UPSC PRELIMS 2026

Environment & Ecology

NOTES

BIODIVERSITY

NEETU SINGH

DIRECTION

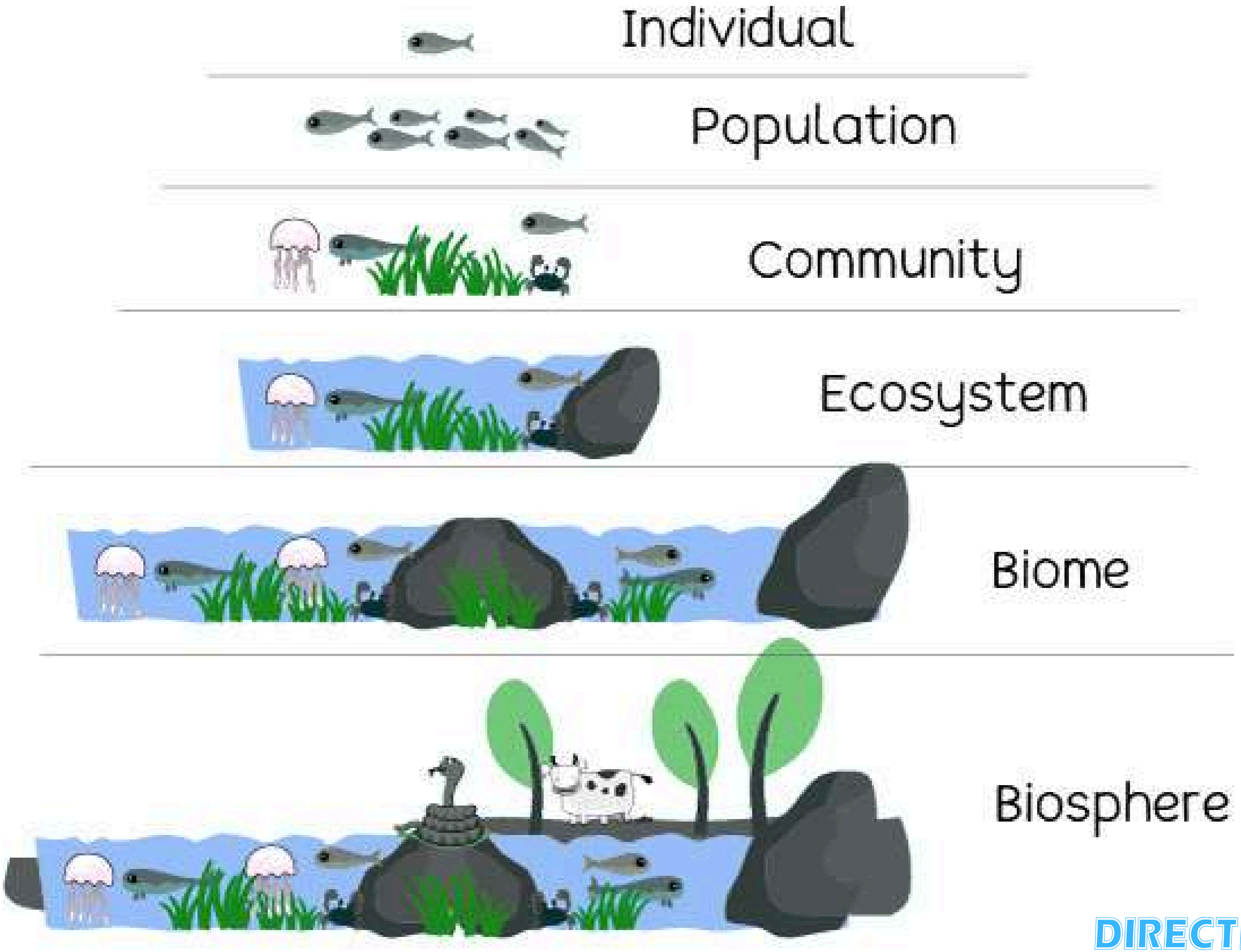
What is Ecology

The word ecology is a combination of the Greek ‘oikos,’ for house, and ‘logy’ for knowledge. Literally translated, ecology means ‘the study of our house.’ Our house is planet Earth.

Ecology is the study of every living thing in every environment, at every scale, from the bacteria living on your skin to a blue whale breaching in the Southern Ocean, It’s the ocean itself and everything in it. It’s vast and tiny, planet-wide and microscopic.

The term "ecology" was coined by the German biologist Ernst Haeckel in 1866.

DIRECTION


Individual
Population
Community
Ecosystem
Biome
Biosphere

Organismal ecology is all about looking at how individual organisms are shaped—both physically and behaviorally—to thrive in their environments.

For example:

Morphological adaptations: A cactus has thick, fleshy stems to store water and spines instead of leaves to reduce water loss.

Physiological adaptations: Arctic foxes can change their fur color seasonally—white in winter for camouflage in snow, brown in summer to blend with tundra.

Behavioral adaptations: Birds migrating to warmer regions during winter to access food and better living conditions.

Population Ecology

Population ecology is the study of how the number of individuals of a particular species in a given area changes over time, and the factors that influence these changes.
It focuses on population size, density, distribution, and the processes such as birth, death, immigration, and emigration that regulate population dynamics.

Community ecology It’s the study of how different species interact within the same area and how those interactions shape the structure and dynamics of the community.

Types of interactions:

Competition (species competing for the same resources)

Predation (one species feeding on another)

Mutualism (both species benefit, like bees and flowers)

Commensalism (one benefits, the other is unaffected)

Parasitism (one benefits at the expense of the other)

Consequences of interactions:

Influence on species diversity and abundance

Shaping of food webs and trophic structures

Driving adaptations and co evolution

Affecting ecosystem stability and resilience

DIRECTION

Ecosystem Ecology the study of communities to include both the living components (biotic) and the non-living physical and chemical factors (abiotic) in a given area. It examines how organisms interact with each other and with their environment, creating a dynamic system.

The **environment** simply refers to the surroundings without necessarily emphasizing those interactions.

- **Interaction vs. Surroundings:** The environment is about the general surroundings, while the ecosystem highlights the interactions between organisms and their surroundings.
- **Functional Unit vs. Habitat:** An ecosystem is a functional unit of nature, whereas the environment is the broad habitat itself.
- **Interdependence:** An ecosystem emphasizes the interdependence of its components to maintain stability, a concept not necessarily implied in the broader environment.

Abiotic Factors

Physical Factors:

Temperature: The level of heat or cold in an environment.

Water: The availability of water, including precipitation, and its properties like salinity and dissolved oxygen.

Light: The amount of sunlight available for processes like photosynthesis.

Soil: The type, composition, and nutrient content of the soil.

Atmosphere: Gases in the air, humidity, and wind patterns.

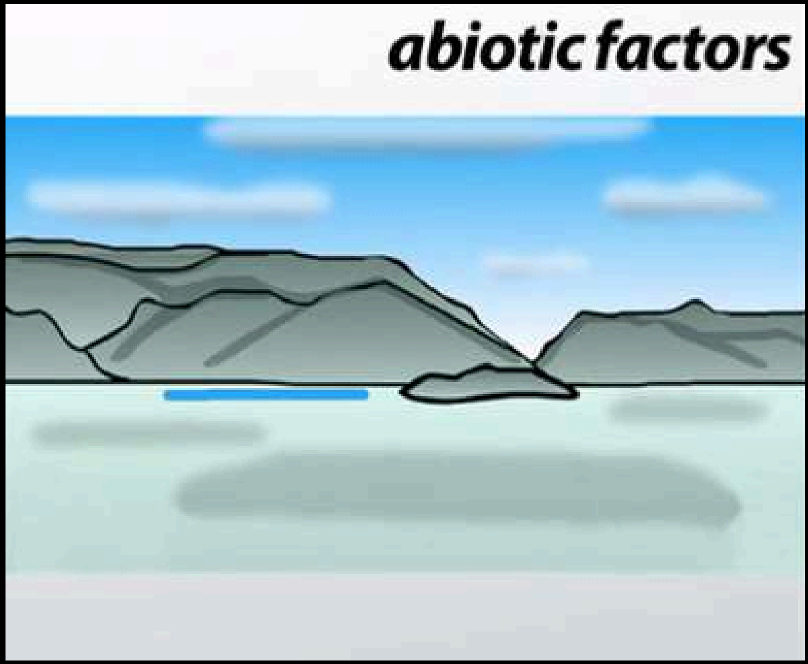
Elevation/Altitude: The height above sea level.

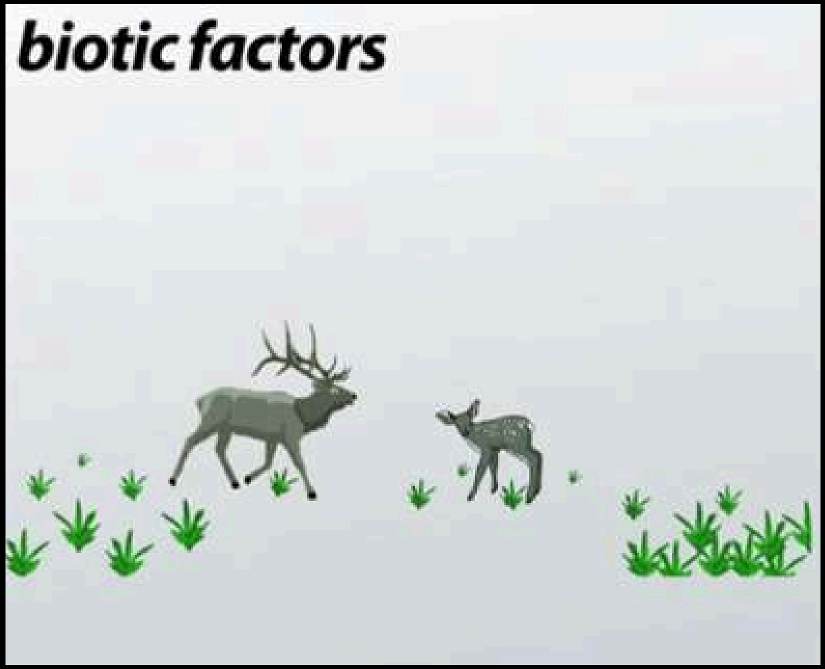
Chemical Factors:

pH: The acidity or alkalinity of the soil or water.

Salinity: The amount of salt in the water, especially relevant in marine ecosystems.

Nutrients: The mineral and organic compounds available in the soil or water.





Temperature

Temperature of the air and water affect animals, plants and humans in ecosystems. A rise in temperature has the potential to change the way a living thing develops, because it changes the metabolic rate of the organism. All living organisms have a tolerance level for temperature range. For example, a human being would die if he stood out in minus 50 degree temperatures for any length of time. Light exposure often affects the temperature. Areas with direct sunlight are warmer.

- Organisms which can tolerate wide fluctuations in temperature are termed - Eurythermal. Eg: Lizards, Birds and Mammal
- Organisms which can tolerate only small variation in temperature are termed Stenothermal organisms Eg: Coral animals, Fishes
- The number of hours of daylight triggers seasonal events, such as: -plants flowering -birds migrating

Homeothermic animals

The term 'homeo' derives from Greek and means 'same' or 'similar'. This is because the definition of a homeotherm is:
An animal or organism that maintains a relatively constant body temperature.
The ability to maintain a relatively steady body temperature is due to internal physiological processes. Since these process are internal, it means they are endothermic (i.e. their heat comes from within). Such processes allow the organism to maintain their bodily functions, even when the external environment changes drastically.

Traditionally, homeothermic animals have been known as 'warm-blooded animals'.
Only birds and mammals are currently considered true homeothermic animals. There is an exception in the reptile group of animals, specifically the Argentine black and white tegu (Salvator merianae). This homeothermic lizard has some endothermic behavior, but also relies on environmental temperature for survival.

DIRECTION

Poikilotherm animals

The term **'poikilo'** is also of Greek origin and means 'varied'. In this case, the definition of a poikilotherm is: An animal or organism that has a considerably variable temperature.

The reason why poikilotherms have a highly variable temperature is because they cannot self-regulate it. Accordingly, their body temperature varies according to the environmental temperature. This means that poikilotherms are **exothermic** since their heat comes from external sources. It is for this reason they are known as 'cold-blooded animals', despite this being and imprecise description of their type of thermoregulation.

Poikilothermic animals are exposed to various temperatures in their environment.

Unlike homeotherms, poikilothermic animals can survive without eating for much longer periods. This is because they do not depend on metabolizing what they ear to maintain body temperature.

DIRECTION

Water

Precipitation: Fog, Mist, Rain, Snow, Sleet, Hail
Runoff: Brook, Creek, Stream, River Water Table: Puddle, Pond, Lake (Ocean not freshwater)
Soil Water: Most useful for plants Aquifers: porous rock, wells, artesian wells, springs
• All living things need water to carry out life processes”
• Plants need water for photosynthesis • Animals need water to digest food and release energy stored in the food
• Desert Oasis: forms when underground water comes to the surface
•Ecosystesm with lots of water can support a large number of different types of plants, which in turn support a variety of types of animals

Types fish migration on the basis of needs:

- Alimentary or Feeding migration: migration for search of feeding ground. It occur when food resources get exhausted.
- Gametic or spawning migration: it occur during breeding season in search for the suitable spawning ground.
- Climatic or seasonal migration: migration in search for suitable climatic condition. Osmoregulatory migration: migration for water and electrolytes balance from sea to fresh water and vice-versa.
- Juvenile migration: it is larval migration from spawning ground to the feeding habitats of their parent.

Types of fish migration

1. Diadromous migration 2. Potamodromous migration 3. Oceanodromous migration

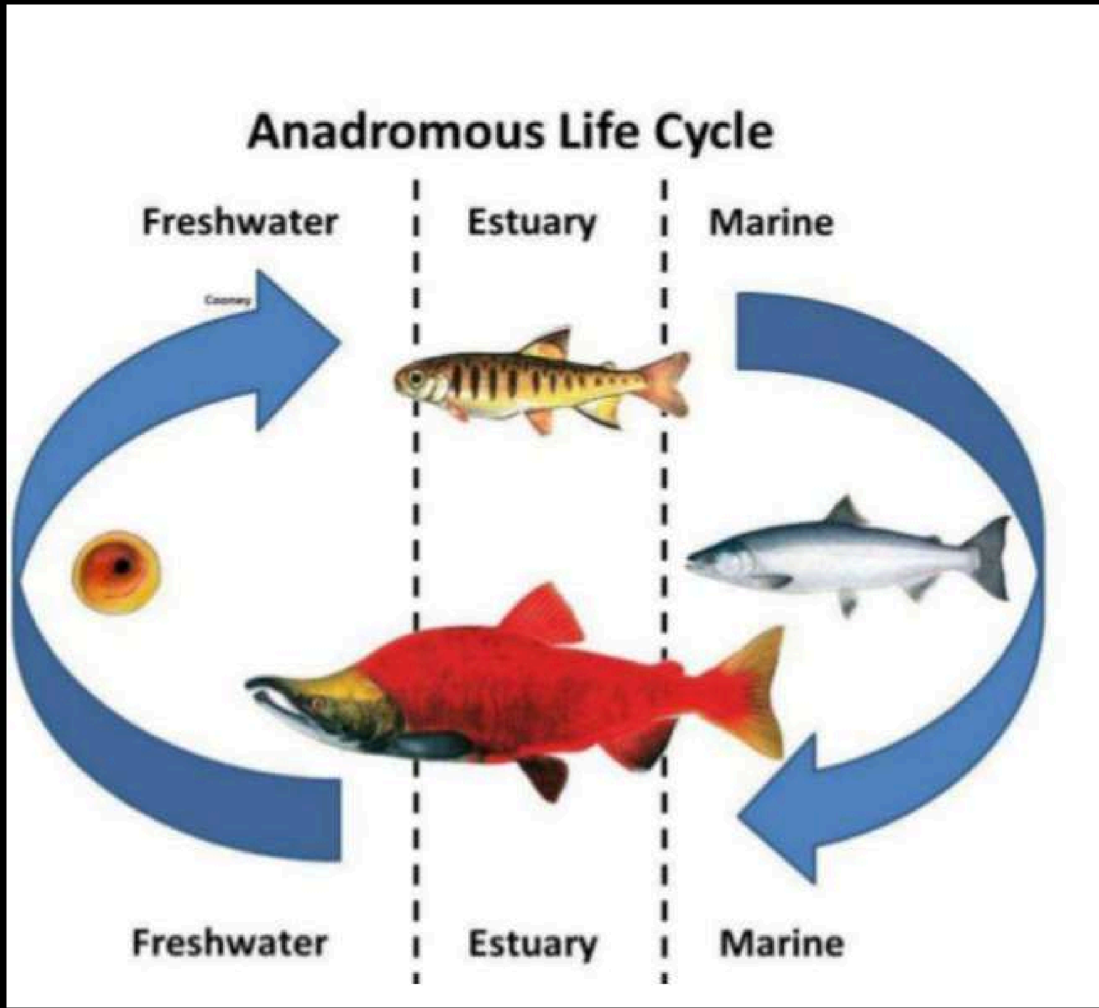
1.Diadromous migration: It is the migration of fish between sea and fresh water.

Diadromous migration is of three types

Anadromous migration

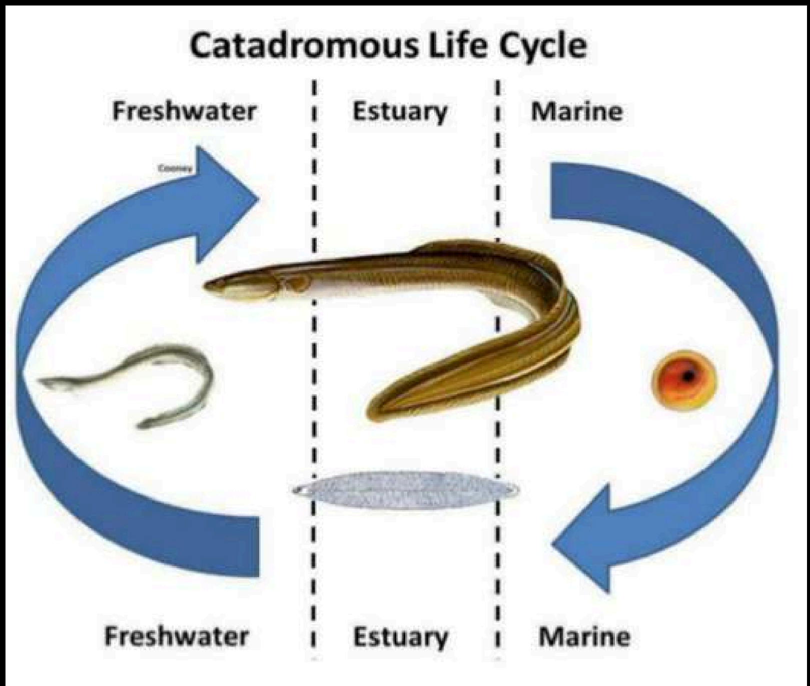
- It is the migration of marine fishes from sea to fresh water for spawning.
- Fishes spend most of their life living and feeding in sea.
- They only migrate during breeding season to the river for spawning ground.

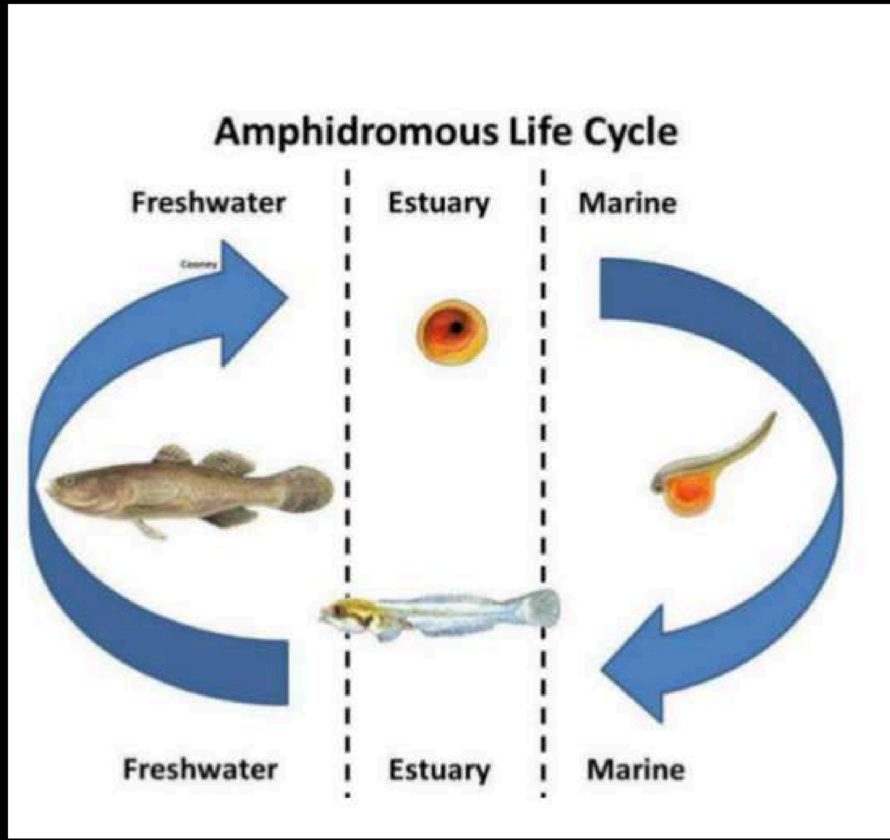
Eg. Salmon, Hilsa etc.



Catadromous migration

- It is the migration of fresh water fishes from river to sea during breeding season for spawning. Eg. Eel (Anguilla spp)
- Both European eel (Anguilla anguilla or Anguilla vulgaris) and the American eel (Anguilla rostrata) migrate from the continental rivers to Sargasso Sea off Bermuda in south Atlantic for spawning, crossing Atlantic Ocean.



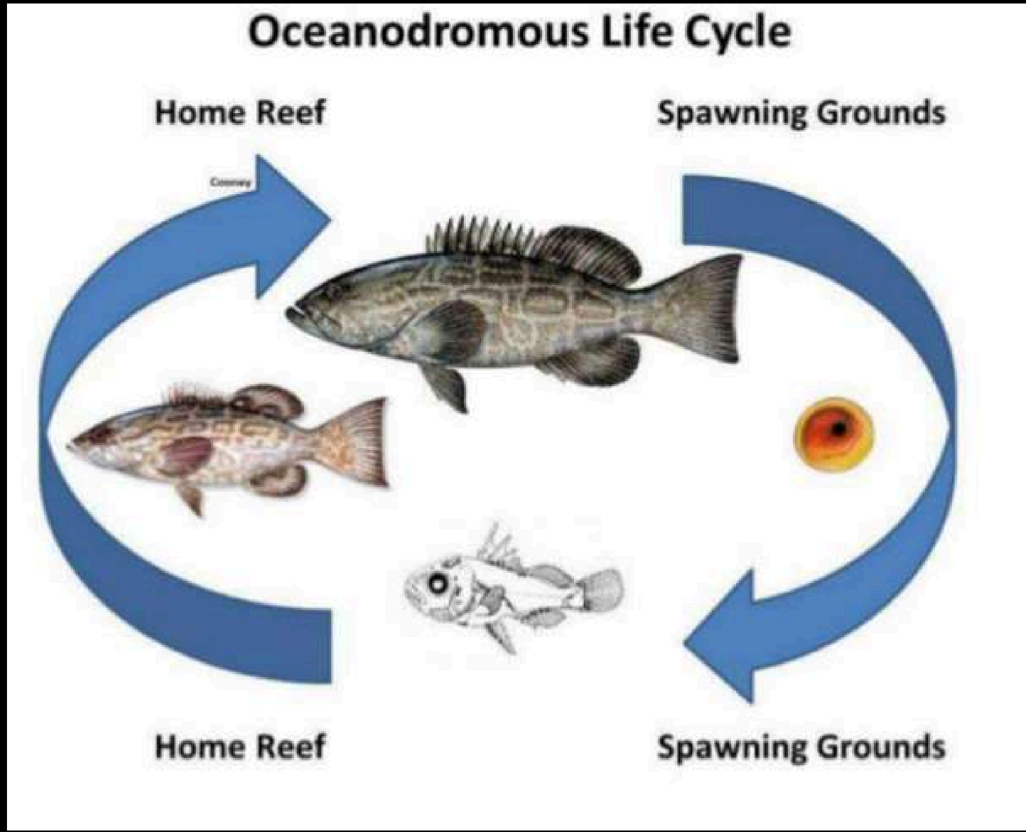


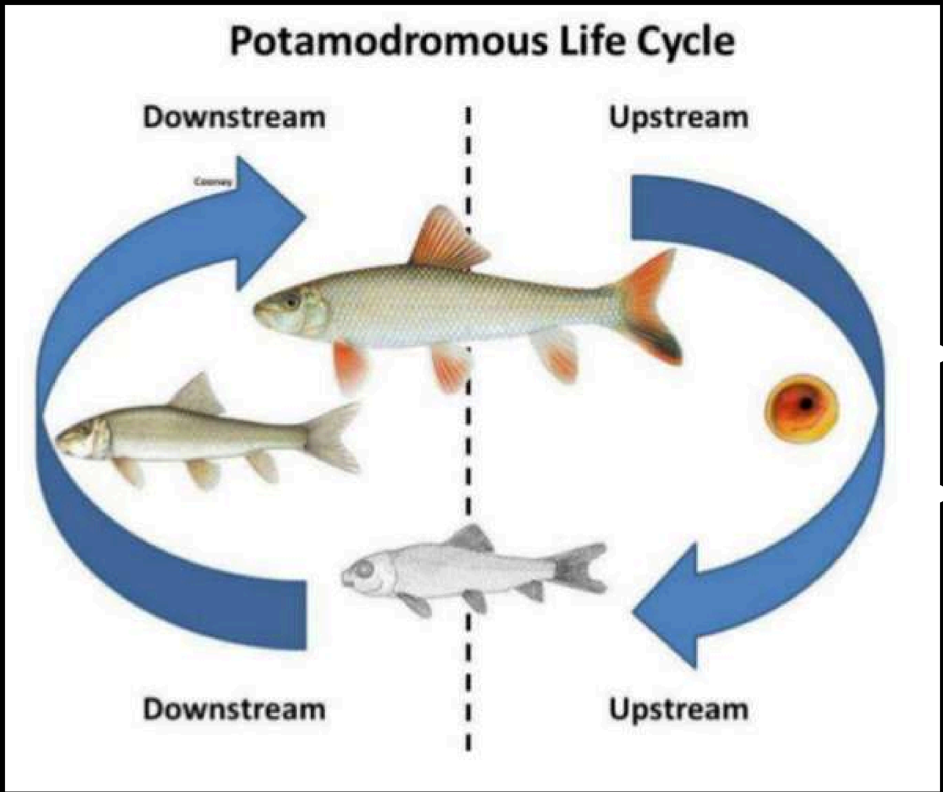
1. Amphidromous migration

Type of migration which involves movement from fresh water to the sea or vice versa, is not for the purpose of breeding. But this migration occurs regularly at some definite stage of the life cycle. examples includes Bigmouth sleeper, mountain mullet, torrentfish, Dolly Varden

2. Potamodromous migration:

- Movement is confined to fresh water . These species travel long distances in river to locate suitable spawning grounds .
- Fish are born in upstream freshwater habitats, then migrate downstream (still in freshwater) as juveniles to grow into adults before migrating back upstream to spawn.
- Examples: catfish, cyprinidies, etc.





