseases are not contagious, others may be transmitted from animal to person (bird flu disease) or from person to person (HIV, and other STDs).
A **contagious disease** is a subset category of infectious diseases (or communicable diseases), which are easily transmitted by physical contact with the person suffering the disease, or by their secretions or objects touched by them. This disease is transferred or communicated from one individual to another. Contagious disease is used to emphase very infectious, easily transmitted, or especially severe communicable disease.
The **non-contagious** category of infectious/communicable diseases usually require a special mode of transmission between hosts. These include need for intermediate vector species (such as a mosquito for yellow fever), direct blood contact (such as transfusion or needle-sharing), or sexual contact (examples are AIDS and hepatitis B).

Epidemiology

Usually, epidemics are caused only by contagious diseases. This is because epidemics may also be regarded in terms of proportion of people infected with a transmissible disease. Because of the nature of non-contagious communicable diseases, such as yellow fever, their spread is little affected or not affected by medical isolation (for ill persons) or medical quarantine (for exposed persons). Thus, a "contagious disease" is sometimes defined in practical terms of whether isolation or quarantine make sense as a public health response.

Morbidity is the rate of incidence of a disease.
Educating instead of medicating.
Nutrition value
Healthy functioning of immune system.
Prevent disease and prolong health rather than prolong life.
Causes
Lack of proper nutrition
Lack of exercise
Use of pesticides/pollutants

Epidemiology
Study of occurrence of diseases in a population.

Epizootiology
Study of occurrence of diseases in a animals.

Outbreaks
It refers to a large number of cases occurring within a short period of time.

Infectious diseases	**Non infectious diseases**
Viral	Shock
Bacterial	Nutritional
Parasitic	Physical injuries
Protozoans	Poisoning etc
Management	
Determine source	Supplementation of food and nutrition
Proper disposal	

Infection diseases

- Transmitted diseases
- Contamination of neglected wound where the skin is broken serve as common portals of entry for microorganisms
- Contamination of mucus membranes primarily the mouth, with faces or urine
- Once it is entered into the system, it is free to grow and spread
- So, infectious diseases starts out as small localized infections and will only spread through the system if it gain access to the blood system
-

Transmission
Lateral transmission: transmission of an infection from an individual to any other individual in a population.
Vertical transmission: transmission of an infection from one individual to its offsprings.

The cause of disease may be infectious agents (e.g., bacteria, viruses etc) or non-infectious (e.g., poisoning, starvation etc.)

Viral Diseases

1.Foot and Mouth Diseases (FMD)

- Viral disease of cloven footed animals
- Picorna virus
- Highly contagious

Transmission

- Horizontal transmission both direct and indirect
- Virus shed in vesicular epithelium, fluids, saliva, milk, faces, urinesemen, vaginal secretaion
- Indirect dissemination of virus in meat, milks and other animals products
- Mechanically by living vectors

Signs

- Depression, anorexia
- Vesicles develop on dorsum of tongue, dental pad, gums, muzzle and also on limbs

Diagnosis and control

- Clinical signs and lab test
- Control by vaccination
- Hygiene and sanitation

2.Rabies

- Acute infectious diseases of central nervous system (CNS)
- Transmitted by bite
- Warm blooded animals
- Reservoirs-jackals, wolves, mongoose, foxes
- Rhabdo virus
- Destroyed by sunlight and UV radiations

Signs

- Marked change in behavior
- Furious form (excitation phase lasts for 1-6 days)
- Dumb form (animal paralysed and died shortly)

Diagnosis

- Demonstration of negri bodies
- Biological test
- Virus isolation and identification

Immunity

- Anti rabies vaccine- pre exposure and post exposure

Human anti rabies treatment

- Local wound treatment (immediate washing and flushing with carbolic soap and water)
- Rabies immune globulin
- Vaccination
    - Pre exposure: high rism group, veterinarian, animal handlers, lab workers (0,721 or 28 days and booster every 2-3 years)
    - Post exposure: 0,3,7,14,30 days after the serum which precedes vaccination

Control

- Vaccination
- Control and eventual elimination of the disease from wildlife reservoir and vector population
- Elimination of street dogs

3.Rinderpest (cattle plague)

- Viral disease of cloven hoofed artiodactyles characterized by fever, erosive stomatitis and gastroenteritis
- Reported on bison, wild pig, blue bull, buffalo, gaur, antelope, and deer

Transmission

- Ruminants and pigs are natural hosts
- Requires close contact between sick and healthy animals and not by indirect methods

Signs

- Sudden high fever and death within 48 hrs
- Aggressive nature in buffaloes
- Nasal and lactrimal discharge
- Pregnant animals abort in 3-4 hrs
- Death due to dehydration and rapid emanciation

Diagnosis and control

- Clinical signs and lab aid
- Ample supply of clean drinking water
- Symptomatic treatment (counteract dehydration, prevent secondary infection)
- Routine vaccination of domestic cattle since the results of vaccination in wild is unpredictable

Bacterial diseases

1.Antrax

- Acute highly contagious bacterial disease of domestic and wild animal and human manifested by high fever, colic, hemorrhage on mucus membranes and bloody diarrhea
- Bacillus antracis
- Spores are highly resistant to normal environmental temperatures, sunlight, prolonged drying, gastric juices and many standard disinfectants. Remain viable for years in soil, in water, on hair and other matters

Transmission

- Infection soil borne (soil and water contaminated with carcasses of infected animals as well as by excreta and discharges of diseases animals)
- Hyena, jackals, foxes, vultures, crow, earthworms are highly resistant and play important role in dissemination of diseases
- Human get infection from exposure to infected animals

Signs

- Sudden death, severe straining with bloody discharge
- Spleen enlarged and semi liquid in consistency

- Carnivores show sub acute to chronic symptoms (1-3 days)

Diagnosis

- Clinical signs
- Lab aid

Management

- Proper and rapid disposal of carcasses at the site
- Incineration
- Burial (2.5 meter deep under quick lime layer)
- Due care by personal handling carcasses
- Mass vaccination

2.Brucellosis

- Highly contagious infection
- *Brucella abortus, B suis, B meletensis, B canis*
- Affects domestic as well as wild animals
- Zoonotic importance and leads to undulant fever in man

Transmission

- Contaminated pastures-oral exposures but also by contamination of eyes, wounds, genital tract
- Aborted fetuses, placenta, vaginal discharge
- Human by ingestion of milk, contact with infected materials

Signs

- Ruminants: abortion (3^{rd} trimester)
- Chronic infection of bones and joints
- Swollen bursae

Spread

- Wolf, foxes may act as mechanical carriers of diseases by shedding the organism in their excreta after ingesting aborted fetuses and placentas
- Blood sucking parasites may act as vectors
- Crows and sparrows act as reservoirs of infection

Treatment and control

- Use of antibiotics
- Vaccine
- Carriers state interferes in complete eradication
- Precautionary measures

3.Tuberculosis

- Serious clinical entity in wild animals
- Zoonotic importance
- Caused by M*ycobacterium bovis, M tuberculosis, M avium*
- Predisposing factors
    - Unhygienic surroundings, poor ventilation and poor nutrition contribute to the infection

Transmission

- Through contaminated feed and water
- Aerosol transmission/droplets containing bacilli
- Non human primates-extensive diseases involving lung and extra pulmonary tissues

Signs

- Pulmonary tuberculosis-cough, difficulty in breathing, purulent discharge from nasal cavity, emanciation, rough hair coat
- Visceral form: gastric upset, enlarged spleen and liver

Diagnosis

- Clinical signs
- Radiological examination
- Tuberculin skin test

Treatment and control

- Long term treatment required
- Hygiene and sanitation
- Quarantine: max. 60 days or preferably 120 days
- Destruction of animals disinfection of premises

4.Salmonellosis

- Caused by Salmonell of more than 120 species
- Mostly in waterfowld and water birds, and reptiles
- Possible zoonotic importance

Signs

- Diarrhoea, vomiting and mild fever
- Pale oral mucosa
- Increased cloacal temperature
- Polydipsia

Diagnosis

- Fecal culture
- Serology
- Postmortem lesions

Treatment

- Oral administration of nitrofurazone
- Use of anti microbials
- Disinfection of area
- Rodents and insects control

Protozoan

Protozoa are single-celled microscopic organisms noted for their motility, i.e., ability to move independently. Examples are amoeba, paramecium, and euglena. They live in many different environments; they can drift in the ocean, creep across vegetation in fresh water rivers and ponds, crawl in deep soil, and even reproduce inside the bodies of other organisms. Many protozoans can survive in harsh conditions or severe changes in the environment, such as nutrient deficiency, drought, decreased oxygen concentration, or pH or temperature changes, by forming cysts.

Helminthes

Many species are parasitic. Examples are tapeworms, roundworms.