3. Oceanodromous migration:

- Truly migratory fishes which live and migrate in the sea.
- Many marine fishes like the cod , the herrings (Clupea), mackerels (Scomber) and the tunnas (Thunnas) travel long distance in the sea to deposit their eggs, and later return to the feeding grounds.

DIRECTION

Light

Light is a complex environmental factor that produces diverse ecological effects. Light energy (sunlight) is the primary source of energy in nearly all ecosystems. It is the energy that is used by green plants (which contain chlorophyll) during the process of photosynthesis; a process during which plants manufacture organic substances by combining inorganic substances.

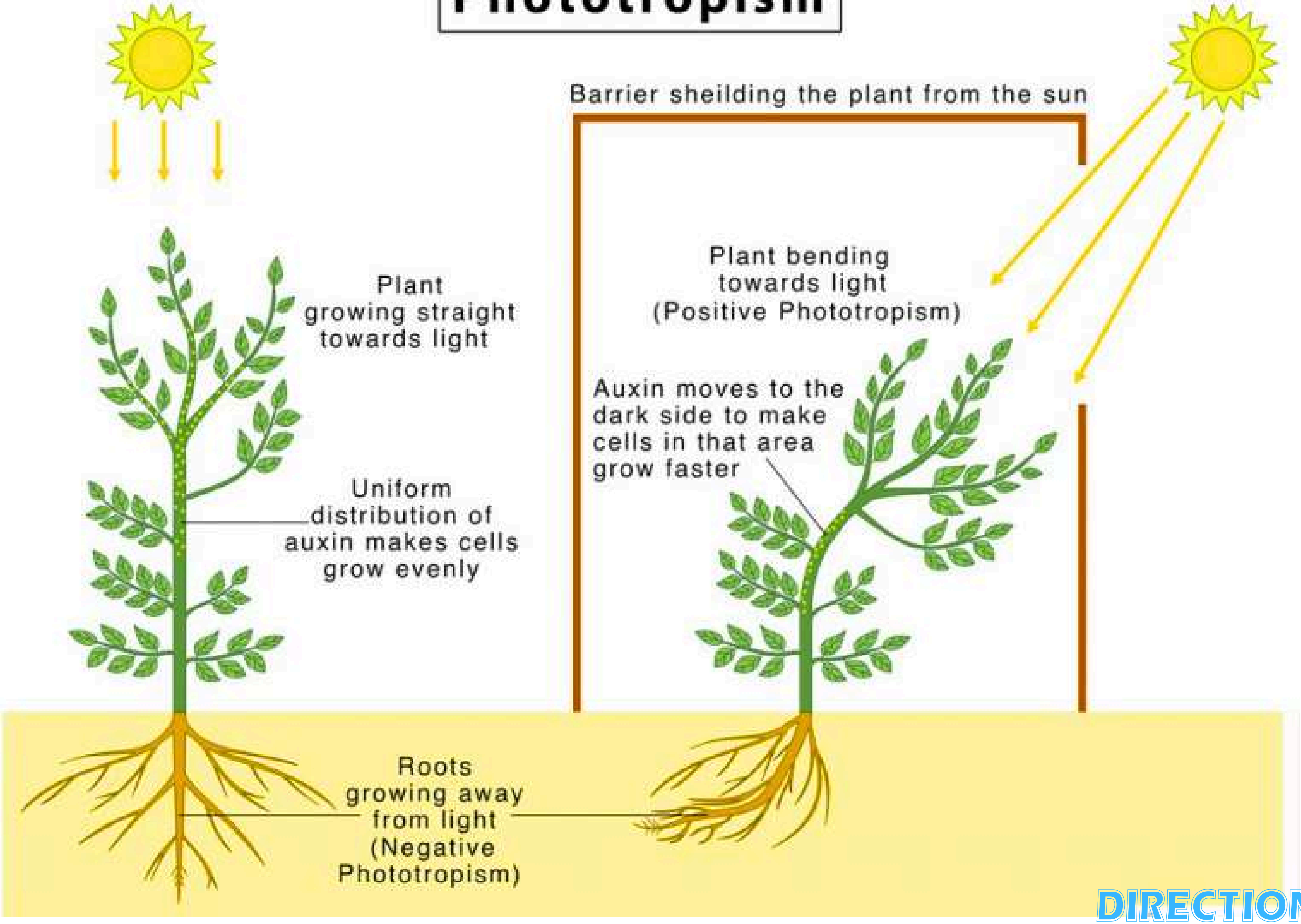
Photoperiodism can be defined as the relative lengths of daylight and darkness that effect the physiology and behaviour of an organism.

Phototropism is the directional growth of plants in response to light where the direction of the stimulus determines the direction of movement; stems demonstrate positive phototropism i.e. they came towards the light when they grow.

- Light requirements of plants differ and as a result distinct layers, or stratification, can be observed in an ecosystem.

Plants which grow well in bright sunlight are called **heliophytes** (Greek helios, sun) and plants which grow well in shady conditions are known as **sciophytes** (Greek skia, shade)

Phototropism

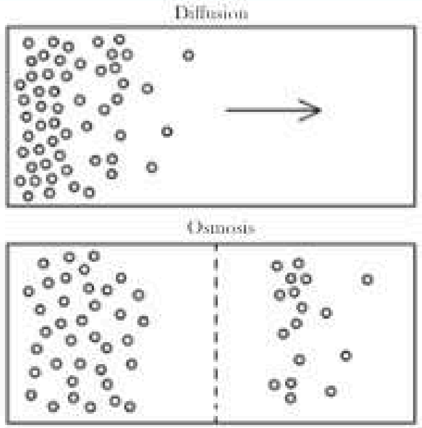


Salinity

Salinity is an important abiotic factor because the normal functioning of animals depends on the regulation of the water and ions in their internal environment, which is influenced by the water and ions in their external environment .

The relative concentration of salts inside organisms compared to their external environment affects biophysical processes such as **diffusion and osmosis,** which impacts chemical reactions including metabolism.

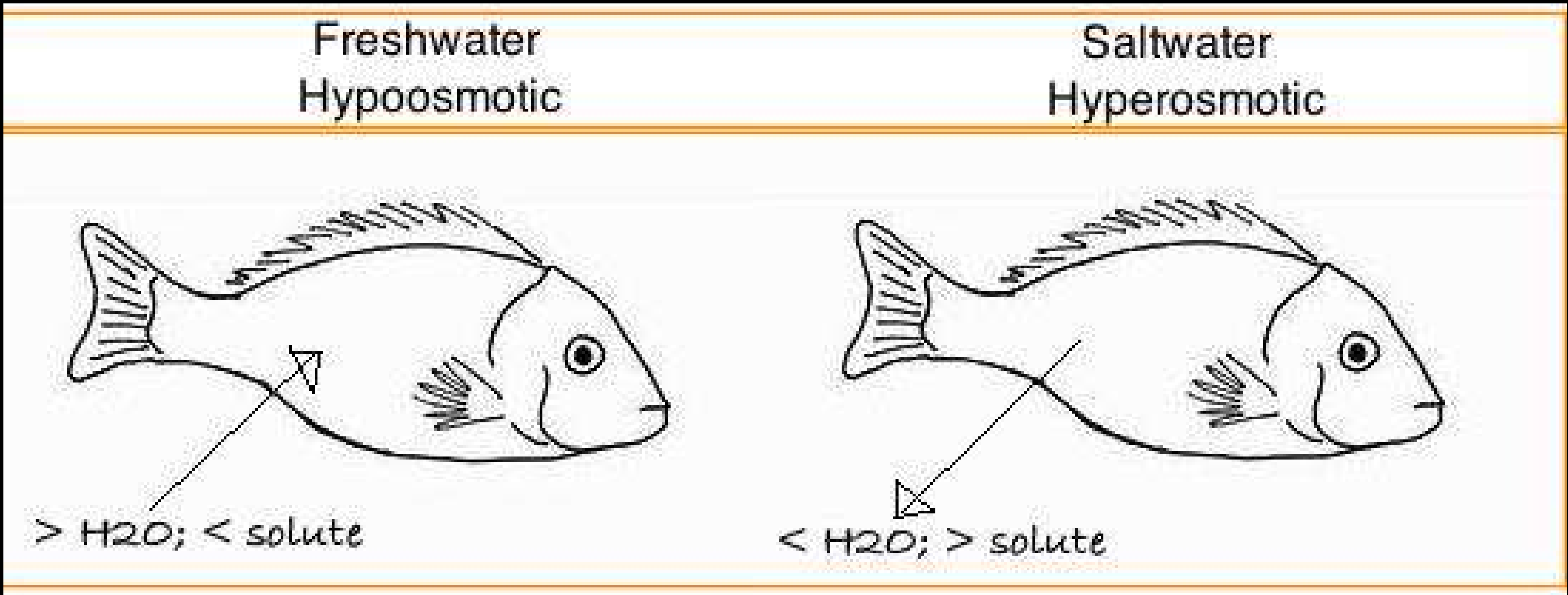
Diffusion is the natural movement of all molecules, including water, from an area of high concentration to an area of low concentration.



Osmosis refers to the movement of water through a membrane. When two solutions with different concentrations of solutes (compounds dissolved in a liquid) are separated by a membrane, water will move from the side with a lower solute concentration to the side with a higher solute concentration.

In a **hyposmotic environment**, such as a lake, the solute concentration in the environment is typically lower than in the cells. Cells will swell up due to the osmotic influx of water.

In a **hyperosmotic environment**, such as ocean, the solute concentration in the environment is often higher than in the cells. This causes water to move out of the cells.



DIRECTION

Variations in salinity could cause osmotic stress to animals. Osmotic stress occurs when organisms are exposed to water and solute concentrations that are different from their normal internal concentrations . Animals use two general strategies for coping with variations in salinity — osmoconformation and osmoregulation

Osmoconformers, such as most marine invertebrates (e.g. marine sponges, jellyfish, and flatworms), exhibit an internal water and solute concentration that is similar to that of their external environment. They do not expend a lot of energy to move solutes in response to changes in environmental salinities; instead, their internal solute concentration changes to be the same as the salinity of the environment. The resulting increases or decreases in salt concentrations in cells can affect their metabolic rate. Osmoregulators, such as most marine vertebrates (e.g. bony fish, sea turtles, and sea otters), maintain an internal water and solute concentration that is within a narrow range independent of the external environment. Considerable energy is required to control water and salt balance during the process of osmoregulation. This could reduce the amount of energy available for other normal activities and behaviours.

Some animals (e.g. some species of crabs) use a combination of both osmoregulation and osmoconformation depending on the salinity of the environment.

DIRECTION

Ecosystem Principles

1. SPECIATION
2. DIVERSITY
3. HABITAT
4. ADAPTATION
5. INTERDEPENDENCE
6. EVOLUTION

SPECIATION

Speciation is the process of formation of a new genetically independent group of organisms, called species, through the course of evolution.

Speciation occurs in two ways.

- Transformation of old species into new species over time.
- Splitting of a single species into several, that is the multiplication of species.

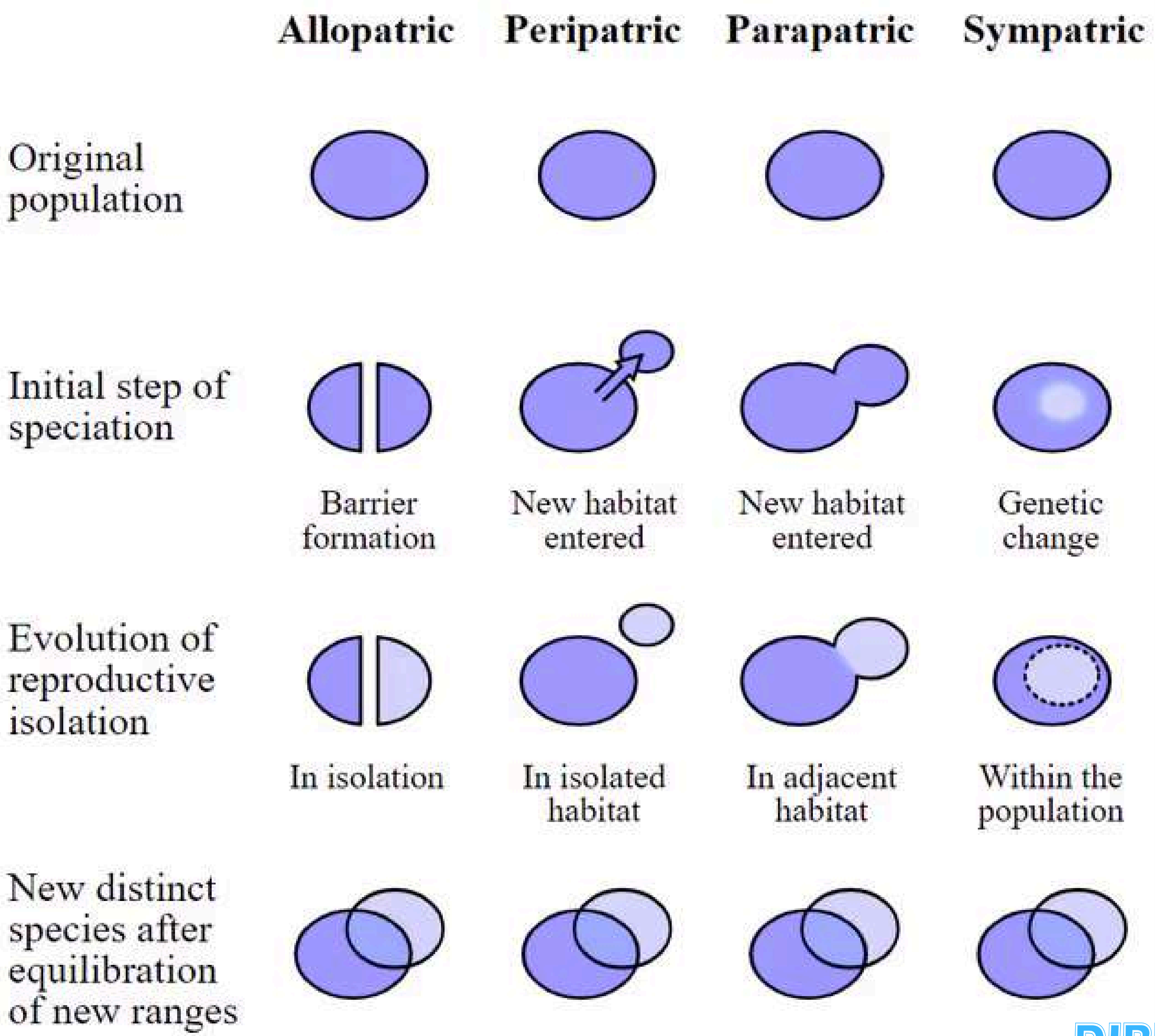
Speciation process (how does speciation occur?) Classically, speciation has been observed as a three-stage process:

- Isolation of populations.
- Divergence in traits of separated populations (e.g. mating system or habitat use).
- Reproductive isolation of populations that maintains isolation when populations come into contact again (secondary contact).

Types of speciation/Modes of speciation

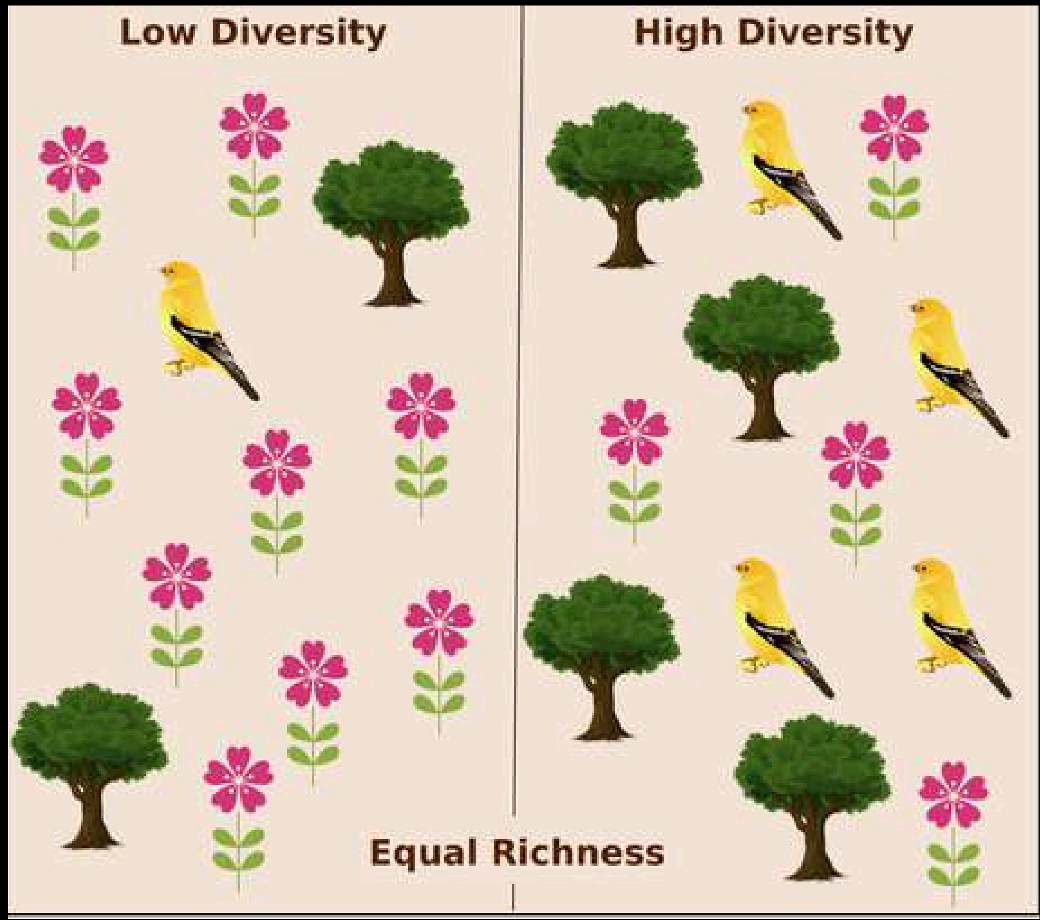
1. allopatric speciation- geographic isolation., physical barrier, like a mountain range or ocean, separates a population, preventing gene flow.
2. peripatric speciation, a form of allopatric speciation where a small population becomes geographically isolated from the larger population and evolves into a new, distinct species
3. parapatric speciation, a type of speciation where new species evolve from a continuously distributed population that is partially reproductively isolated. and
4. sympatric speciation refers to a speciation process when two groups of identical species lived in identical geographical areas, they evolve in such a way that they could no longer interbreed.

DIRECTION


Allopatric
Peripatric
Parapatric
Sympatric
Original population
Initial step of speciation
Barrier formation
New habitat entered
New habitat entered
Genetic change
Evolution of reproductive isolation
In isolation
In isolated habitat
In adjacent habitat
Within the population
New distinct species after equilibration of new ranges

DIVERSITY

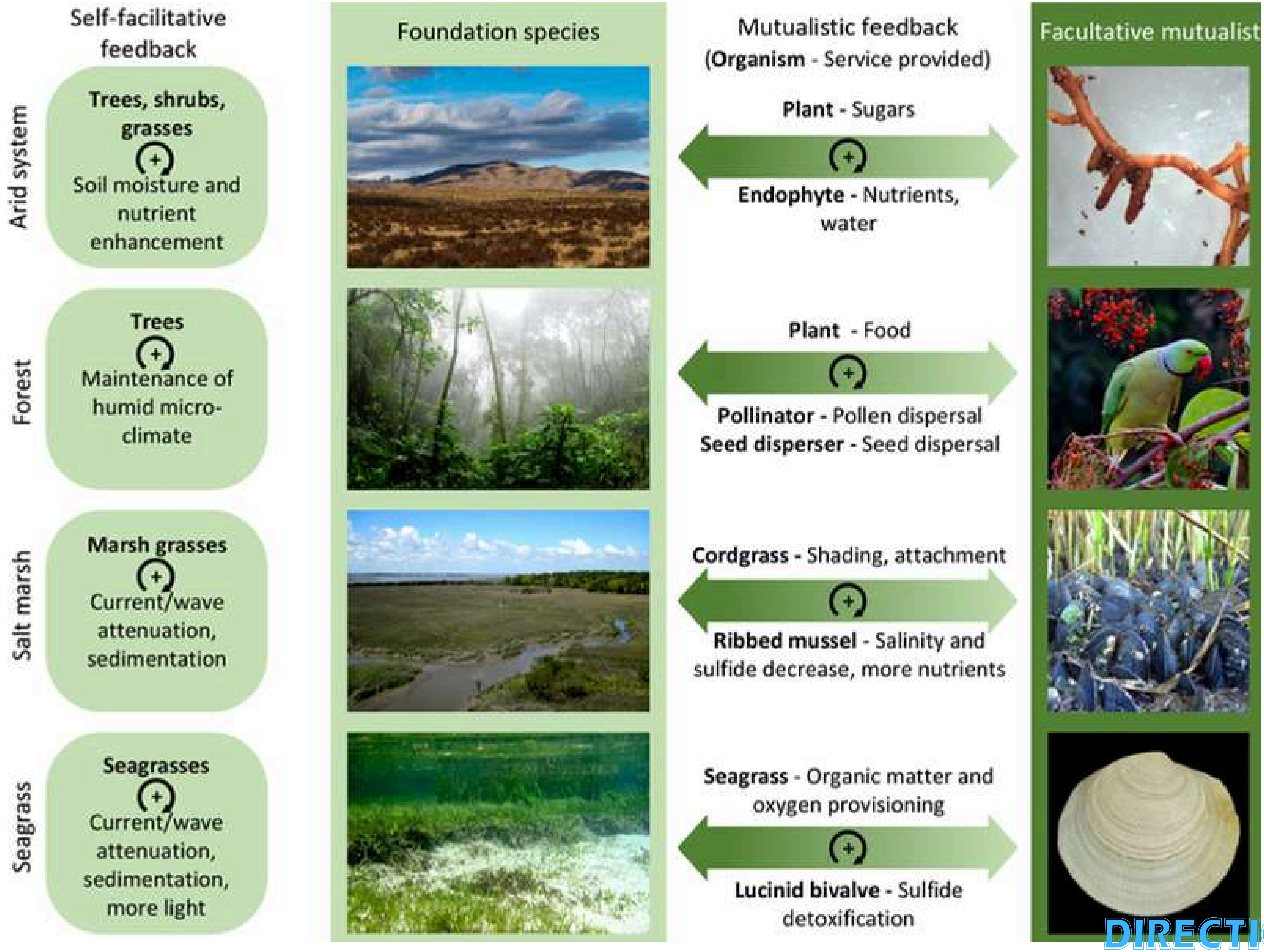
Species diversity is the number of different species in a particular area and their relative abundance. The area in question could be a habitat, a biome, or the entire biosphere.



Species richness, the number of species living in a habitat or other unit, is one component of biodiversity.

Species evenness is a component of species diversity based on relative abundance (the number individuals in a species relative to the total number of individuals in all species within a system).

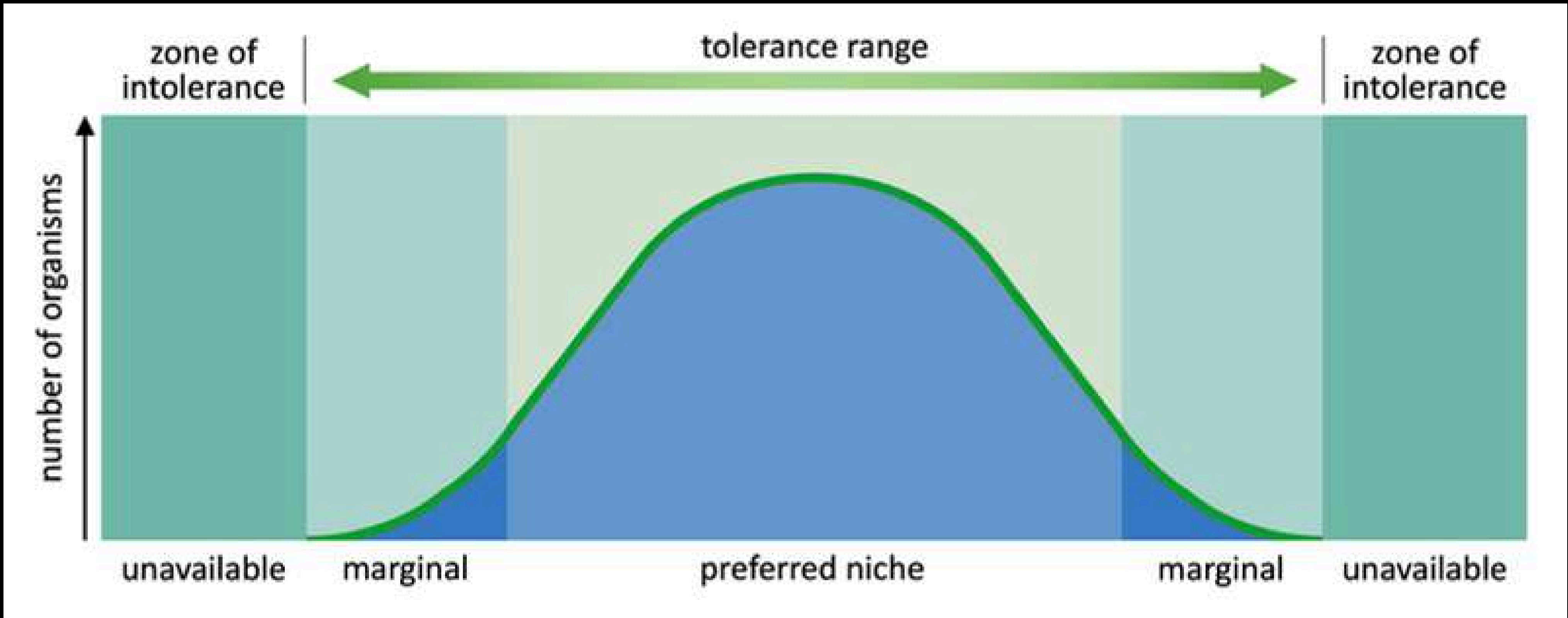
Foundation species are considered the “base” or “bedrock” of a community, having the greatest influence on its overall structure. They are usually the primary producers: organisms that bring most of the energy into the community. Kelp, a brown algae, is a foundation species that forms the basis of the kelp forests off the coast of California.


Self-facilitative feedback
Foundation species
Mutualistic feedback
(Organism - Service provided)
Facultative mutualist
Arid system
Trees, shrubs, grasses
+
Soil moisture and nutrient enhancement
Plant - Sugars
+
Endophyte - Nutrients, water
Forest
Trees
+
Maintenance of humid micro-climate
Plant - Food
+
Pollinator - Pollen dispersal
Seed disperser - Seed dispersal
Salt marsh
Marsh grasses
+
Current/wave attenuation, sedimentation
Cordgrass - Shading, attachment
+
Ribbed mussel - Salinity and sulfide decrease, more nutrients
Seagrass
Seagrasses
+
Current/wave attenuation, sedimentation, more light
Seagrass - Organic matter and oxygen provisioning
+
Lucinid bivalve - Sulfide detoxification

HABITAT

A **habitat** is the specific natural environment where an organism lives and thrives, providing the essential resources like food, water, shelter, and space for survival and reproduction

Large Scale: The Galapagos Islands serve as a habitat for several unique finch species.
Small Scale: A single rotten log can be a habitat for insects and other small organisms.
Specific Location: The bark of a tree can be a habitat for certain insects, providing them with both food and shelter.



DIRECTION

Ecological Niche

An ecological niche refers to the interrelationship of a species with all the biotic and abiotic factors affecting it. This definition of niche though has changed over time.

Joseph Grinnell in 1917 coined the term niche, which he used as mostly equivalent to a species habitat.

In 1927, Charles Sutherland Elton regarded niche to be equivalent to the position of a species in a trophic web.

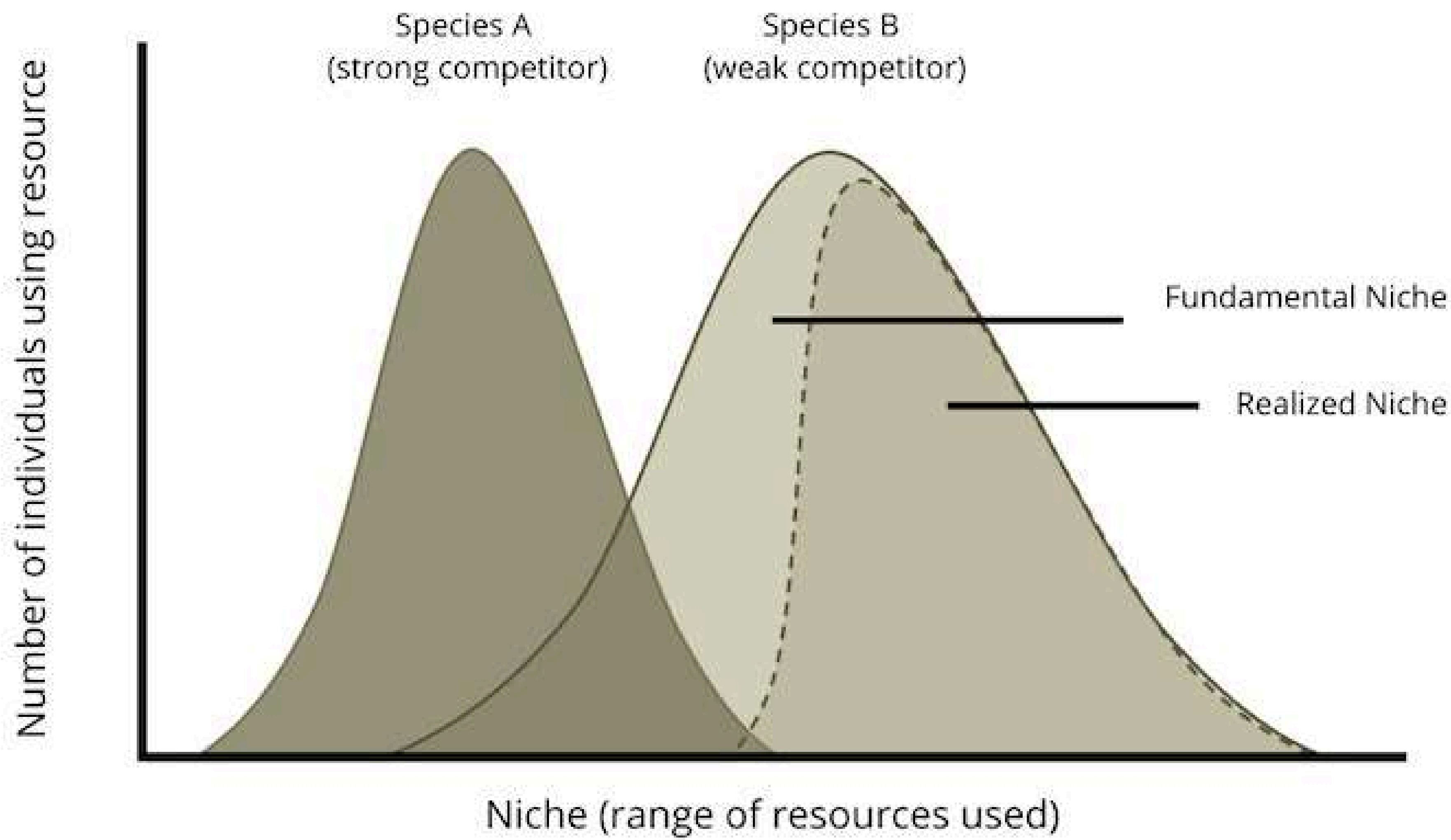
In 1958, George Evelyn Hutchinson used the term niche to describe the multi-dimensional space of resources available to and used by a species.

A niche pertains to any of the following:

- The specific area where an organism inhabits
- The role or function of an organism or species in an ecosystem
- The interrelationship of a species with all the biotic and abiotic factors affecting it

DIRECTION

Competition as Niche determiner



DIRECTION

Ecotone, Ecocline & Ecotope

An **ecotone** is the junction where two major communities or biomes meet and blend. It is a transition zone between two or more communities such as forest and grassland, hard bottom or marine communities, etc. An ecotone can be small or large in size.

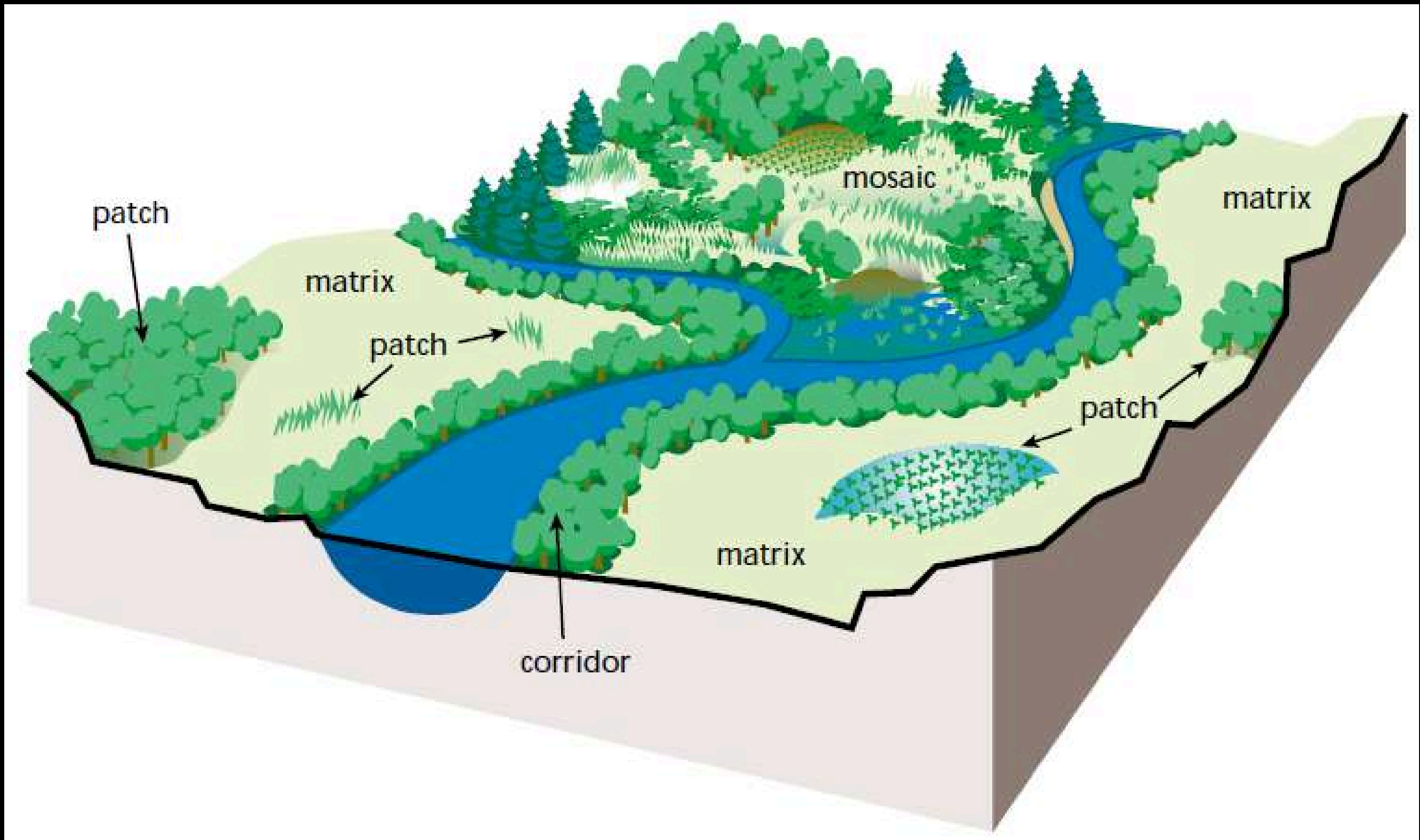
- Sudden changes in an environment can often lead to the formation of ecotones.
- The vegetation here can be narrow or wide. A narrow ecotone is visible between a grassland and a forest while the ecotone between a desert and a forest is often wide.
- Ecotones promote diversity as it opens new opportunities for other organisms to come and inhabit these areas. It often supports a higher diversity of species than the adjacent ecosystems alone.

Edge Effect

The edge effect is the change in characteristics shown by the organisms in the ecotone when compared to the respective communities. Such differences between adjacent communities happen due to changes in their environment. These changes occur due to the differences in moisture, light, soil, biotic pressure, exposure, soil conditions, temperature, humidity, and vegetation structure. The edge effect creates a distinct microenvironment that is different from the interior of the ecosystems on both sides. It favors certain species and allows them to coexist and interact. At the same time, these transitional zones can make some species vulnerable to changes, increase predation, competition, etc.

An ecocline is another type of landscape boundary, but it is a gradual and continuous change in environmental conditions of an ecosystem or community. Ecoclines help explain the distribution and diversity of organisms within a landscape because certain organisms survive better under certain conditions, which change along the ecocline. They contain heterogeneous communities which are considered more environmentally stable than those of ecotones .

An ecotope is a spatial term representing the smallest ecologically distinct unit in mapping and classification of landscapes . Relatively homogeneous, they are spatially explicit landscape units used to stratify landscapes into ecologically distinct features. They are useful for the measurement and mapping of landscape structure, function, and change over time, and to examine the effects of disturbance and fragmentation.



ADAPTATION

Organisms are equipped in a number of ways to cope with their environment. The adjustments made by the individuals in response to the specific environmental conditions are known as adaptations. Adaptations are structural or physiological characteristics that allow an organism to exist under the conditions imposed by its habitat.

Types of Adaptation:

Morphological Adaptations (Physical Changes) These are permanent physical characteristics of an organism's body that aid its survival.

- Thick fur: in polar bears provides insulation in cold climates.
- Streamlined bodies: in dolphins allow for efficient movement through water.
- Long roots: in plants help them access water in dry environments.

Physiological Adaptations (Functional Changes) These are internal body functions or chemical processes that help organisms survive.

- Efficient kidneys: in desert animals conserve water.
- The ability of some plants to photosynthesize in low light environments.
- Antifreeze proteins: in arctic animals prevent them from freezing.

Behavioral Adaptations (Actions or Habits) These are learned or inherited actions that an organism takes to improve its chances of survival and reproduction.

- Birds migrating: to warmer areas during winter.
- Nocturnal activity: in hot climates, where animals are active at night.
- Mating calls: used by species to attract mates of the same kind.

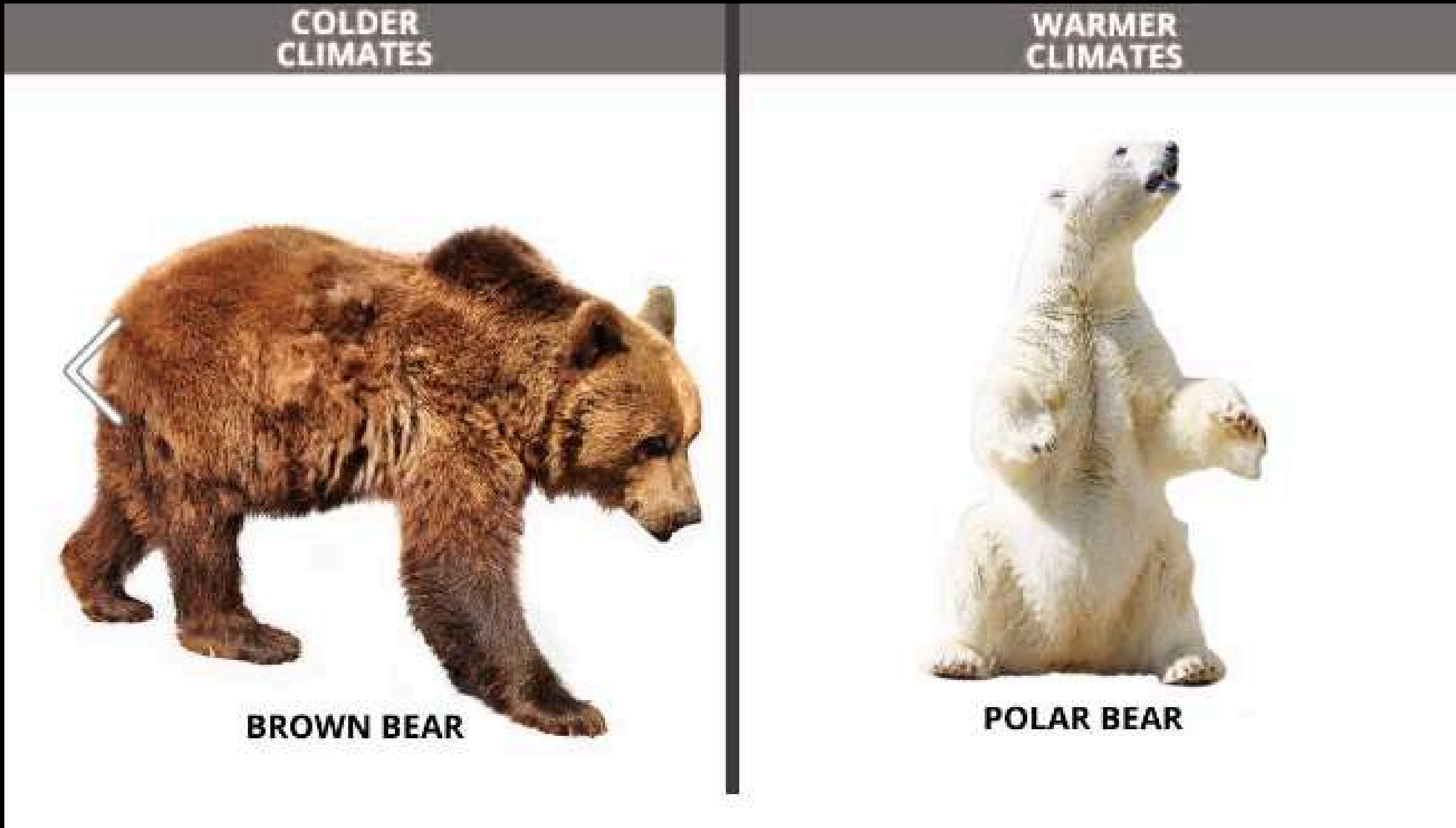
Bergmann's Rule:

This rule, given by Karl Bergmann, suggests that within a species, larger individuals are found in colder climates because a larger body mass has a smaller surface-area-to-volume ratio, which reduces heat loss

DIRECTION

Gloger's Rule:

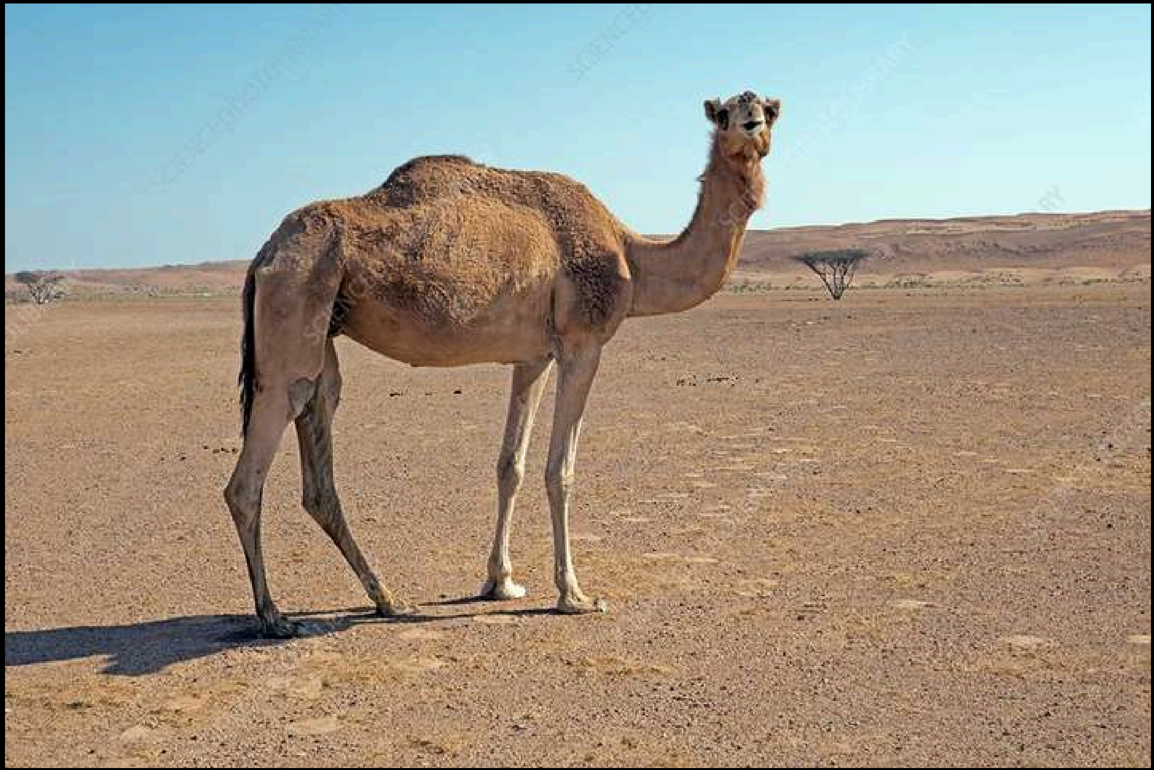
Within a species, darker pigmentation is found in more humid or tropical environments, possibly as a form of UV protection



DIRECTION

Wilson's Rule:

Arctic animals often have thicker insulation, such as a dense layer of fur or fat, to better withstand cold temperatures



DIRECTION

INTERDEPENDENCE

Many living things interact with other organisms in their environment. In fact, they may need other organisms in order to survive. This is known as interdependence

Commensialism – where one species benefits while the other is unaffected.

Mutualism – both species benefit.

Parasitism – one species benefits while one is harmed.

Competition – neither benefits.

Predation – one species benefits while the other dies, and

Neutralism – both species unaffected.

DIRECTION

Symbiotic relationships, or symbioses (plural), are close interactions between individuals of different species over an extended period of time which impact the abundance and distribution of the associating populations.

Commensalism

A commensalistic relationship occurs when one species benefits from the close, prolonged interaction, while the other neither benefits nor is harmed. Birds nesting in trees provide an example of a commensal relationship. The tree is not harmed by the presence of the nest among its branches. The nests are light and produce little strain on the structural integrity of the branch. Most of the leaves, which the tree uses to obtain energy by photosynthesis, are above the nest, so they are unaffected. The bird, on the other hand, benefits greatly. If the bird had to nest in the open, its eggs and young would be vulnerable to predators.

Mutualism

A second type of symbiotic relationship, mutualism, is where two species both benefit from their interaction. Some scientists believe that these are the only true examples of symbiosis.

For example, Humans and gut bacteria
The pollinator, such as an insect or bird, gets a food reward, like nectar or pollen, while the plant receives the crucial service of pollen transfer, allowing it to reproduce and exchange genetic material.

Parasitism

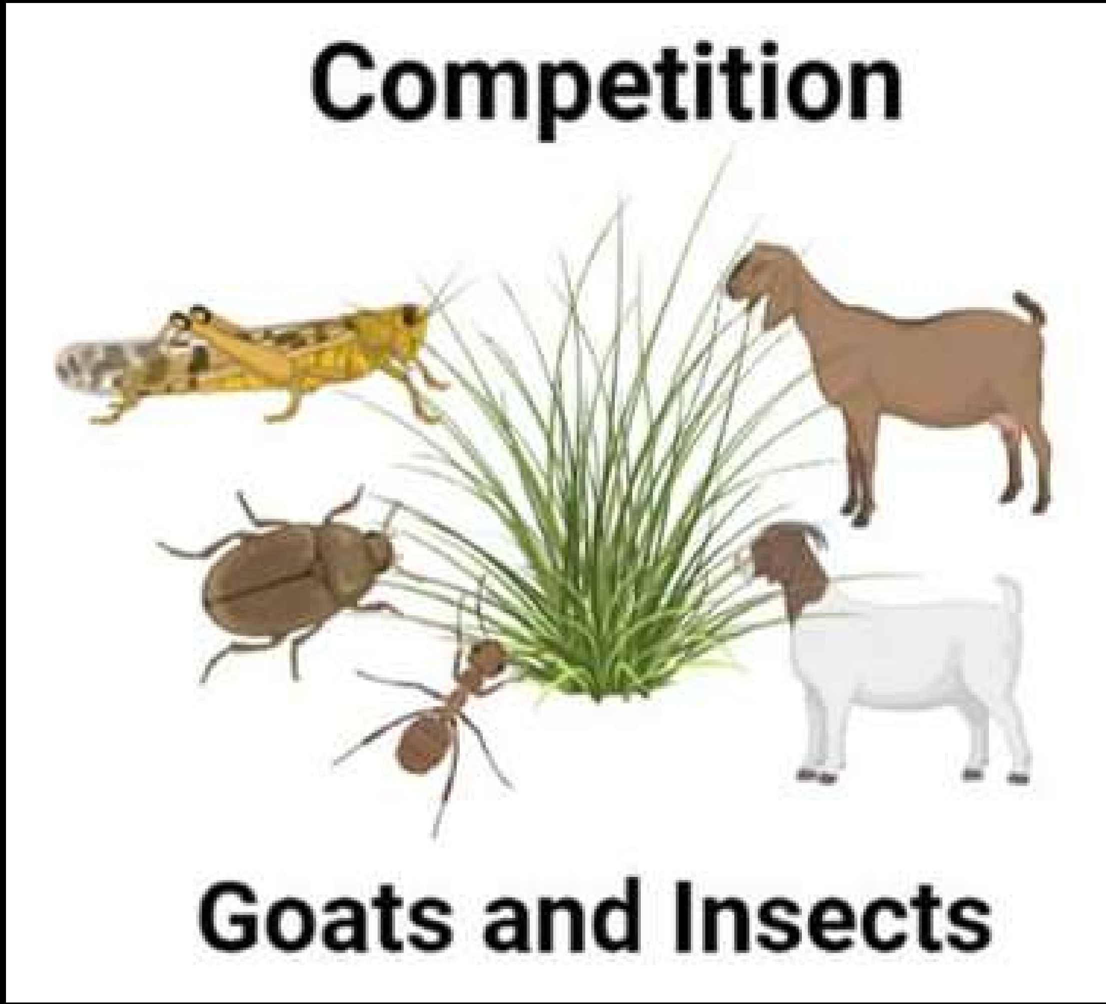
A parasite is an organism that lives in or on another living organism, deriving nutrients from it. In this relationship the parasite benefits, but the organism being fed upon, the host, is harmed. The host is usually weakened by the parasite as it siphons resources the host would normally use to maintain itself. The parasite, however, is unlikely to kill the host. This is because the parasite needs the host to complete its reproductive cycle by spreading to another host.

DIRECTION

Amensalism is a type of negative ecological interaction where one of the species is harmed or destroyed while the other either benefits or remains unaffected.

Amensalism can be divided into two distinct types depending on the species involved and the effect of the interaction.

1. Competition



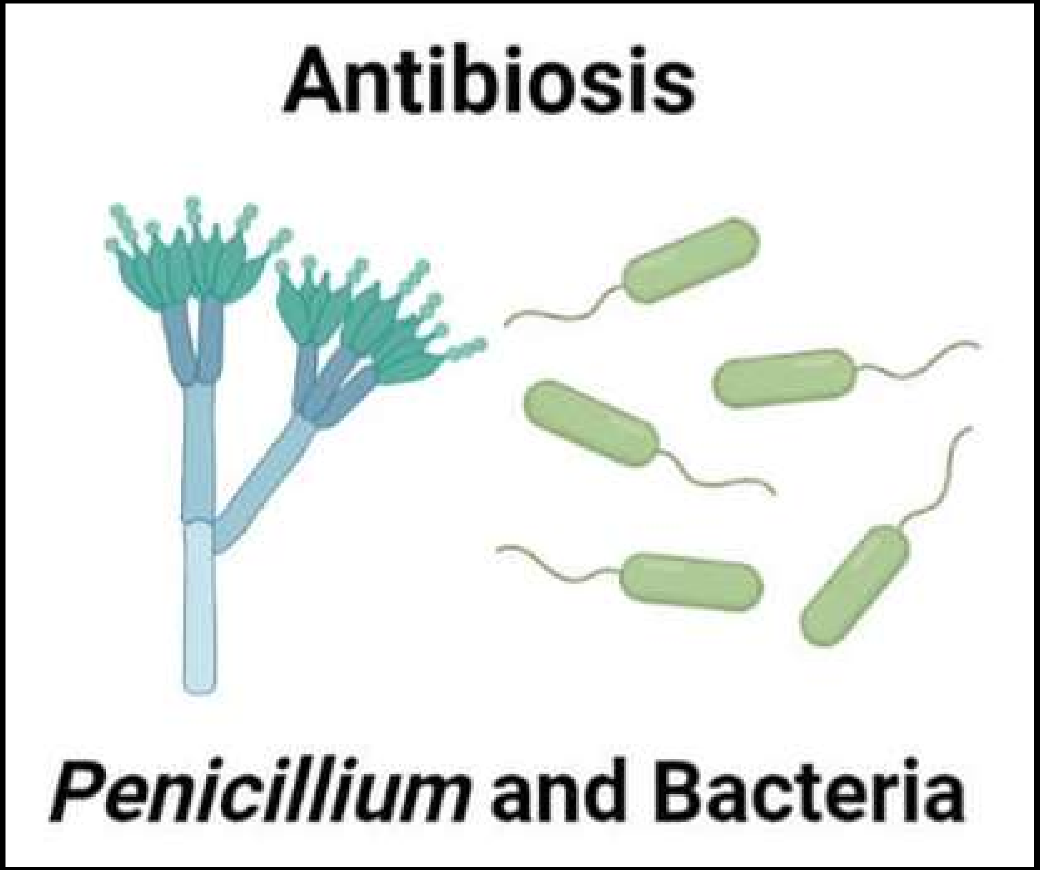
- Competition is a type of negative interaction where the larger or stronger species deprives the small species from food or living species.
- The species involved in such interactions share a common niche in the ecosystem. This results in the scarcity of nutrients as well as living spaces for the weaker species.

Goat and insects

- Herbivores like goats share the same ecological niche as insects like grasshoppers. This results in competition between the two species for food resources.
- The goat feeds on the same type of shrubs or grass and insects. This results in a scarcity of food resources for the insects.

2. Antibiosis

Antibiosis is an important type of amensalism where one of the species is killed by a chemical secretion while the other remains unaffected.
The term antibiosis is derived from the French term ‘antibiose’ to define the antagonistic relationship between species colonizing similar ecological niches.
One of the species involved in the species produces antibiotics as a form of defensive mechanism against possible predators. Some species might even produce toxins.
Penicillium and bacteria



- A classic example of antibiosis can be observed between the fungal species Penicillium and different bacterial species.

DIRECTION

Neutralism describes a type of species interaction where two species coexist in the same habitat with no direct positive or negative effect on each other.

Key characteristics of neutralism:

- No interaction: Neither species is directly affected by the other.
- No benefit or harm: Neither species gains nor loses anything from the other's presence.
- Coexistence: Species can live in the same environment while remaining independent in terms of their direct impact on one another.

Cacti and tarantulas:

- Similarly, cacti and tarantulas living in a desert environment might not have a significant direct impact on each other

DIRECTION

Competition

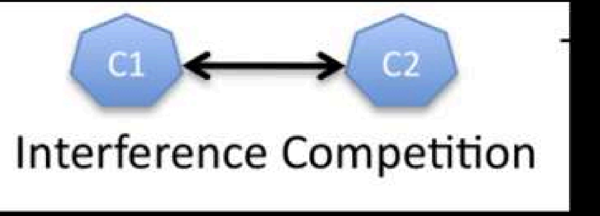
Competition is an interaction between organisms or species in which both require a resource that is in limited supply (such as food, water, or territory) .

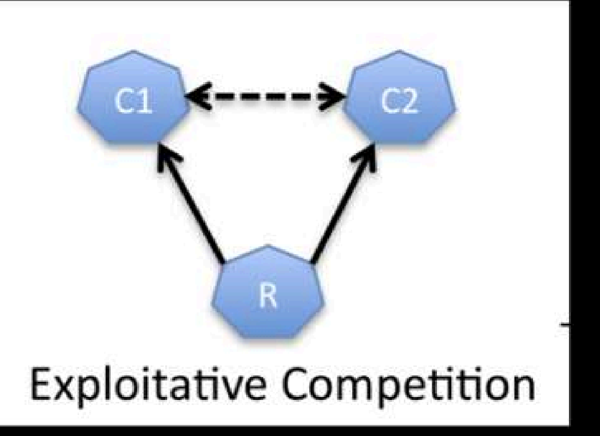
Competition lowers the fitness of both organisms involved, since the presence of one of the organisms always reduces the amount of the resource available to the other

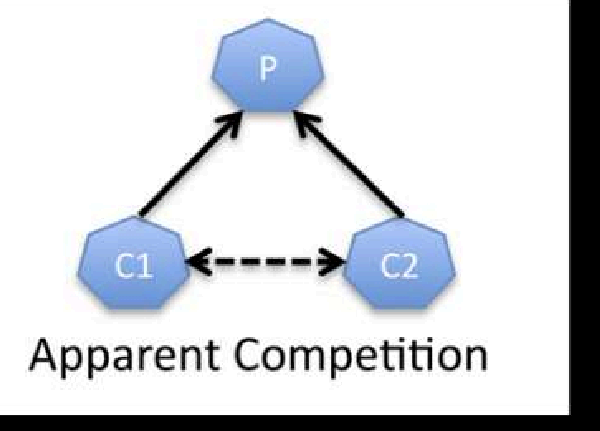
Competition among members of the same species is known as intraspecific competition, while competition between individuals of different species is known as interspecific competition.

There are three major mechanisms of competition: interference, exploitation, and apparent competition

DIRECTION







Diagrams illustrating the three major types of competitive interactions where the dashed lines indicate indirect interactions and the solid lines direct interactions that are part of ecological communities. C1 = Competitor #1, C2 = Competitor #2, P = Predator, R = Resource.

interference competition. When an individual directly alters the resource-attaining behavior of other individuals, the interaction is considered interference competition. For example, when a male gorilla prohibits other males from accessing a mate by using physical aggression or displays of aggression, the dominant male is directly altering the mating behavior of other males. This is also an example of an intra-specific interaction

Exploitation competition occurs when individuals interact indirectly as they compete for common resources, like territory, prey or food. Simply put, the use of the resource by one individual will decrease the amount available for other individuals. DIRECTION

Apparent competition occurs when two individuals that do not directly compete for resources affect each other indirectly by being prey for the same predator . Consider a hawk that preys both on squirrels and mice. In this relationship, if the squirrel population increases, then the mouse population may be positively affected since more squirrels will be available as prey for the hawks. However, an increased squirrel population may eventually lead to a higher population of hawks requiring more prey, thus, negatively affecting the mice through increased predation pressure as the squirrel population declines.

DIRECTION

CANNIBALISM

Typically, predation occurs between species (inter-specific); but when it occurs within a species (intra-specific) it is cannibalism. Cannibalism is actually quite common in both aquatic and terrestrial food webs . It often occurs when food resources are scarce, forcing organisms of the same species to feed on each other

Different forms include

sexual cannibalism (e.g., the red-backed spider eating its mate),

size-structured cannibalism (e.g., larger fish eating smaller conspecifics), and

filial cannibalism (e.g., a mother eating her own sick young).

intrauterine cannibalism (e.g .,siblings can cannibalize others (sibling cannibalism)

Herbivory

Herbivory, which is when an individual feeds on all or part of a photosynthetic organism (plant or algae), possibly killing it . An important difference between herbivory and predation is that herbivory does not always lead to the death of the individual. Herbivory is often the foundation of food webs

Herbivores are classified based on the part of the plant consumed.

Plants, like prey, also have evolved adaptations to herbivory. Tolerance is the ability to minimize negative effects resulting from herbivory, while resistance means that plants use defenses to avoid being consumed. Physical (for example, thorns, tough material, sticky substances) and chemical adaptations (for example, irritating toxins on piercing structures, and bad-tasting chemicals in leaves) are two common types of plant defenses

Herbivores are classified based on the part of the plant consumed.

- Frugivores – Eat mostly fruits.
  Example: Many birds, bats, and primates.
- Folivores – Feed mainly on leaves.
  Example: Koalas, sloths, and pandas.
- Granivores – Consume seeds and grains.
  Example: Pigeons, sparrows, and rodents.
- Nectarivores – Drink nectar from flowers.
  Example: Hummingbirds and some insects like bees.
- Xylophages – Eat wood.
  Example: Termites and some beetles.
- Root eaters (Rhizophages) – Feed on roots.
  Example: Some rodents and insects.
- Gumivores – Consume tree sap or gum.
  Example: Certain marmosets and lemurs.

Evolution

Evolution gives the meaning of gradual changes observed in an organism over a while which gives diagnostic characteristics to them resulting in their proper adaptation to the environment they live in. These changes can be genetic and phenotypic as well.

Based on the pattern of how organisms evolved to have similar characters structurally and functionally although belonging to different classes or having different characters although belonging to the same class evolution can be divided into two types:

- Convergent Evolution
- Divergent Evolution

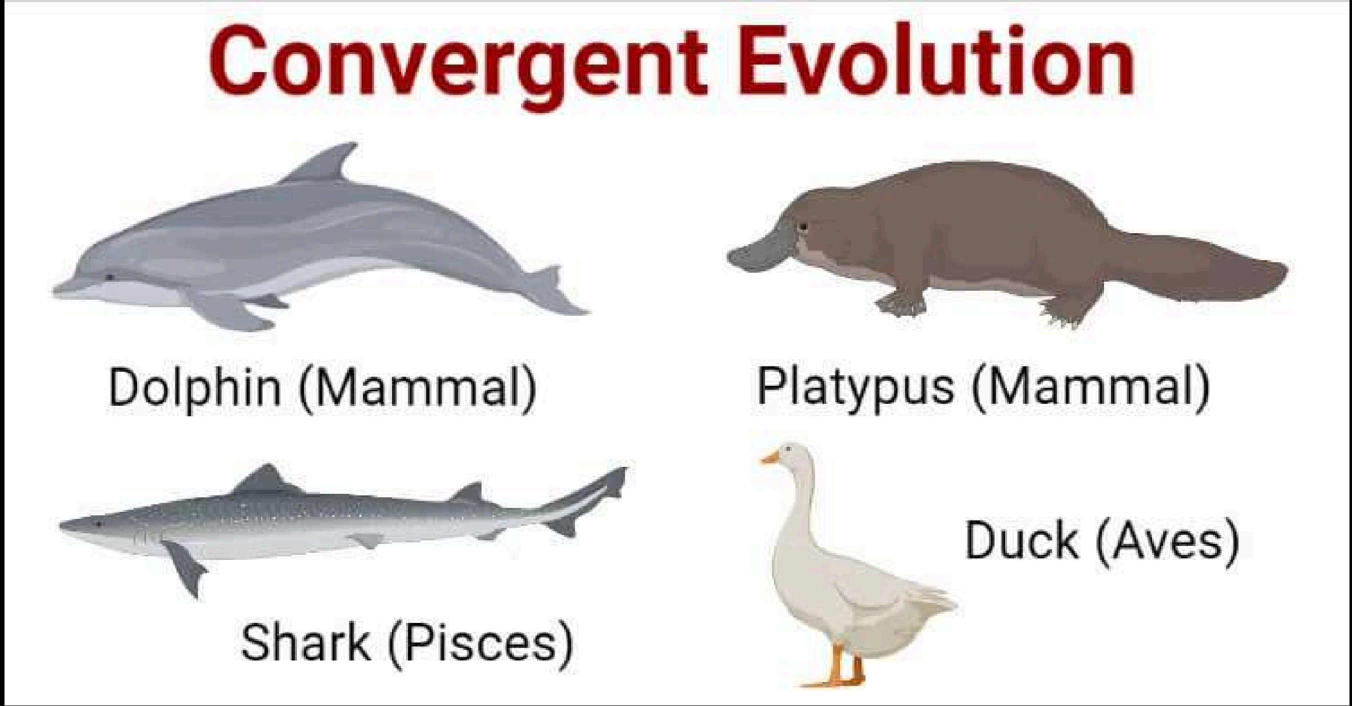
Convergent evolution is the type of evolution in which organisms belonging to different origins (distantly related or organism with different phylogeny) evolve independently to have similar kinds of traits.

These different traits will have the following characteristics:

- Body structures that are anatomically different.
- Different embryological origins
- The traits will have similar functions.

Causes of Convergent Evolution

- Exposure to the same environmental conditions.
- Similar adaptive mechanism to the conditions they need for survival.
- Genetic changes due to mutation occur simultaneously in the different classes of organisms.

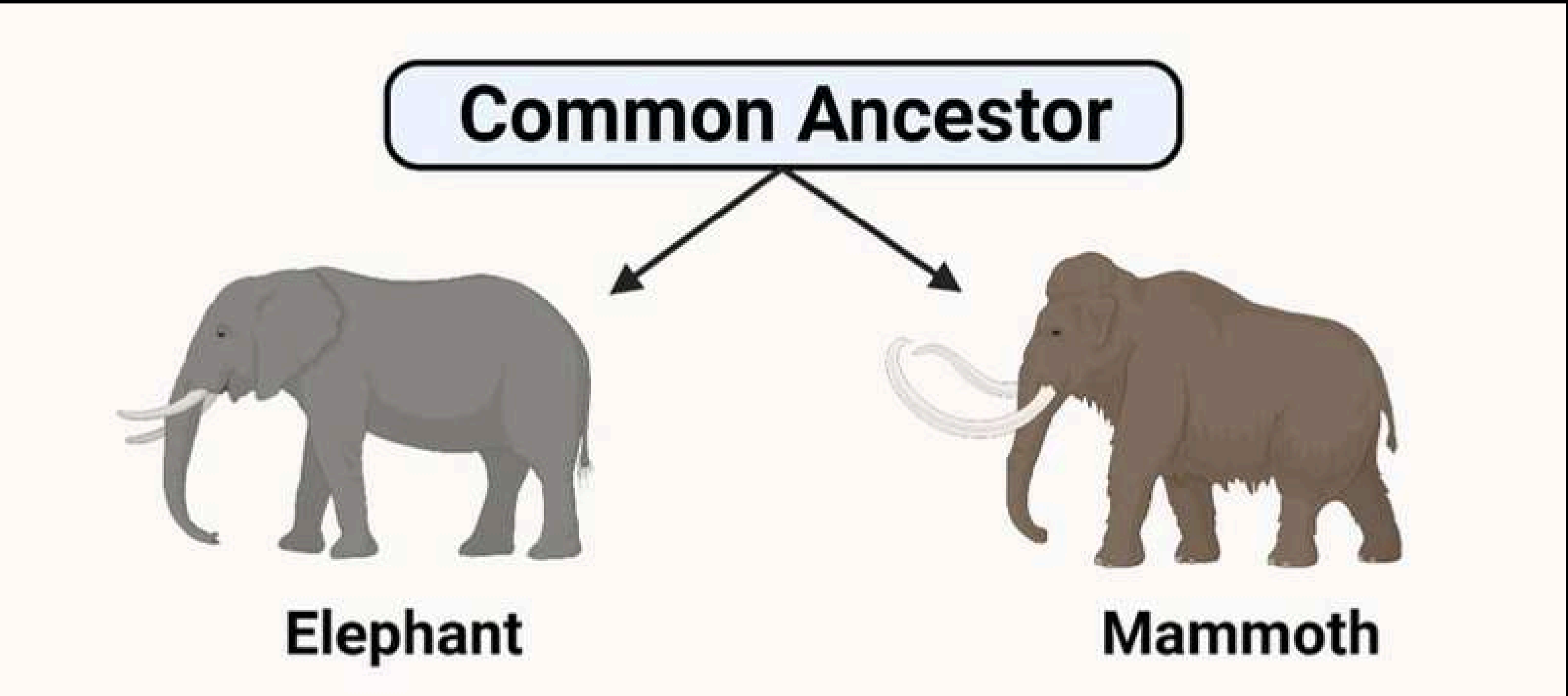


DIRECTION

Divergent evolution is a type of evolution that leads to varying functional developments or changes in similar basic structured organs of organisms belonging to a similar origin or similar ancestry.
The plants developing in various habitats such as desert, plain areas, hills, and Himalaya bring out changes in their leaves, roots, venations, size of corolla based on their requirements such as nutrition, protection mechanisms, water, etc and hence develop homologous structures.

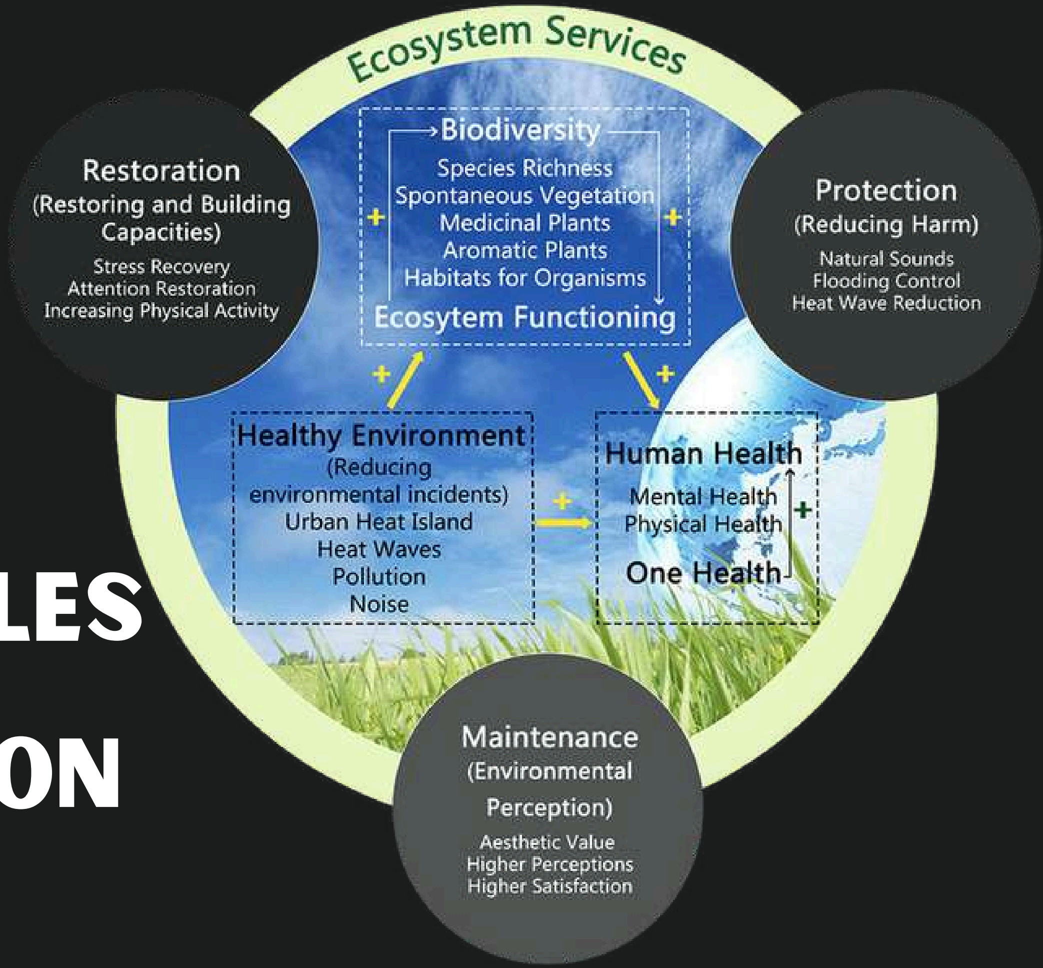
Divergent Evolution Causes

- Alteration in environmental conditions in which the organisms live.
- Migration of organisms into different habitats.
- Different mechanisms of adaptations of the organisms for their survival.
- Genetic changes including mutations



Ecosystem Functions

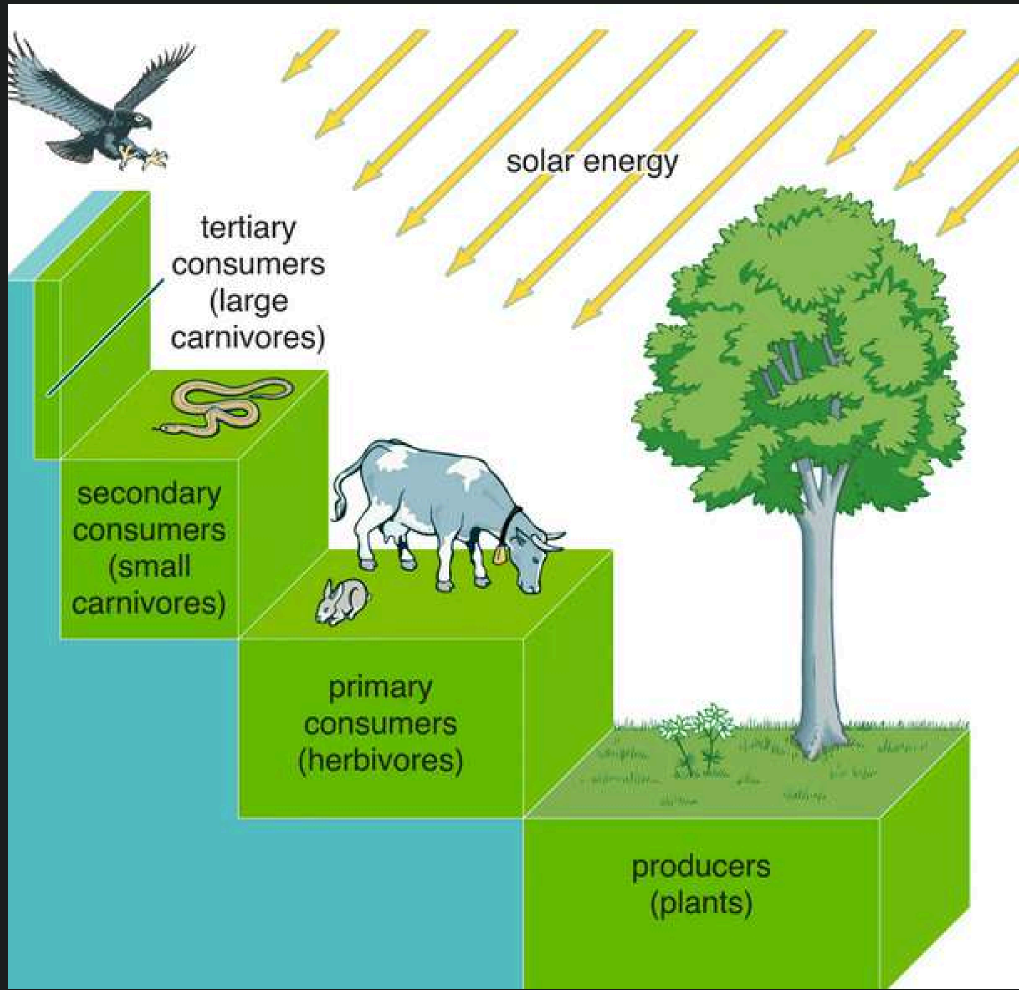
- ENERGY FLOW
- PYRAMIDS
- DECOMPOSITION
- BIO-GEOCHEMICAL CYCLES
- ECOLOGICAL SUCCESSION



DIRECTION

Photosynthetic and Chemosynthetic organisms

Photosynthetic and chemosynthetic organisms are autotrophs, which are organisms capable of synthesizing their own food (more specifically, capable of using inorganic carbon as a carbon source).
Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, and chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy source.



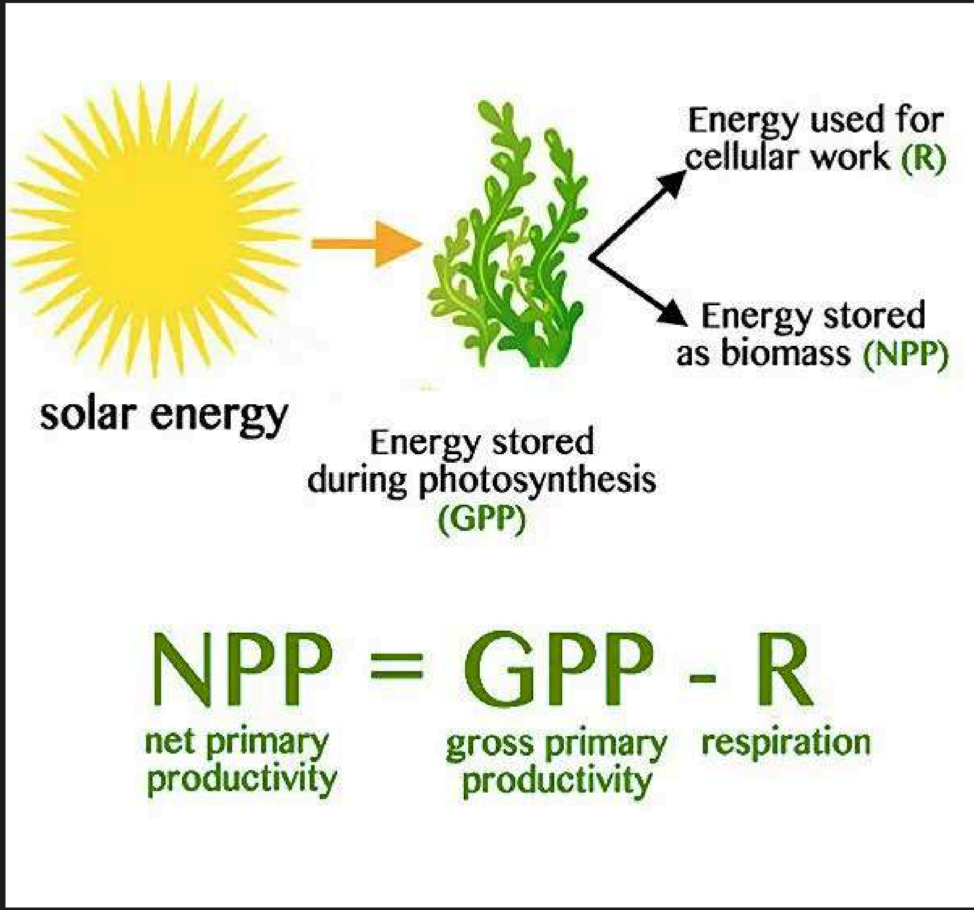
Autotrophs are critical for ecosystems because they occupy the trophic level containing producers. Without these organisms, energy would not be available to other living organisms, and life would not be possible.
Photoautotrophs, such as plants, algae, and photosynthetic bacteria, are the energy source for a majority of the world's ecosystems. Photoautotrophs harness the Sun's solar energy by converting it to chemical energy.

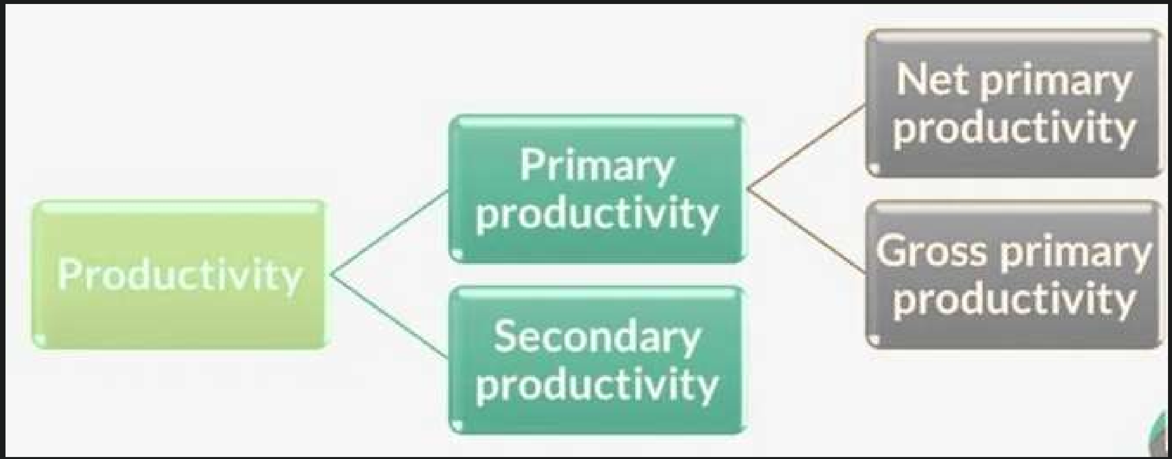
DIRECTION

Productivity

The rate at which photosynthetic producers incorporate energy from the Sun is called gross primary productivity. However, not all of the energy incorporated by producers is available to the other organisms in the food web because producers must also grow and reproduce, which consumes energy.

Net primary productivity is the energy that remains in the producers after accounting for these organisms' metabolism and heat loss. The net productivity is then available to the primary consumers at the next trophic level.





Secondary productivity stands for the production of biomass from organic molecules. Here the main conversion is of organic molecules to some other form of organic molecules. This duty is performed by the "heterotrophs" of the ecosystem.

DIRECTION

Chemoautotrophs are primarily bacteria and archaea that are found in rare ecosystems where sunlight is not available, such as those associated with dark caves or hydrothermal vents at the bottom of the ocean . Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H_2S), which is released from the vents, as a source of chemical energy. This allows them to synthesize complex organic molecules, such as glucose, for their own energy and, in turn, supplies energy to the rest of the ecosystem.

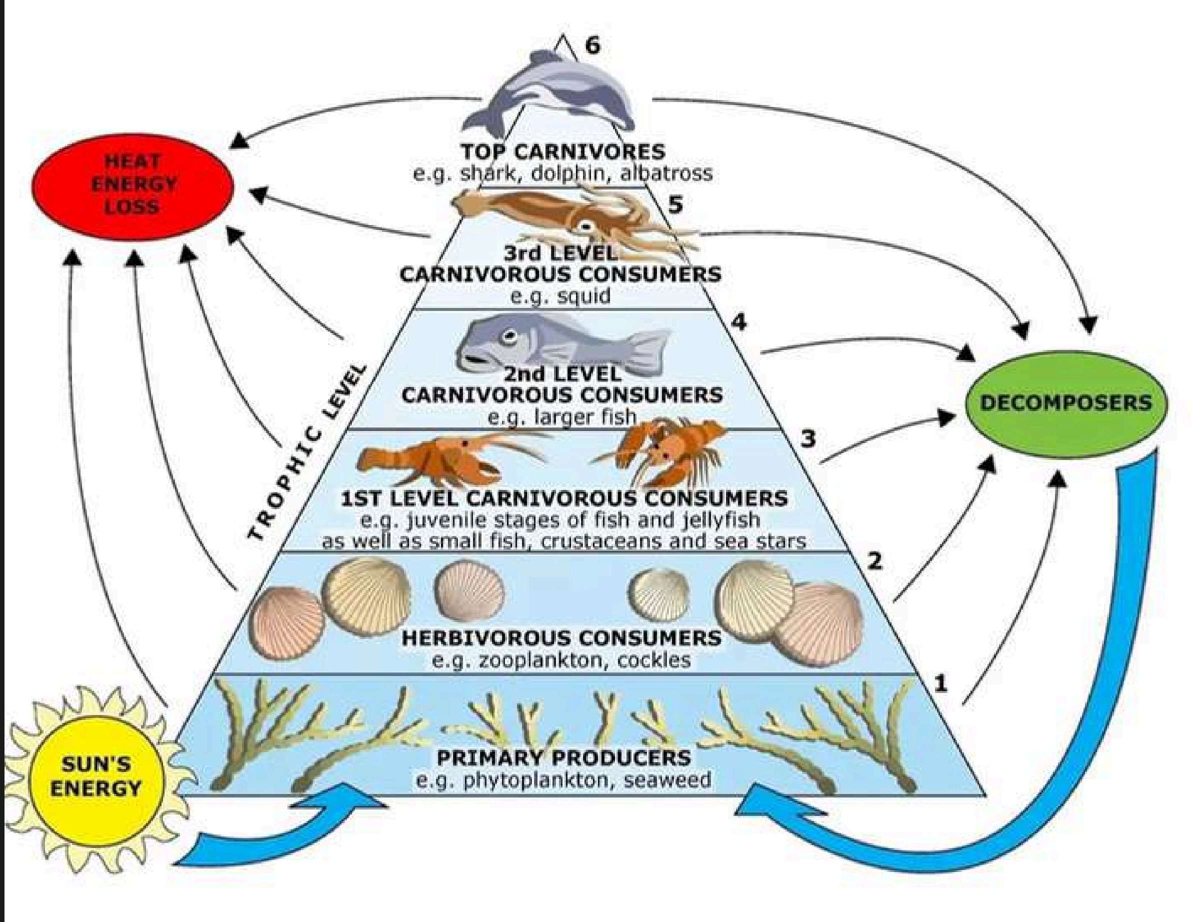
DIRECTION

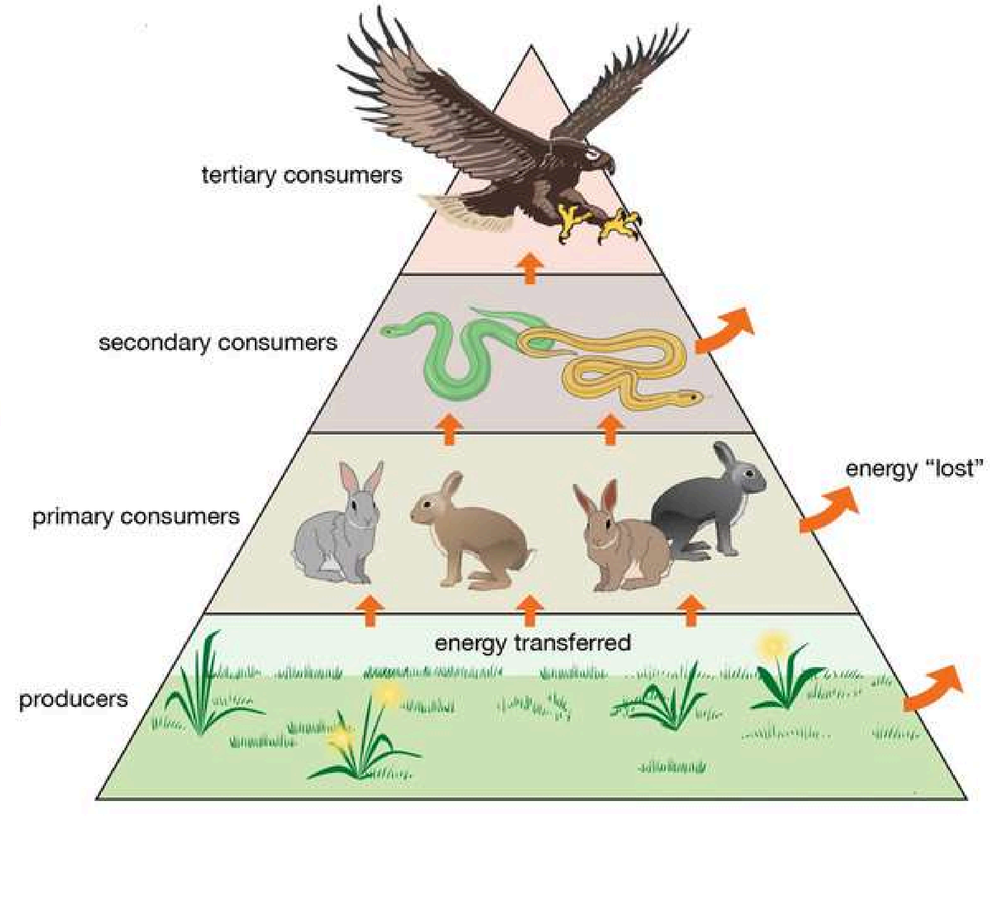
Hundreds of vent mussels are seen at a hydrothermal vent at the bottom of the ocean. As no sunlight penetrates to this depth, the ecosystem is supported by chemoautotrophic bacteria and organic material that sinks from the ocean's surface.

Trophic Levels

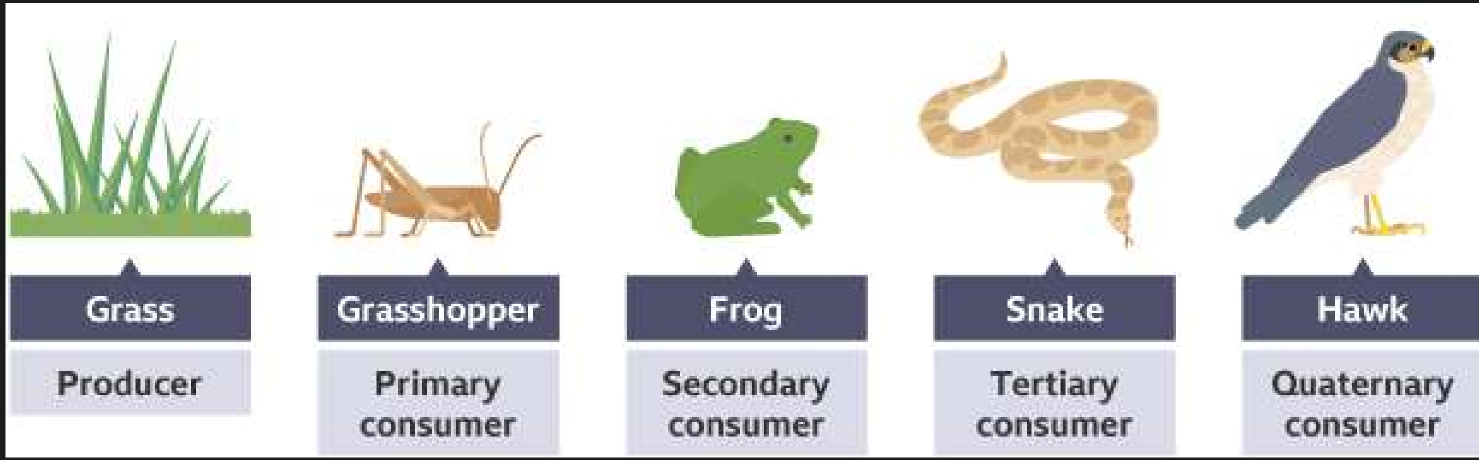
The feeding positions in a food chain or web are called trophic levels. The different trophic levels are defined in the Table below. Examples are also given in the table. All food chains and webs have at least two or three trophic levels. Generally, there are a maximum of four trophic levels.

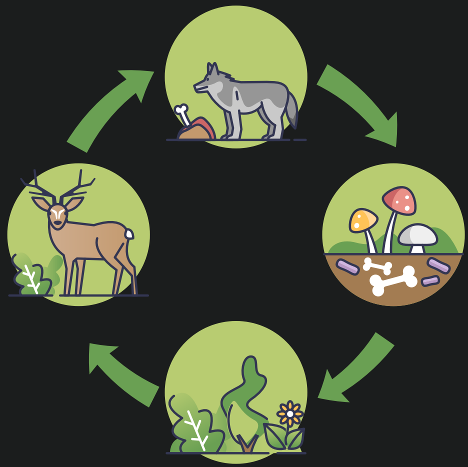
Many consumers feed at more than one trophic level. Humans, for example, are primary consumers when they eat plants such as vegetables. They are secondary consumers when they eat cows. They are tertiary consumers when they eat salmon.





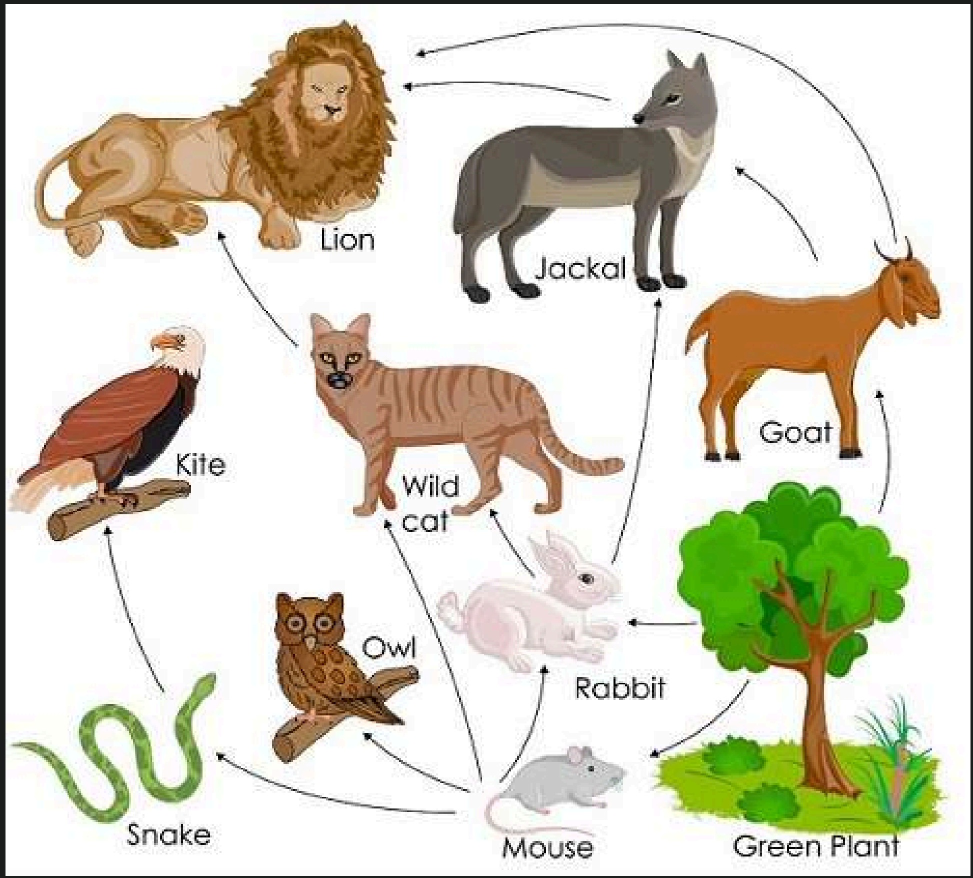
A **food chain** is a list of organisms in a habitat that shows their feeding relationship, i.e what eats what. The organisms are joined by arrows which show the transfer of energy in food between them. The stages in food chains are called trophic levels.





Food webs

Most populations of organisms that live in a habitat usually have more than one food source. They usually consume more than one organism from the trophic level below. This means that there are almost always more than one food chain and these are interlinked into a food web.



DIRECTION

Ecological pyramids

In 1927, the concept of ecological pyramid was first proposed by English Ecologist named Charles Elton.
An ecological pyramid is basically a pyramidal depiction of the number of organisms, biomass, and productivity in each trophic level in an ecosystem.
Typically, ecological pyramids start with producers located at the bottom and transcend through various trophic levels as you go up the pyramid. The top of the pyramid represents the highest level in the food chain.

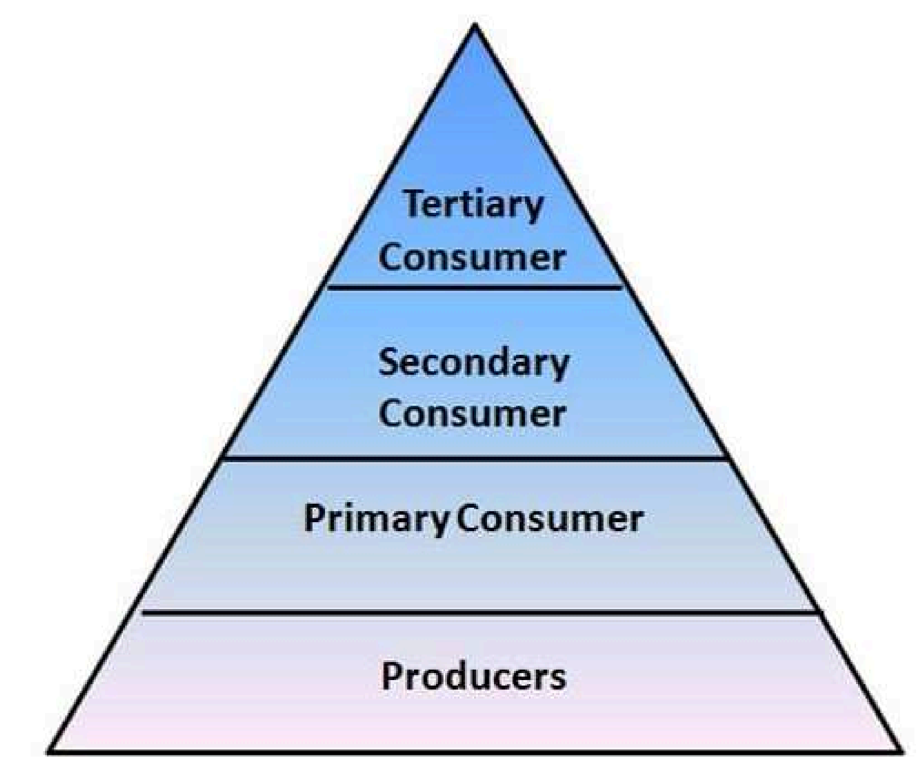
Ecological pyramids include:

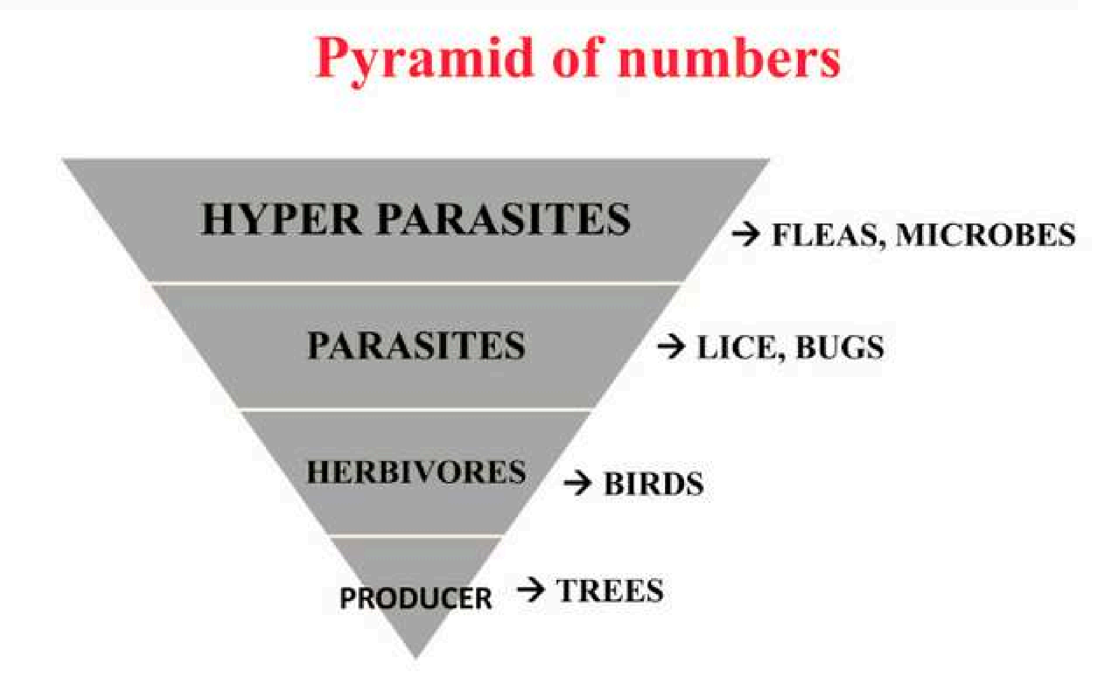
- Pyramids of numbers
- Pyramids of biomass
- Pyramids of energy (also known as pyramids of productivity)

The first pyramid is the **pyramid of numbers** which graphically represents the population (total number of individuals) present at each trophic level.

This type of pyramid can have two different forms depending on the number of organisms: upright and inverted.

In an **upright pyramid** of number, the number of organisms generally decreases from the bottom to top. This generally occurs in grassland and pond ecosystems where the plants (usually the grasses) occupy the base of the pyramid. The succeeding levels of the pyramid include the consumers.



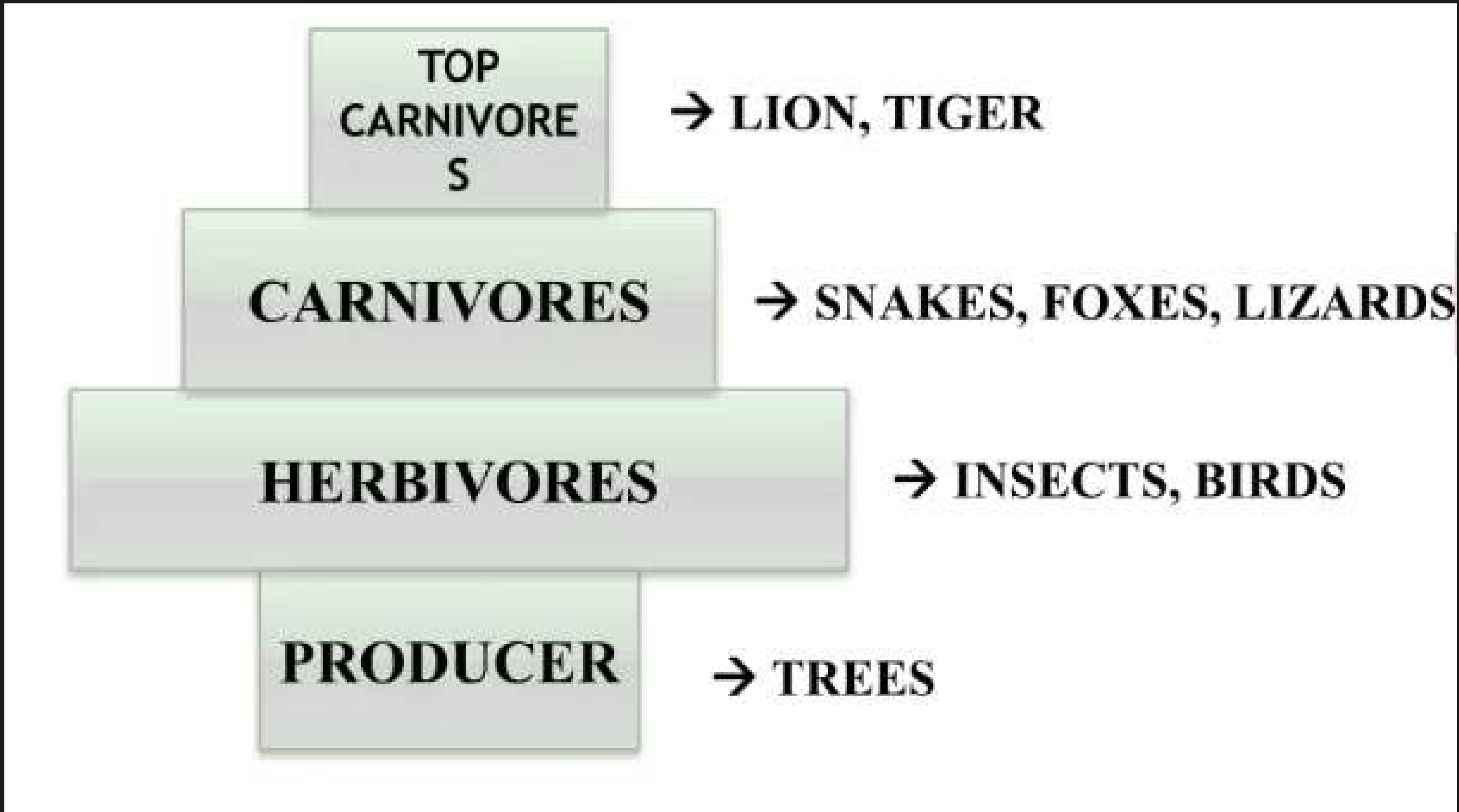


An **inverted pyramid** of number, on the other hand, is just the opposite of the former. It is usually observed in parasites and tree ecosystems with the trees as the producers and the insects as consumers.

DIRECTION

A spindle-shaped ecological pyramid, specifically the pyramid of numbers in a forest ecosystem, is characterized by a narrow base, a broad middle, and a narrow apex, showing a decreasing number of organisms from the producers (large trees), to a large number of primary consumers (herbivorous insects), and then a decline in secondary consumers (like birds) and higher-level predators

The Pyramid of number od a tree ecosystem is spindle shaped.

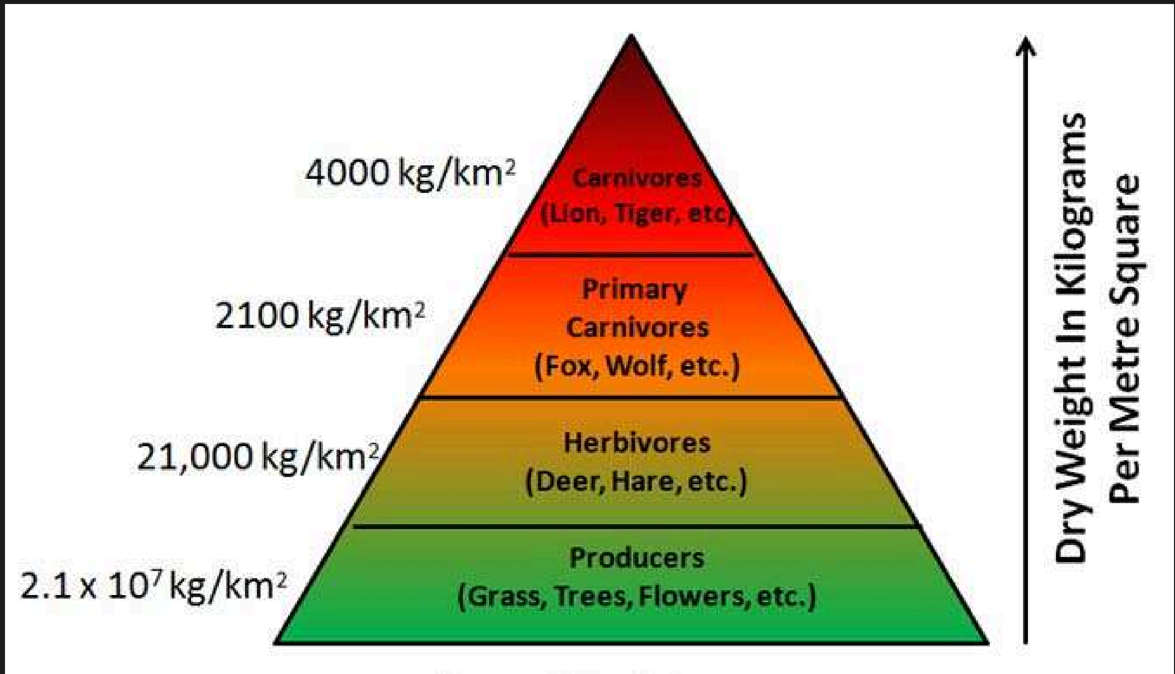


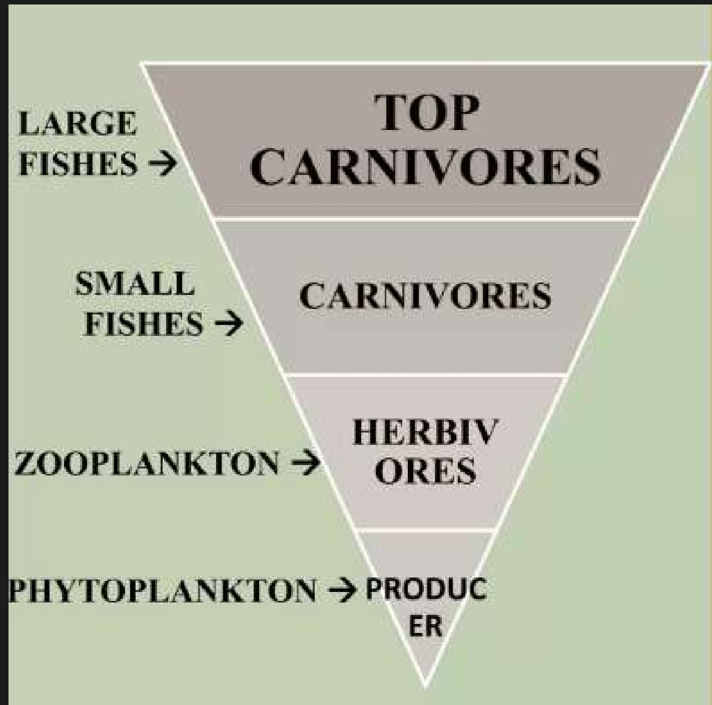
DIRECTION

Biomass is defined as the amount of biomass per unit area product of the living material present in an organism and the total number of organisms present) in a specific trophic level. In less complicated terms, it refers to the food available for the succeeding trophic level.

For instance, a pyramid of biomass is a depiction of the amount of food available and how much energy is being passed on at each trophic level. Most the biomass that animals consume is used to provide the energy, converted to new tissues, or just remain undigested.

Most of the time, pyramids of biomass are in a true pyramidal shape with biomass in the lower trophic levels are greater than the trophic levels above them.





Usually, terrestrial ecosystems are characterized by an upright pyramid of biomass having a larger base (primary producers) with the smaller trophic levels (consumers) located at the top.

On the other hand, aquatic ecosystems are the complete opposite as they will assume the inverted structure of the pyramid. This is because the phytoplankton producers (with generally smaller biomass) are located at the base while the consumers having larger biomass are located at the top of the pyramid.

Pyramid of Energy

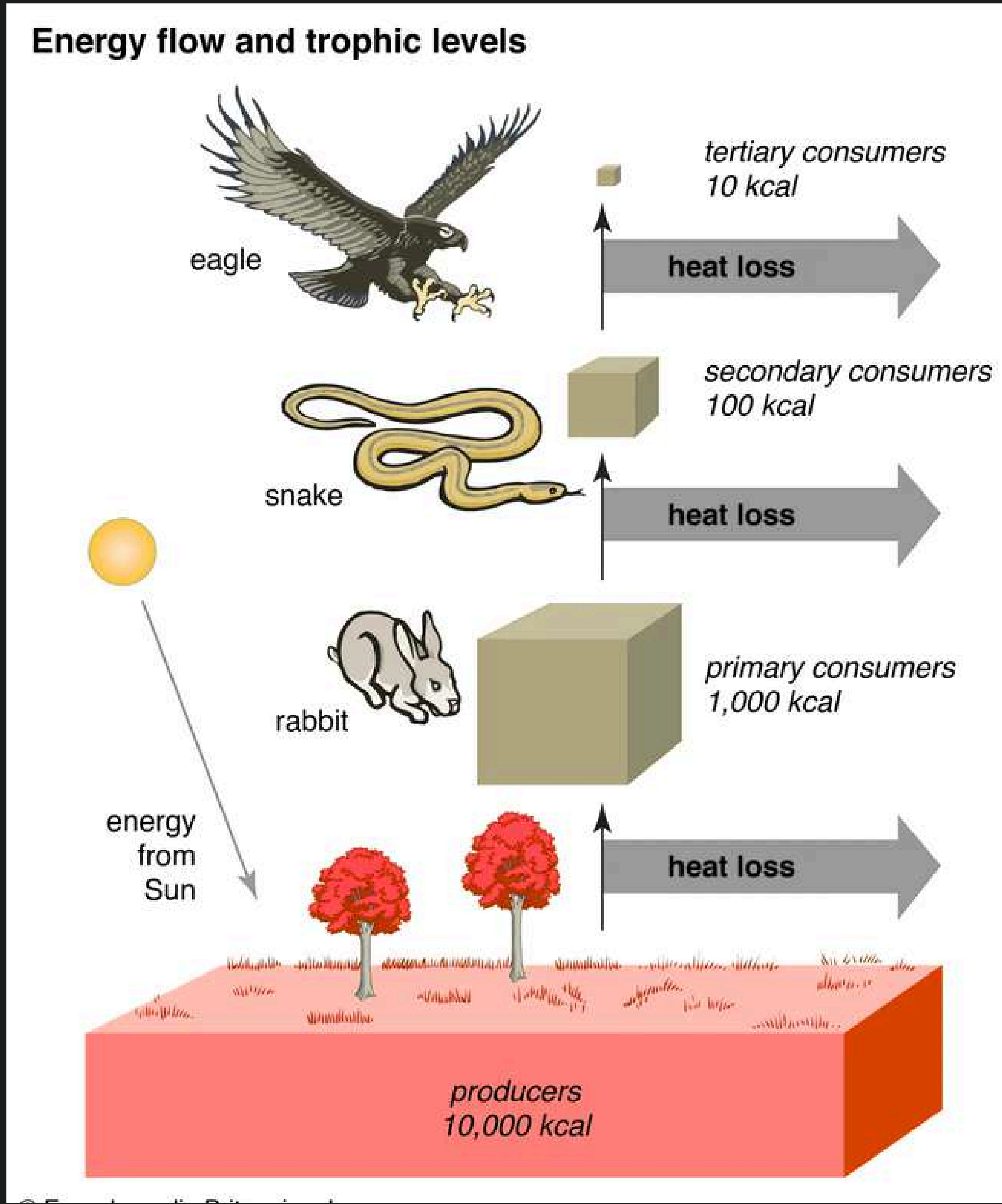
Last but not the least, is the pyramid of energy that shows the overall energy in the ecosystem and how much energy is required by organisms as it flows up the higher trophic levels.

The pattern of the energy flow in this type of pyramid is based on the principles of thermodynamics. This law specifically says that energy is neither be created nor destroyed; only transformed into another form.

This pyramid shows that energy is transferred from lower trophic levels with more amount of energy (producers) to higher ones (consumers) and converted in the biomass.

Therefore, it can be concluded that organisms found at the highest trophic levels of shorter food chains bear a greater amount of energy than the ones found in longer ones.

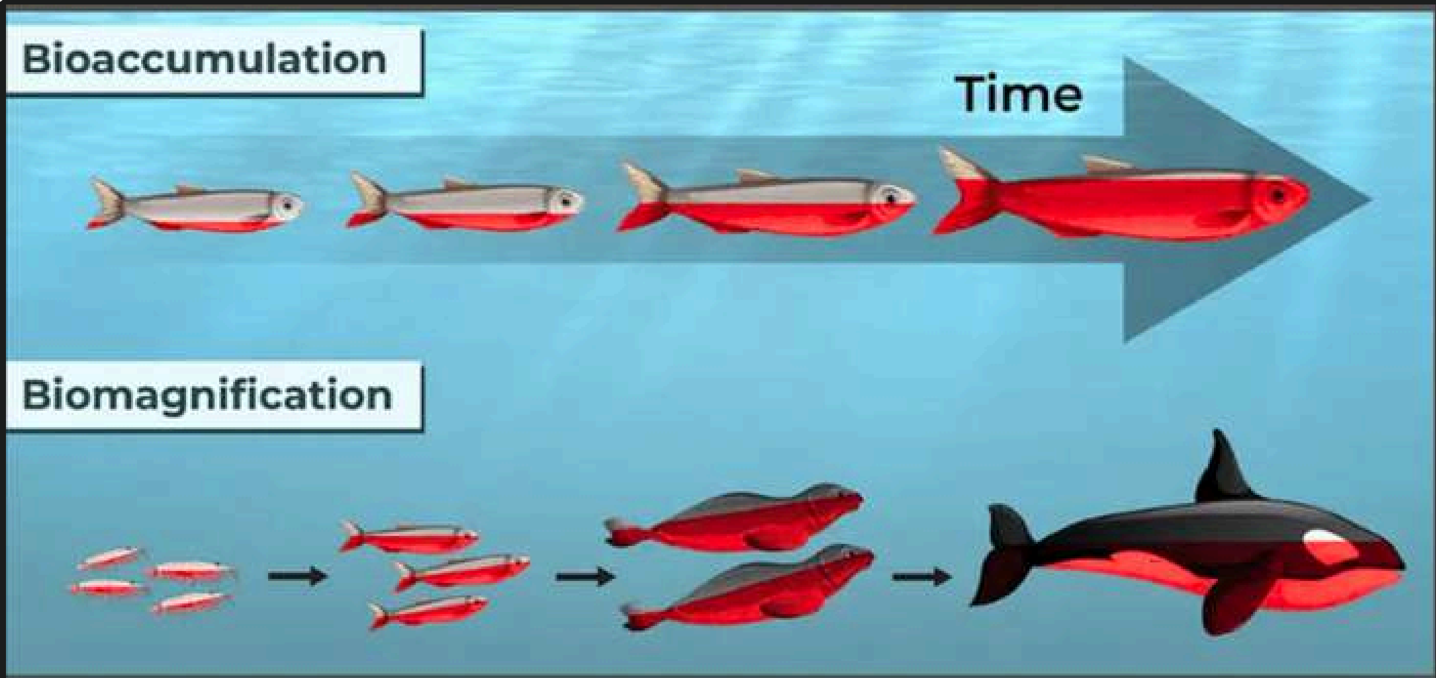
Unlike the first two ecological pyramids, the pyramid of energy is always illustrated in an upright position, with the largest energy carriers at the base.



Bioamplification or biomagnification, refers to an increase in the concentration of a substance as you move up the food chain. This often occurs because the pollutant is persistent, meaning that it cannot be, or is very slowly, broken down by natural processes. These persistent pollutants are transferred up the food chain faster than they are broken down or excreted.

In contrast, bioaccumulation occurs within an organism, where a concentration of a substance builds up in the tissues and is absorbed faster than it is removed.

Bioaccumulation often occurs in two ways, simultaneously: by eating contaminated food, and by absorption directly from water. This second case is specifically referred to as bioconcentration.



DIRECTION

Decomposition

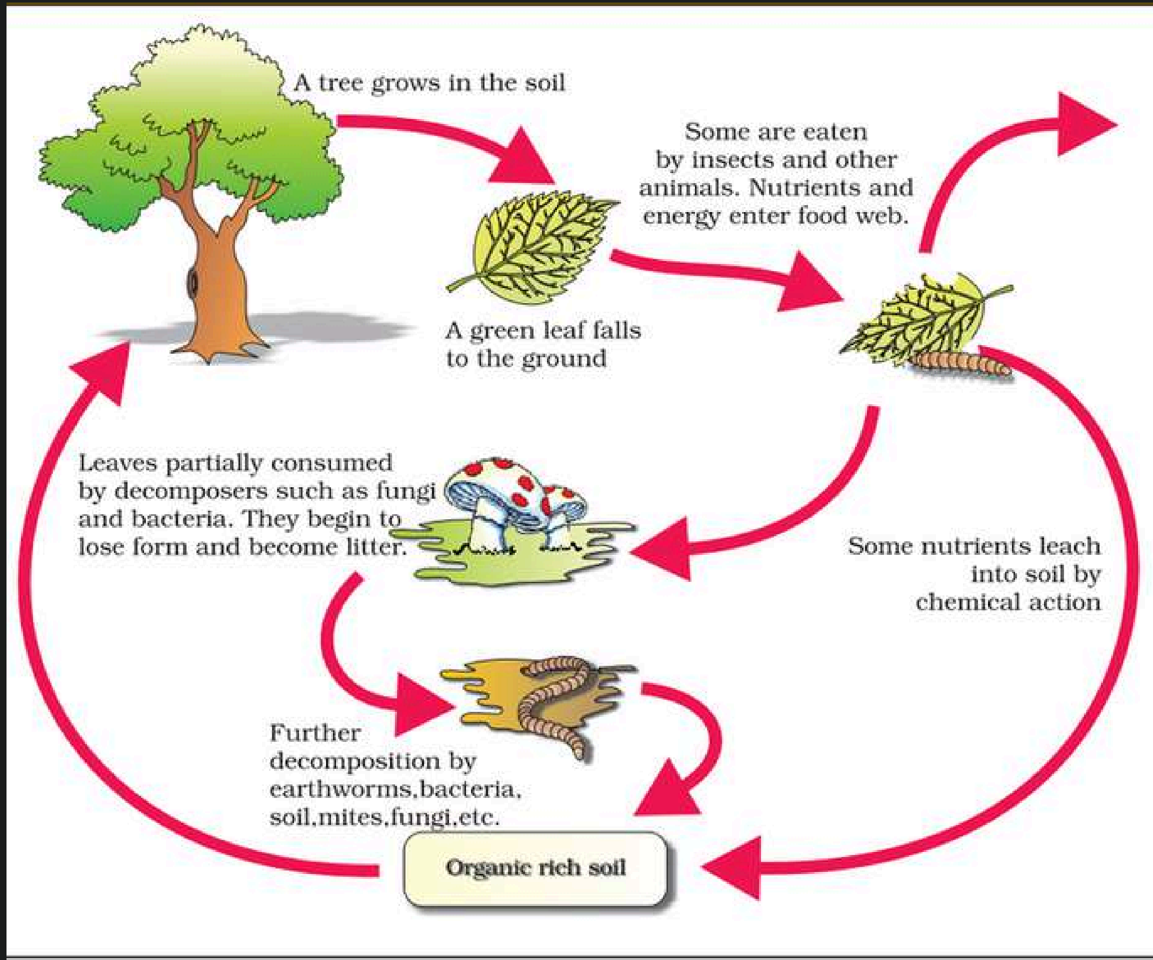
Decomposers are the organisms that decompose or break down the complex organic compound into simpler forms in a dead body, and the process of breakdown of complex compounds into simpler compounds refers to decomposition.

Decomposers are reducers or saprophytic, which means they live in the dead body and acquire nourishment from feeding decaying organic matter.

- They include microorganisms (like fungi, bacteria), insects, earthworms, etc. They produced different digestive enzymes to break down the organic materials.
- Decomposers are responsible for the flow of energy and recycling of the material in the ecosystem.
- Decomposers provide essential nutrients to the soil needs of the producers by feeding the dead organic matter left by consumers and recycling it.

DIRECTION

The raw materials which undergoes decomposition including dead plant and animal remains and their faecal matter are called detritus.



Steps in Decomposition

- Fragmentation: The process of breaking down of detritus into smaller particles is called fragmentation, e.g., as done by earthworm.
- Leaching: The process by which water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts is called leaching.
- Catabolism: The enzymatic process by which degraded detritus is converted into simpler inorganic substances is called catabolism.
- Humification: The process of accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate is called humification.
- Mineralization: The process by which humus is further degraded by some microbes to release inorganic nutrients is called mineralization.

DIRECTION

Decomposers are two major groups, including detritivores and saprotrophs. Detritivores consume and digest it internally, while saprophytes (or saprotrophs) externally secrete digestive enzymes and absorb the broken-down nutrients.

Detritivores

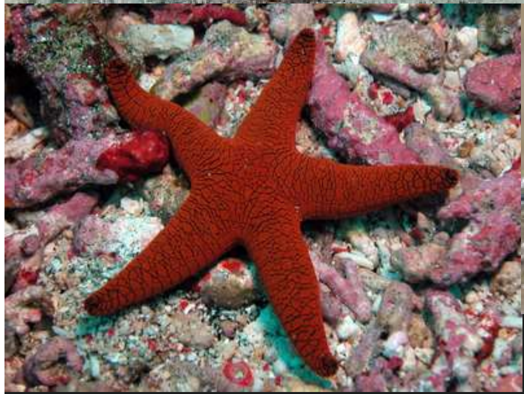
Method of feeding: They ingest dead and decaying organic matter.
Internal digestion: They digest the matter within their bodies.
Examples: Earthworms, millipedes, snails, and certain beetles.
Role: They fragment organic matter, accelerating the decomposition process and recycling nutrients.

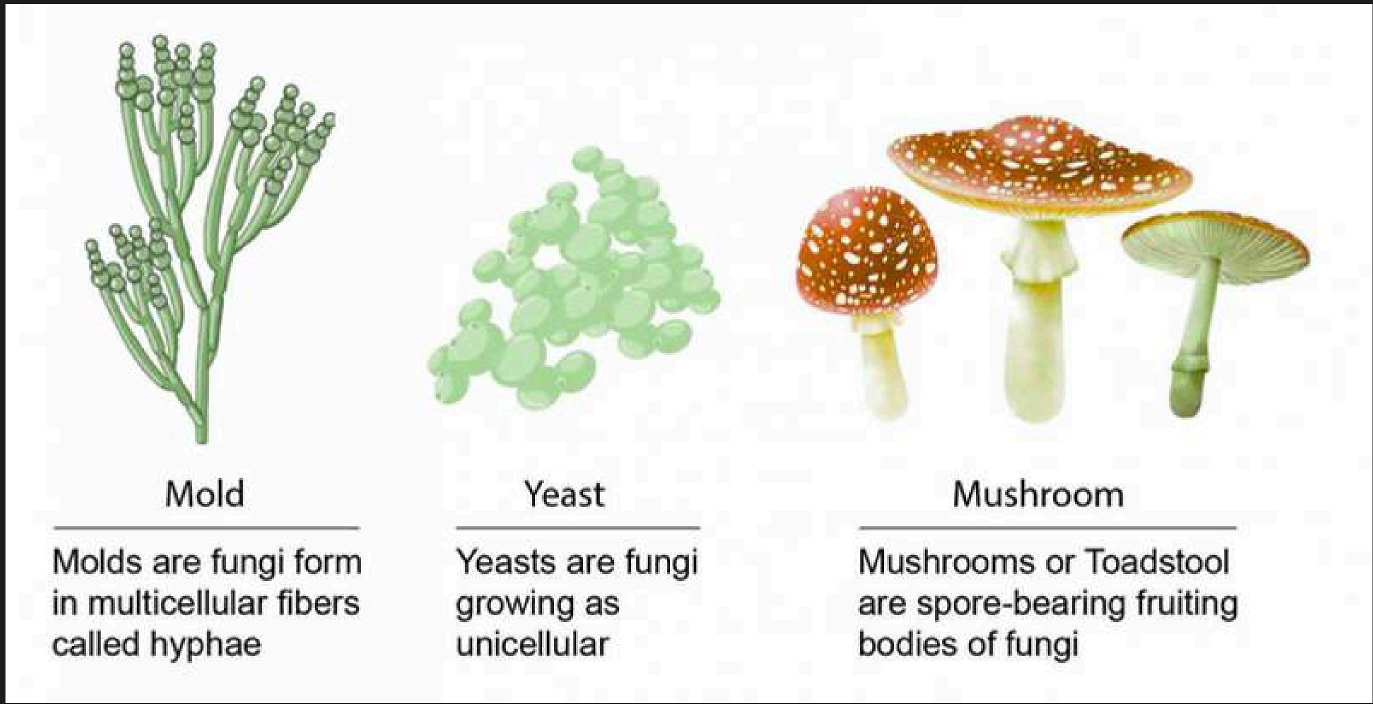
Saprophytes

Method of feeding: They secrete digestive enzymes onto dead organic matter.
External digestion: These enzymes break down the matter into simpler compounds outside the organism.
Absorption: The saprophyte then absorbs these simpler nutrients directly.
Examples: Fungi and bacteria.
Role: They are critical for breaking down complex organic compounds into essential inorganic nutrients that producers can use again

DIRECTION

sea cucumbers, sea stars, and fiddler crabs





DIRECTION

Scavengers

Animals that feed on dead animals that have not been killed by the scavenger itself. Examples: Vultures are classic examples of avian scavengers.

Relationship to Raptors:

Raptors can be opportunistic scavengers. For example, some raptors are known to feed on carcasses, playing an important role in removing them from the environment. However, being a scavenger is not exclusive to raptors, and some scavengers are not raptors at all.

DIRECTION

Raptors (birds of prey) are defined by their predatory behaviors, using sharp talons and hooked beaks to hunt live prey, though some also scavenge. Scavengers are animals that feed on dead and decaying organic matter. Therefore, while some raptors are also scavengers, scavenging is a characteristic of some animals that are not raptors, and some raptors are primarily predators that only occasionally scavenge.

Examples: Hawks, eagles, owls, falcons.
Behavior: While their main diet consists of live animals (vertebrates), some raptors, like certain eagles and vultures, will also consume carrion.

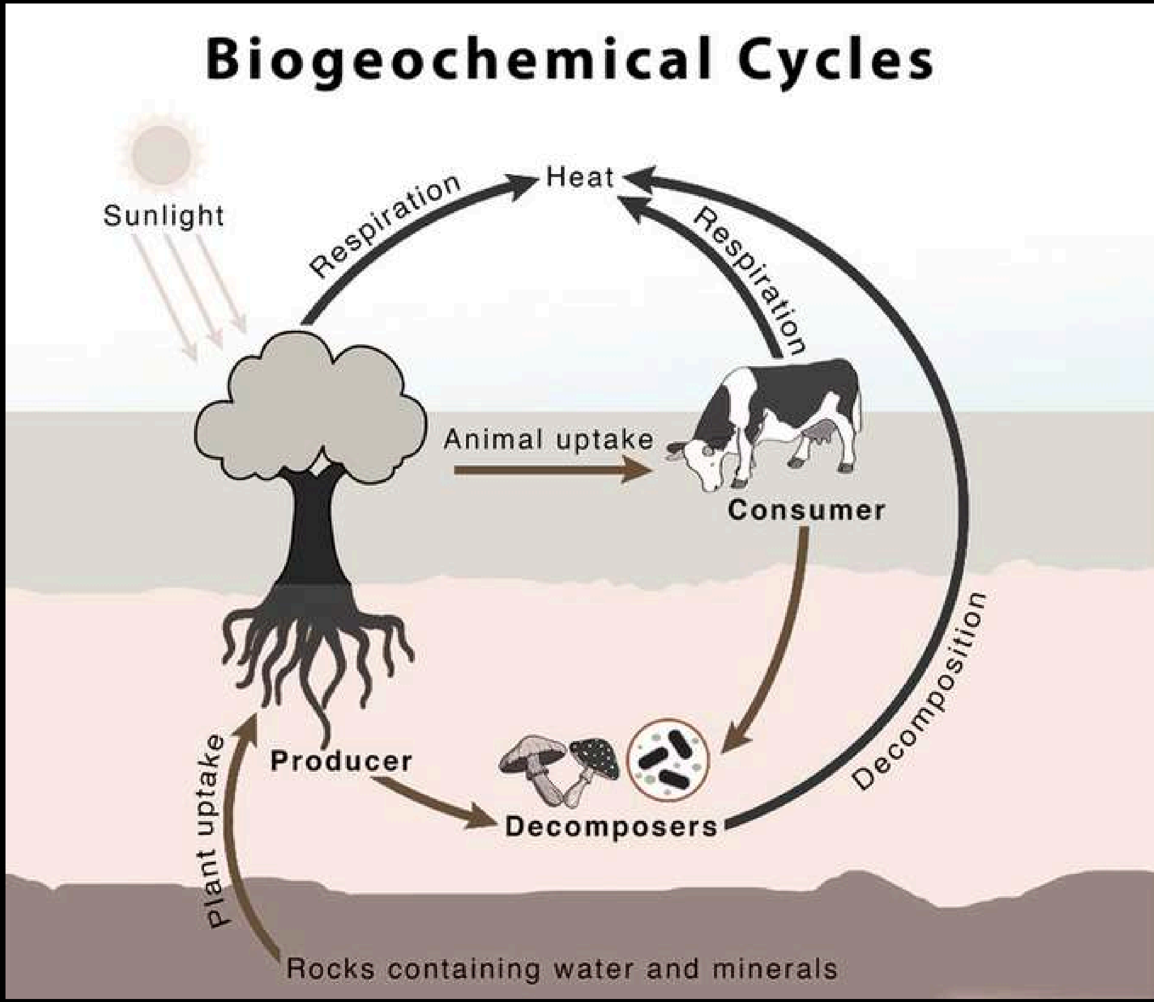
DIRECTION

Ecosystem Functions- 2

- BIO-GEOCHEMICAL CYCLES
- ECOLOGICAL SUCCESSION

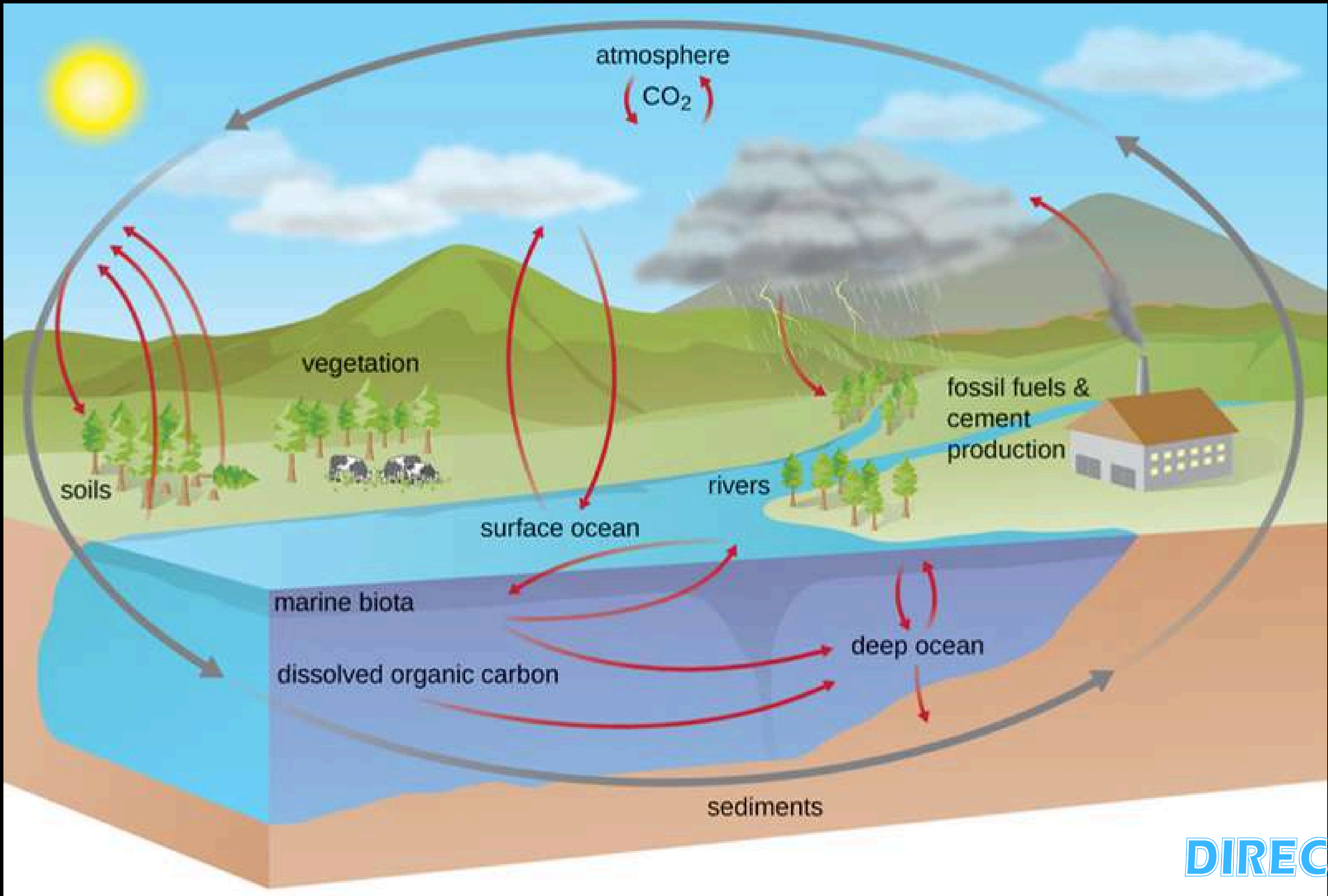
DIRECTION

Biogeochemical cycles, also known as nutrient cycles, describe the movement of chemical elements through different media, such as the atmosphere, soil, rocks, bodies of water, and organisms. Biogeochemical cycles keep essential elements available to plants and other organisms. The biogeochemical cycles of four elements—carbon, nitrogen, phosphorus, and sulfur—are discussed below. The cycling of these elements is interconnected with the water cycle. For example, the movement of water is critical for the leaching of sulfur and phosphorus into rivers, lakes, and oceans.



The Carbon Cycle

Carbon is the basic building block of all organic materials, and therefore, of living organisms. The carbon cycle is actually comprised of several interconnected cycles: one dealing with rapid carbon exchange among living organisms and the other dealing with the long-term cycling of carbon through geologic processes



DIRECTION

Carbon dioxide in the atmosphere is converted to organic carbon through photosynthesis by terrestrial organisms (like trees) and marine organisms (like algae).

Respiration by terrestrial organisms (like trees and deer) and marine organisms (like algae and fish) release carbon dioxide back into the atmosphere. Additionally, microbes that decompose dead organisms release carbon dioxide through respiration.

Weathering of terrestrial rocks also brings carbon into the soil. Carbon in the soil enters the water through leaching and runoff. It can accumulate into ocean sediments and reenter land through uplifting.

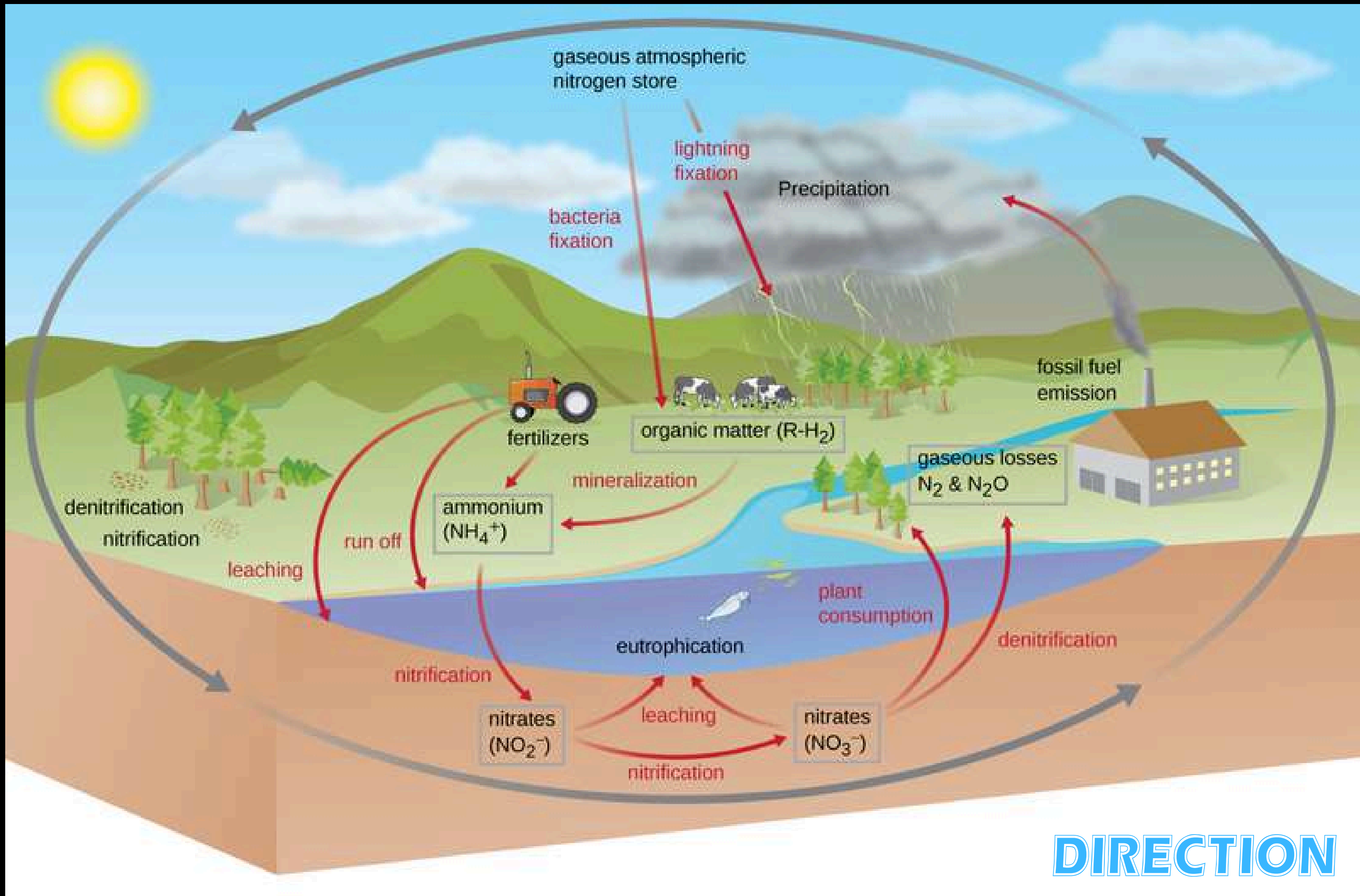
Long-term storage of organic carbon occurs when matter from living organisms is buried deep underground and becomes fossilized.

Volcanic activity and, more recently, human emissions stored carbon back into the carbon cycle.

DIRECTION

The Nitrogen Cycle

All organisms require nitrogen because it is an important component of nucleic acids, proteins, and other organic molecules. Getting nitrogen into living organisms is difficult. Plants and algae are not equipped to incorporate nitrogen from the atmosphere (where it exists as tightly bonded, triple covalent N2) although this molecule comprises approximately 78 percent of the atmosphere. Because most of the nitrogen is stored in the atmosphere, the atmosphere is considered a reservoir of nitrogen.



In the nitrogen cycle, nitrogen-fixing bacteria in the soil or legume root nodules convert nitrogen gas (N_2) from the atmosphere to ammonium (NH_4^+).

Nitrification occurs when bacteria convert ammonium to nitrites (NO_2^-) and then to nitrates (NO_3^-). Nitrates re-enter the atmosphere as nitrogen gas through denitrification by bacteria. Plants assimilate ammonium and nitrates, producing organic nitrogen, which is available to consumers.
Decomposers, including aerobic and anaerobic bacteria and fungi, break down organic nitrogen and release ammonium through ammonification.

DIRECTION

Three processes are responsible for most of the nitrogen fixation in the biosphere.

- **The first is atmospheric fixation by lightnin**g. The enormous energy of lightning breaks nitrogen molecules and enables their atoms to combine with oxygen in the air forming nitrogen oxides. These dissolve in rain, forming nitrates, that are carried to the earth. Atmospheric nitrogen fixation probably contributes some 5-8% of the total nitrogen fixed.
- **The second process is industrial fixation.** Under great pressure, at a temperature of 600°C (1112°F), and with the use of a catalyst (which facilitates chemical reactions), atmospheric nitrogen and hydrogen can be combined to form ammonia (NH3). Ammonia can be used directly as fertilizer, but most of it is further processed to urea and ammonium nitrate (NH4NO3).
- **The third process is biological fixation** by certain free-living or symbiotic bacteria. Some form a symbiotic relationship with plants in the legume family, which includes beans, peas, soybeans, alfalfa, and clovers . Some nitrogen-fixing bacteria even establish symbiotic relationships with animals, e.g., termites and "shipworms" (wood-eating bivalves).

N**itrogen-fixing cyanobacteria** are essential to maintaining the fertility of semi-aquatic environments like rice paddies. Although the first stable product of the process is ammonia, this is quickly incorporated into protein and other organic nitrogen compounds.

DIRECTION

Ammonium is converted by bacteria and archaea into nitrites (NO_2^-) and then nitrates (NO_3^-) through the process of nitrification. Like ammonium, nitrites and nitrates are found in water and the soil.

Some nitrates are converted back into nitrogen gas, which is released into the atmosphere. The process, called denitrification, is conducted by bacteria.

Plants and other producers directly use ammonium and nitrates to make organic molecules through the process of assimilation. This nitrogen is now available to consumers.

Organic nitrogen is especially important to the study of ecosystem dynamics because many processes, such as primary production, are limited by the available supply of nitrogen.

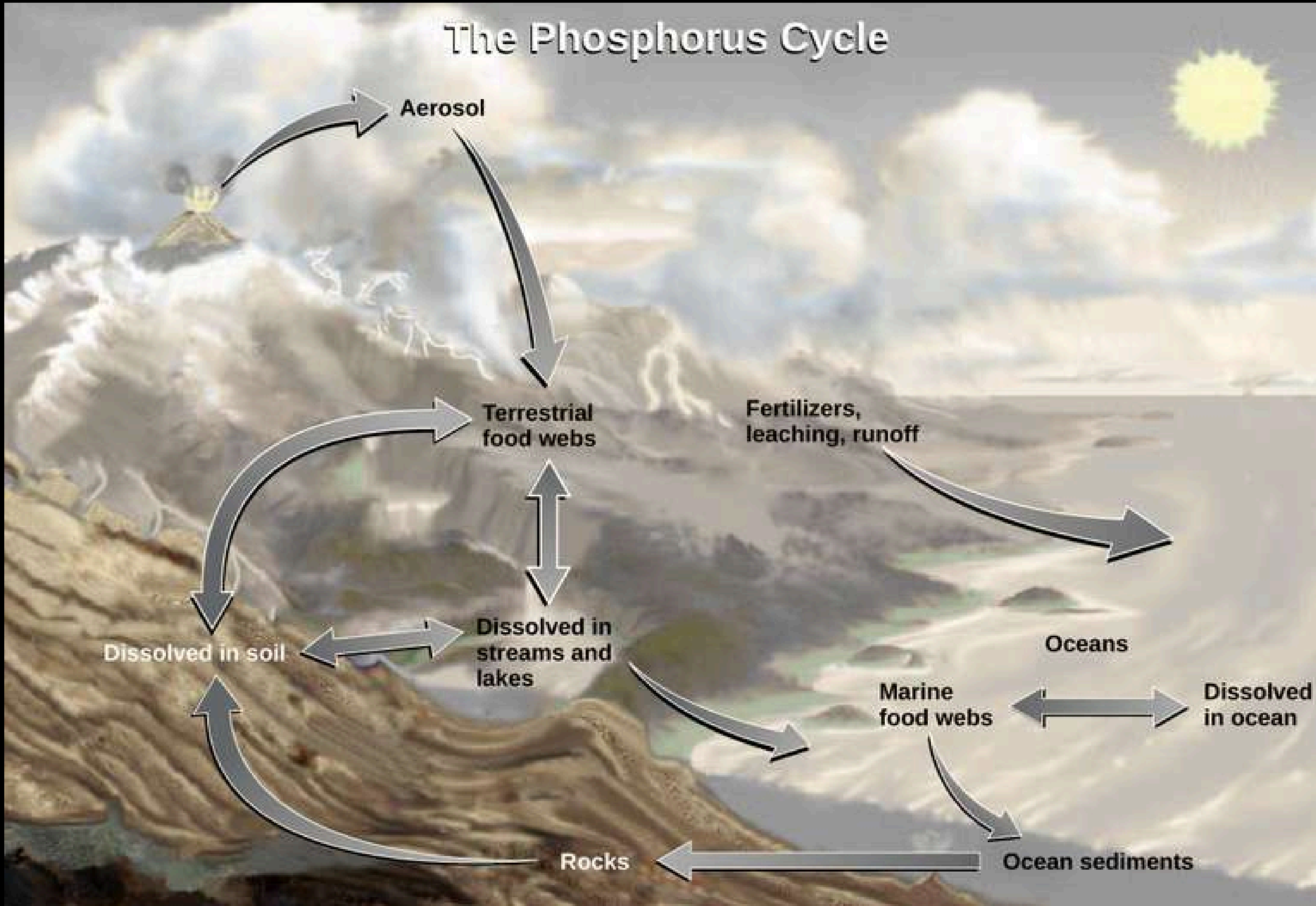
Consumers excrete organic nitrogen compounds that return to the environment.

Additionally dead organisms at each trophic level contain organic nitrogen. Microorganisms, such as bacteria and fungi, decompose these wastes and dead tissues, ultimately producing ammonium through the process of ammonification.

DIRECTION

The Phosphorus Cycle

Several forms of nitrogen (nitrogen gas, ammnoium, nitrates, etc.) were involved in the nitrogen cycle, but phosphorus remains primarily in the form of the phosphate ion (PO_4^{3-}). Also in contrast to the nitrogen cycle, there is no form of phosphorus in the atmosphere. Phosphorus is used to make nucleic acids and the phospholipids that comprise biological membranes.



DIRECTION

Phosphate enters the atmosphere from volcanic aerosols, which precipitate to Earth.

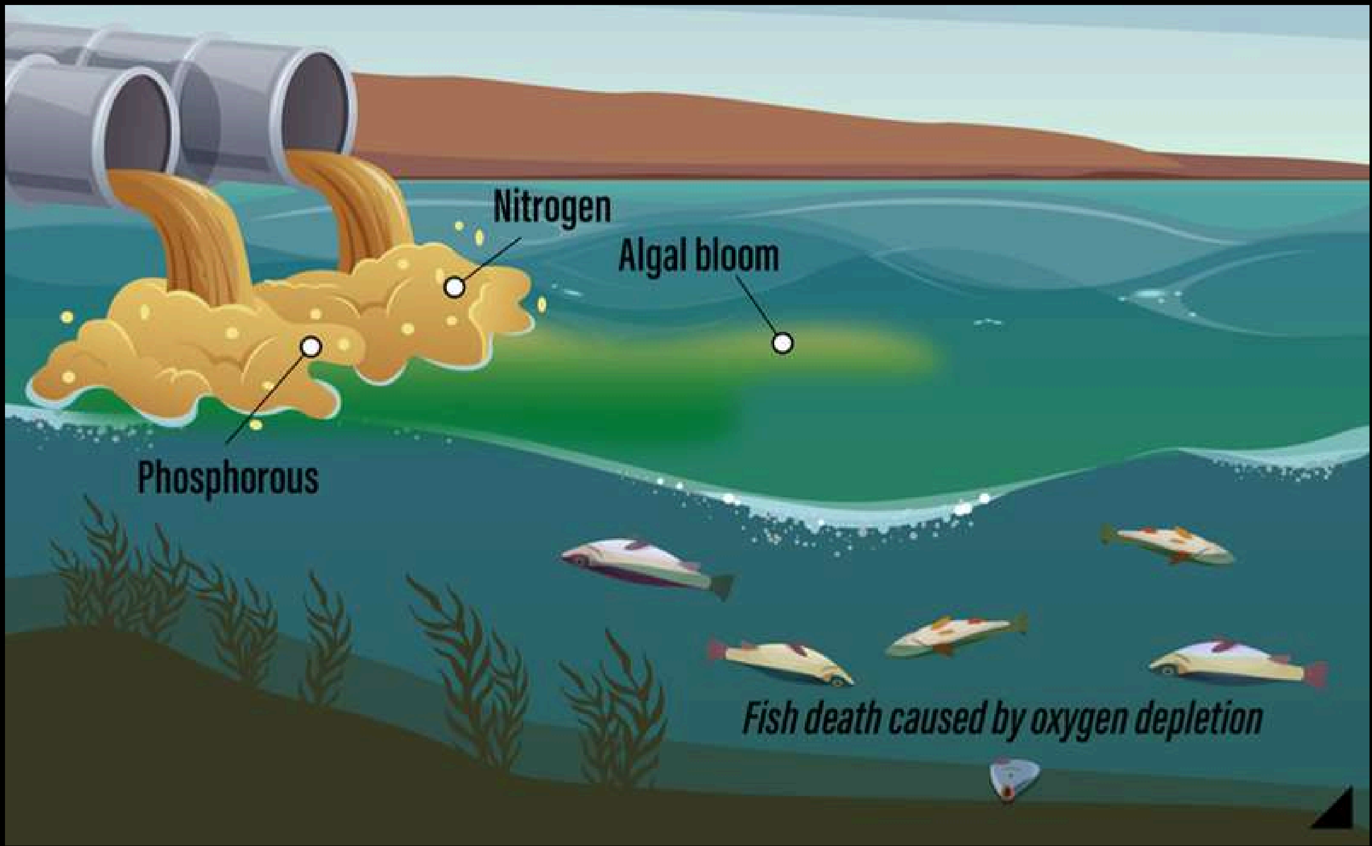
Weathering of rocks also releases phosphate into the soil and water, where it becomes available to terrestrial food webs. Some of the phosphate from terrestrial food webs dissolves in streams and lakes, and the remainder enters the soil. Phosphate enters the ocean via surface runoff, groundwater flow, and river flow, where it becomes dissolved in ocean water or enters marine food webs.

Some phosphate falls to the ocean floor where it becomes sediment. If uplifting occurs, this sediment can return to land.

DIRECTION

Eutrophication and Dead Zones

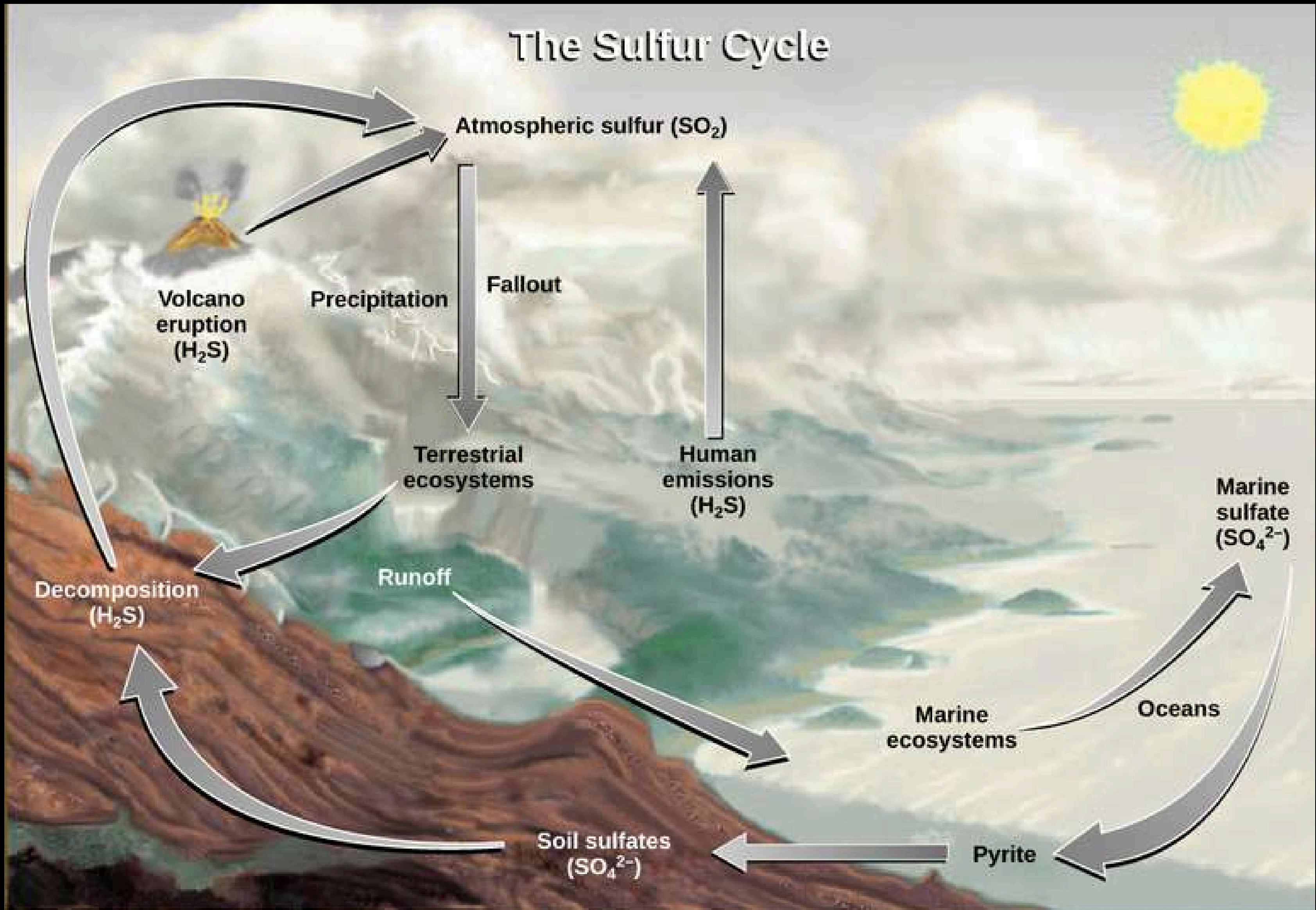
Eutrophication occurs when excess phosphorus and nitrogen from fertilizer runoff or sewage causes excessive growth of algae. Algal blooms that block light and therefore kill aquatic plants in rivers, lakes, and seas. The subsequent death and decay of these organisms depletes dissolved oxygen, which leads to the death of aquatic organisms such as shellfish and fish. This process is responsible for dead zones, large areas in lakes and oceans near the mouths of rivers that are periodically depleted of their normal flora and fauna, and for massive fish kills, which often occur during the summer months. There are more than 500 dead zones worldwide.



DIRECTION

The Sulfur Cycle

Sulfur is an essential element for the molecules of living things. As part of the amino acid cysteine, it is critical to the three-dimensional shape of proteins



DIRECTION

Atmospheric sulfur is found in the form of sulfur dioxide (SO_2), which enters the atmosphere in three ways:

- first, from the decomposition of organic molecules;
- second, from volcanic activity and geothermal vents; and,
- third, from the burning of fossil fuels by humans.

Sulfur dioxide (SO_2) from the atmosphere is dissolved in precipitation as weak sulfuric acid or falls directly to Earth as fallout. This releases sulfates (SO_4^{2-}) into the soil and water. Soil sulfates can be carried as runoff into the water. Marine sulfate can form pyrite, and this can break down to release soil sulfates.

Organisms in terrestrial and marine ecosystems assimilate sulfate, adding sulfur to organic molecules, such as proteins (not shown). Decomposition of these organisms returns sulfates to the soil. Microorganisms can convert sulfates to hydrogen sulfide (H_2S) and vice versa.

Decomposition, volcanic eruptions, and human activities (including burning fossil fuels) can release hydrogen sulfide (H_2S) or sulfur dioxide into the atmosphere

DIRECTION

Ecological succession

Ecological succession is the gradual and sequential replacement of one community by the other in an area over a period of time. According to E.P. Odum (1971), the ecological succession is an orderly process of community change in a unit area. It is the process of change in species composition in an ecosystem over time.

Process of Ecosystem Succession The ecological succession is a complex process and it may take thousands of years. Frederic Clements in 1916 for the first time proposed the sequential phases of an ecological succession.

Different Types of Ecological Succession

Primary succession is initiated when a new area that has never previously supported an ecological community is colonized by plants and animals. This could be on newly exposed rock surfaces from landslides or lava flows.

Secondary succession occurs when an area that has previously had an ecological community is so disturbed or changed that the original community was destroyed and a new community moves in. This is more common than primary succession and is often the result of natural disasters, such as fires, floods, and winds, as well as human interference, such as logging and clear-cutting.

Stages of Succession

Nudation/Bare Area:

The creation of a lifeless area, whether from a disturbance or new habitat formation.

Migration:

The dispersal of seeds, spores, and other propagules from existing communities into the bare area by wind, water, or animals.

Ecesis:

The successful establishment and growth of the colonizing species as they adapt to the new environment.

Aggregation:

The growth in population of these initial species, leading to a denser and more complex community.

Competition and Co-action:

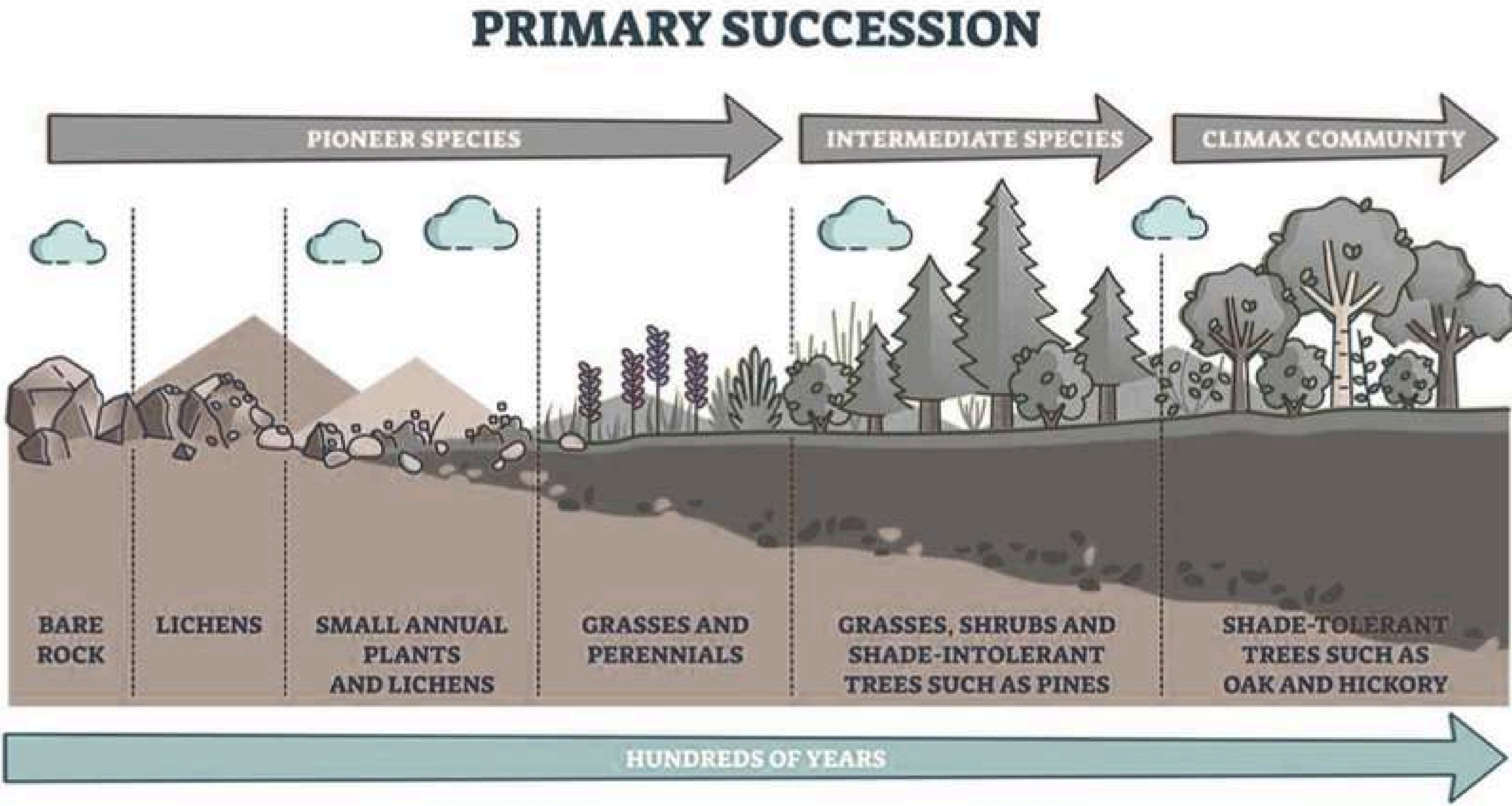
As populations grow, species begin to interact and compete for resources, influencing the community's structure.

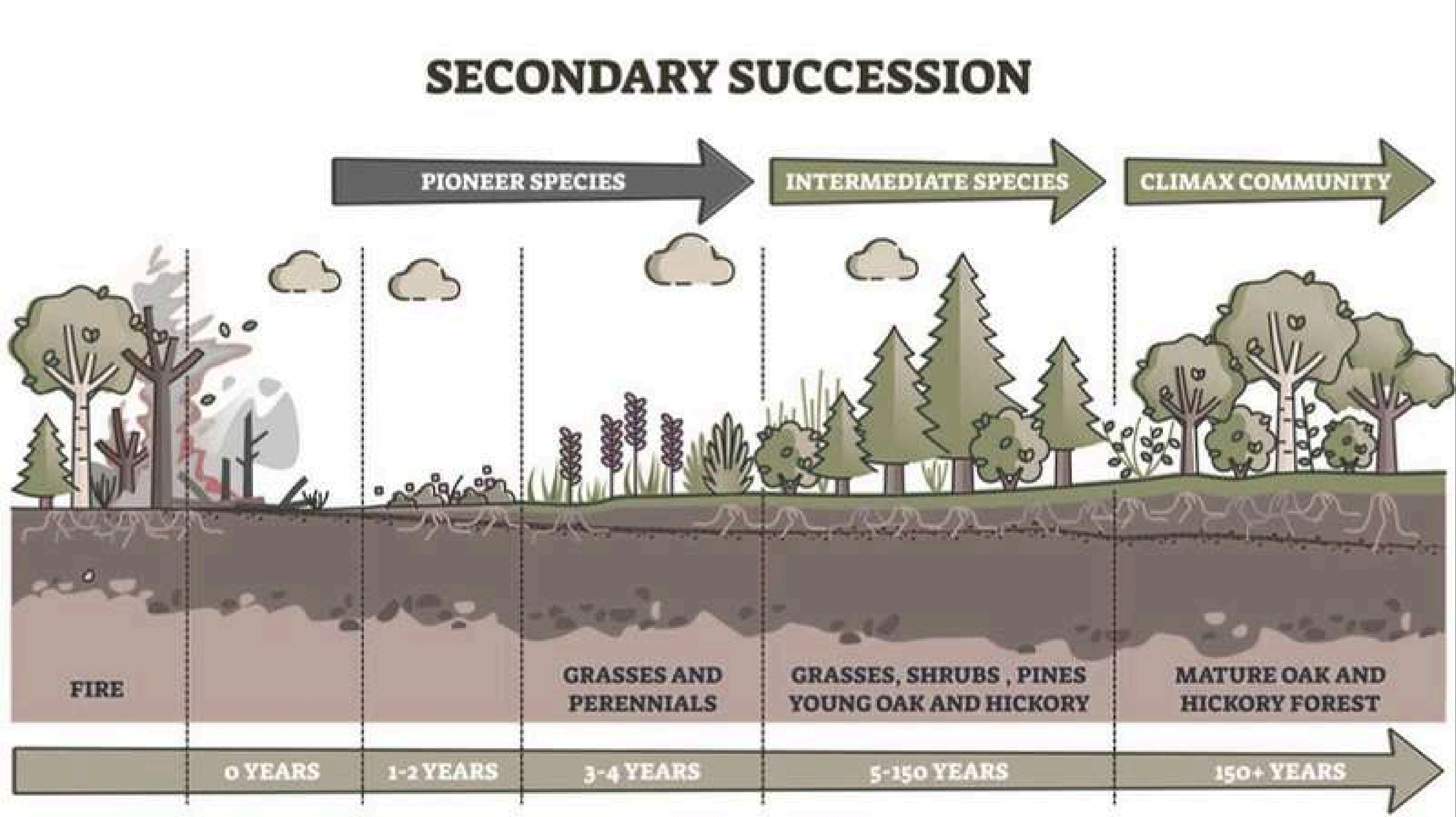
Reaction:

The development of new environmental conditions by the existing community that may hinder its own survival but facilitate the establishment of new species.

Stabilization/Climax Community:

A stable, mature community that is relatively well-adapted to its environment, with high biodiversity and a balanced species composition.

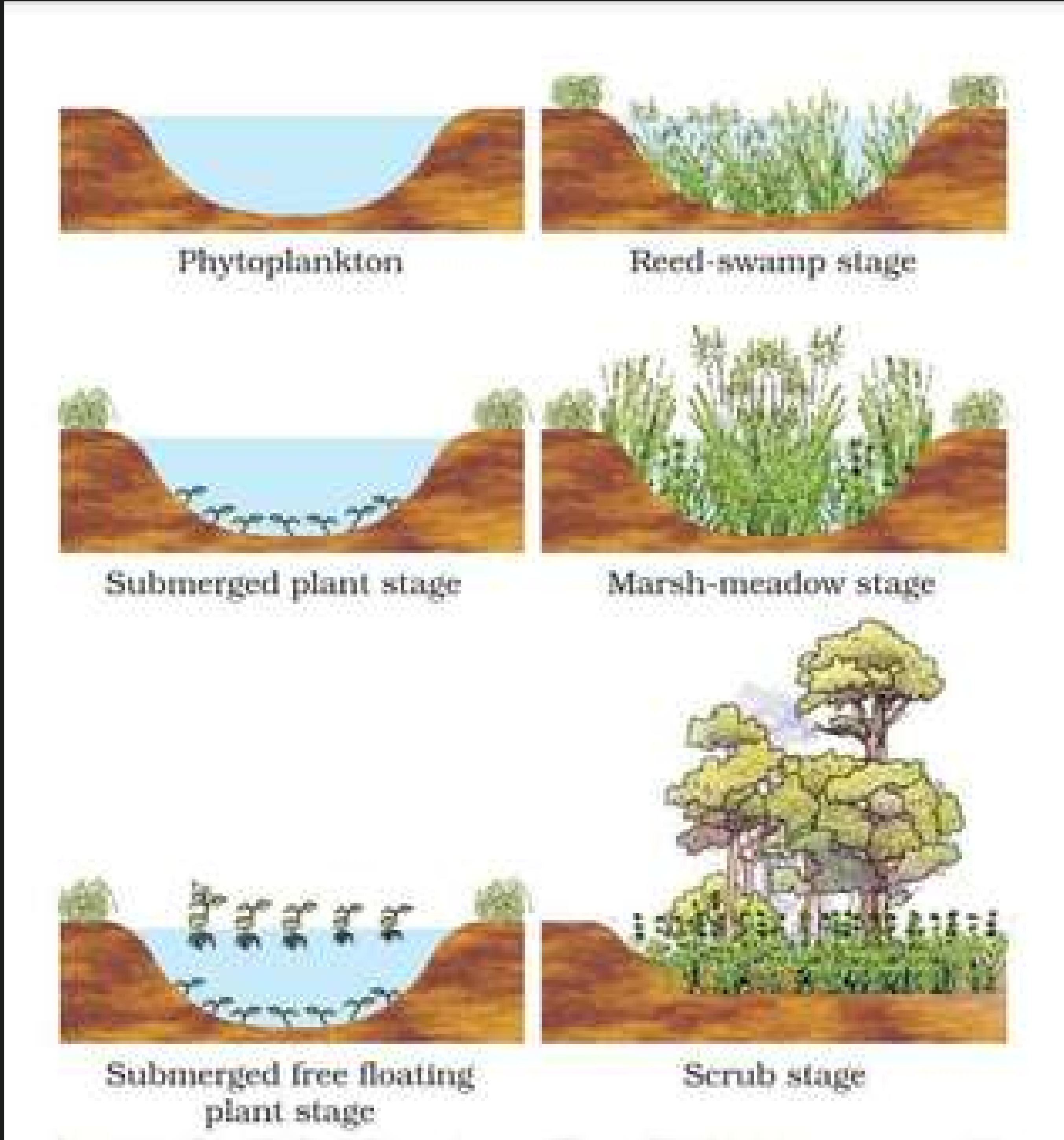

PRIMARY SUCCESSION
PIONEER SPECIES
INTERMEDIATE SPECIES
CLIMAX COMMUNITY
BARE ROCK
LICHENS
SMALL ANNUAL PLANTS AND LICHENS
GRASSES AND PERENNIALS
GRASSES, SHRUBS AND SHADE-INTOLERANT TREES SUCH AS PINES
SHADE-TOLERANT TREES SUCH AS OAK AND HICKORY
HUNDREDS OF YEARS


SECONDARY SUCCESSION
PIONEER SPECIES
INTERMEDIATE SPECIES
CLIMAX COMMUNITY
FIRE
GRASSES AND PERENNIALS
GRASSES, SHRUBS , PINES YOUNG OAK AND HICKORY
MATURE OAK AND HICKORY FOREST
0 YEARS
1-2 YEARS
3-4 YEARS
5-150 YEARS
150+ YEARS

DIRECTION

Classification based on water relationship:

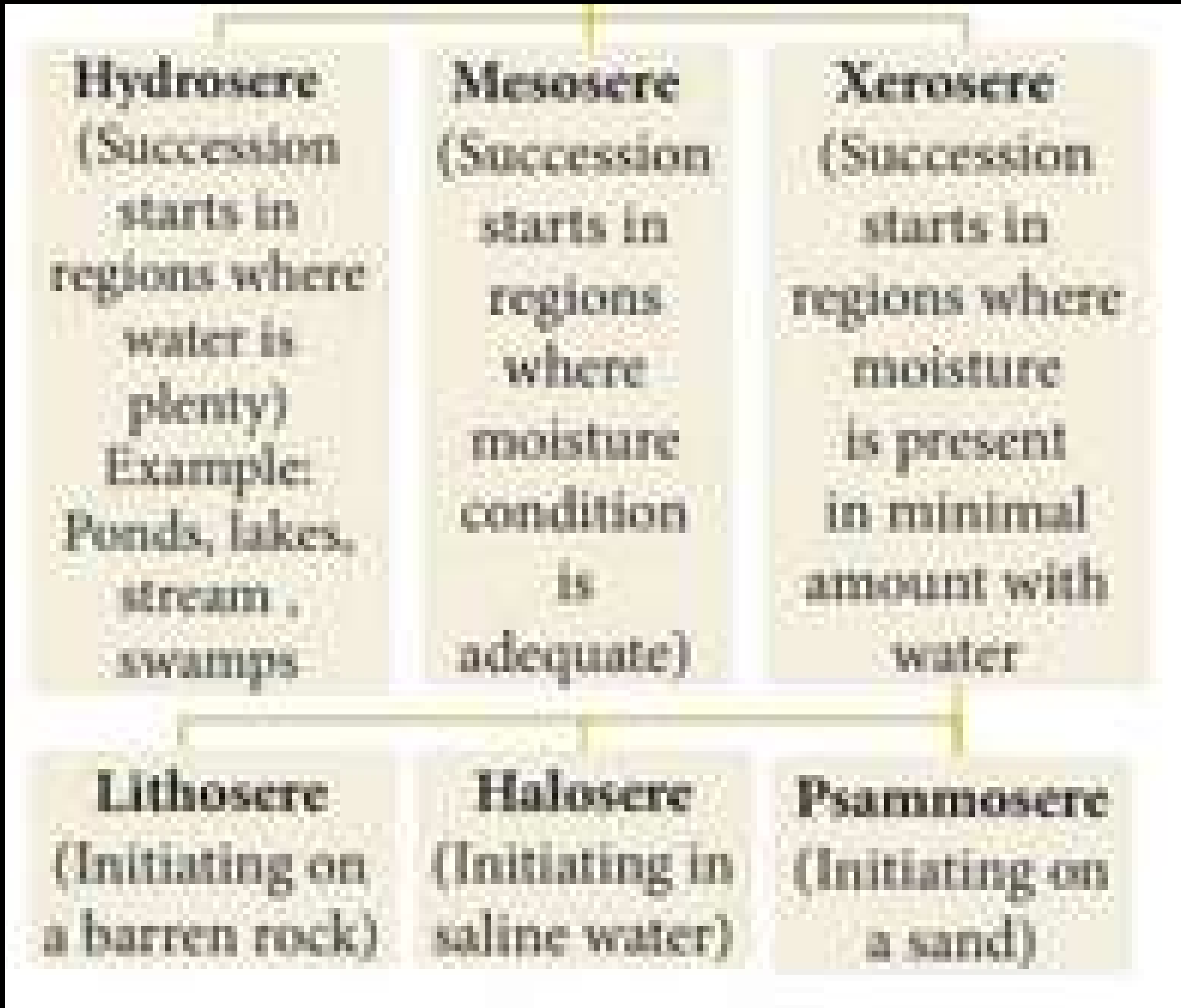
A sere beginning in water is termed as **hydro-sere/ hydrarch.** For example, it refers to the series of aquatic communities found in a lake.



A successional sequence beginning in a place where there is a deficiency of water such as sand dunes, bare rock etc. is termed as Xerosere/ xerarch. The type of xerosere developing on rocks is called a lithosere.
Both hydrarch and xerarch ecological successions lead to mesic conditions, which are environments with medium water availability – neither excessively dry nor excessively wet.

Hydrarch succession starts in a wet (hydric) habitat, progressing from water to mesic conditions, while xerarch succession begins in a dry (xeric) habitat and progresses from xeric to mesic conditions

Plant succession



Causes of Succession:

Autogenic succession: Succession resulting from changes brought about by the organisms within the community is called outogenic succession. Example of autogenic succession is an abandoned agricultural field to a mature forest or filling-in of a pond by rhizomes and organic detritus etc.

Organisms themselves can bring about changes in environment in which they live. This may lead to harmful or beneficial effect on other species in the community.

Allogenic succession: Succession occurring due to forces of change occurring primarily from outside the community is called allogenic succession. Succession on bare rock may cause breakdown of the rock by organisms or by physical and chemical weathering. These latter processes are allogenic. In pond succession, the filling in by sand, silt and clay carried from outside the area is an allogenic factor

Progressive Succession	Retrogressive Succession
A progressive succession from simple to complex life forms.	A community shows regressive change from complex to simper life forms.

DIRECTION

Induced Succession

Gradual deterioration of an ecosystem induced by external activities.

Cyclic Succession

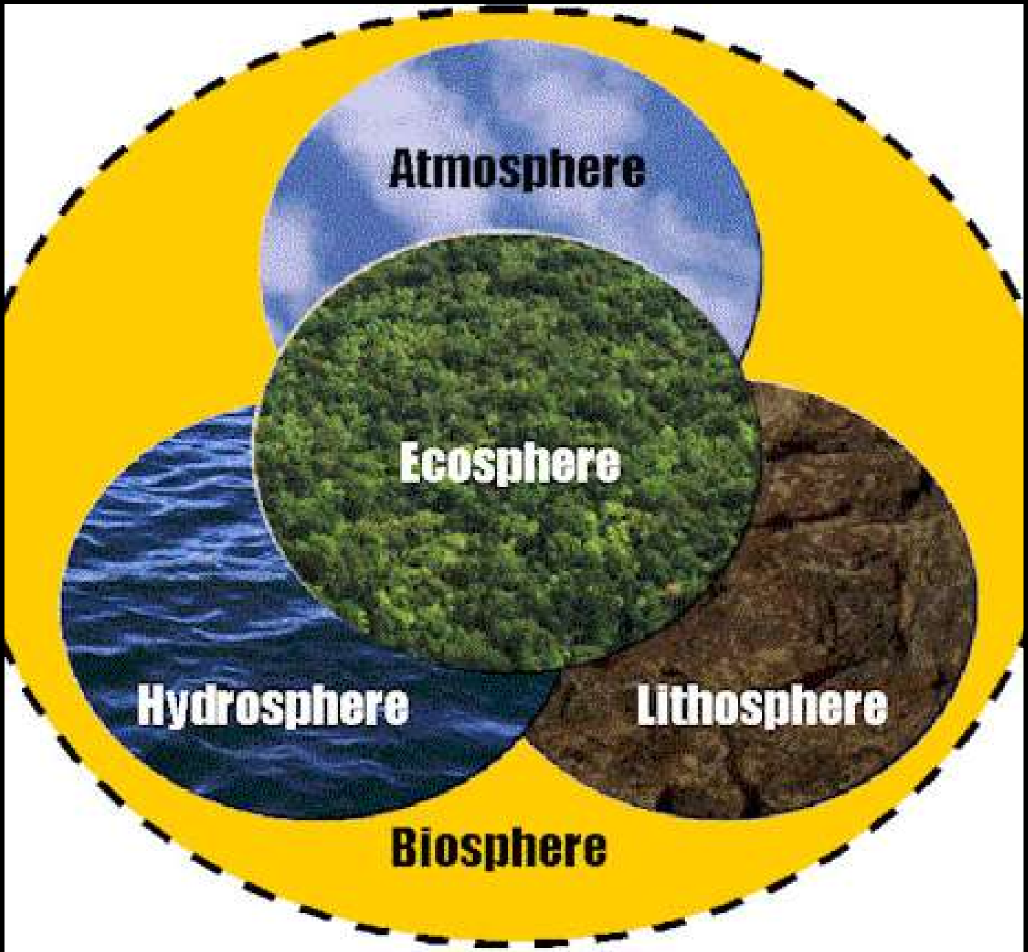
Local succession in a community with some stages are repeated frequently.

Biosphere and Biomes

The biosphere is made up of the parts of Earth where life exists. The biosphere extends from the deepest ocean trenches, to lush rain forests and high mountaintops.

The Earth can be described in terms of spheres. The solid surface layer of the Earth is the lithosphere. The atmosphere is the layer of air that stretches above the lithosphere. The Earth's water—on the surface, in the ground, and in the air—makes up the hydrosphere.

Since life exists on the ground, in the air, and in the water, the biosphere overlaps all these spheres. Although the biosphere measures about 20 kilometers (12 miles) from top to bottom, almost all life exists between about 500 meters (1,640 feet) below the ocean's surface to about 6 kilometers (3.75 miles) above sea level.



The Biosphere can be divided in to much smaller Biomes

DIRECTION

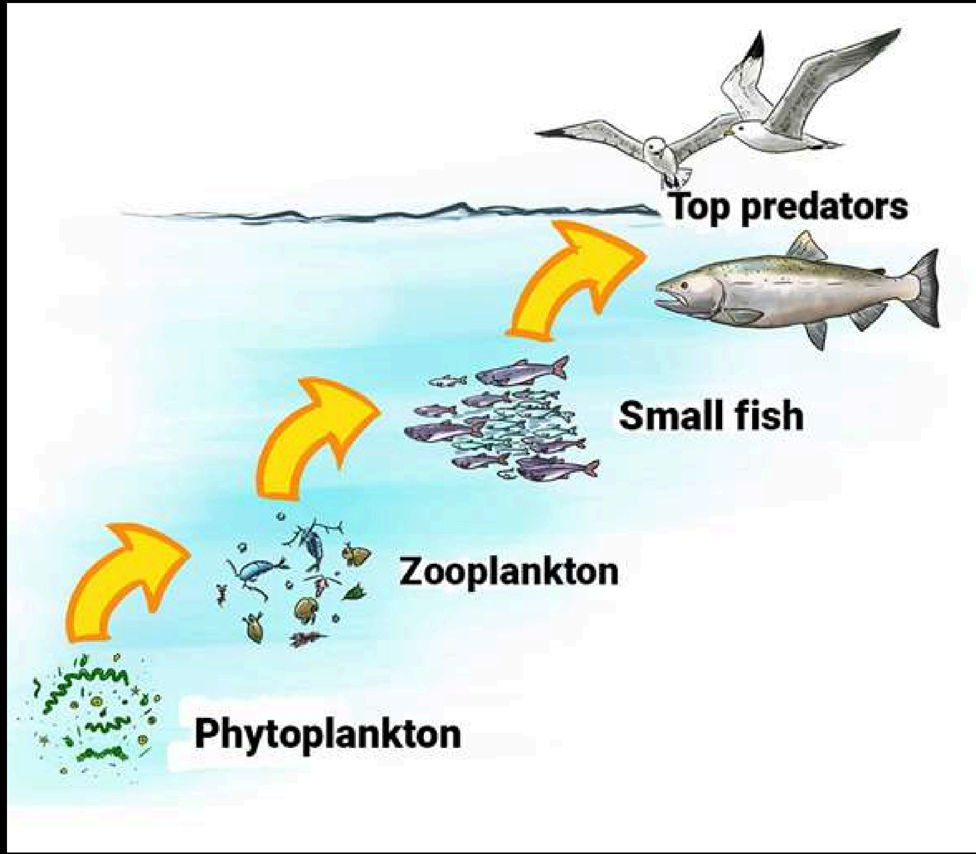
Aquatic ecosystem

An aquatic ecosystem is a specific type of ecosystem found within bodies of water, encompassing both the plants and animals that inhabit these areas.

Covering approximately 70 percent of Earth's surface, aquatic ecosystems are classified into two main categories: saltwater and freshwater.

Saltwater ecosystems, such as oceans and coral reefs, have high salinity and feature diverse habitats including intertidal, pelagic, benthic, and abyssal zones, each supporting unique biological communities.

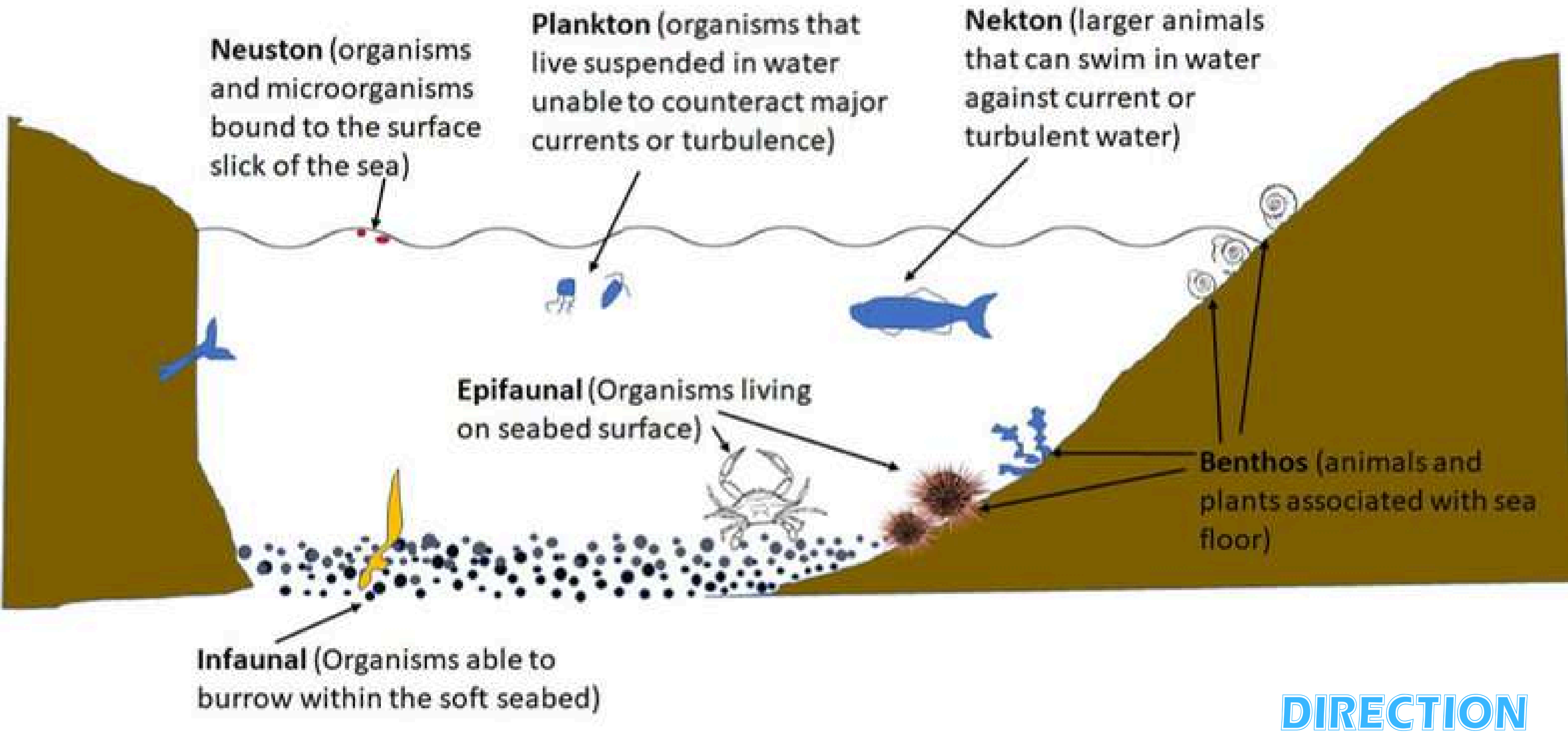
Freshwater ecosystems, which include lakes, rivers, and wetlands, are characterized by low salt concentrations and contain varying habitats, such as the warm littoral zone and the deeper, colder profundal zone.



DIRECTION

Life Forms of Aquatic Biomes

Neuston Plankton Nektons Benthos



DIRECTION

Zooplankton are the heterotrophic (sometimes detritivorous) component of the plankton that drift in the water column of oceans, seas, and bodies of fresh water. Many zooplankton are too small to be individually seen with the unaided eye. Zooplankton is a broad categorisation spanning a range of organism sizes that includes both small protozoans and large metazoans.

It includes holoplanktonic (copepods, salps, and some jellyfish)organisms whose complete life cycle lies within the plankton, and

meroplanktonic(sea urchins, starfish, crustaceans, marine worms, and most fish) organisms that spend part of their life cycle in the plankton before graduating to either the nekton or a sessile, benthic existence.

Mode of life:

Holoplankton- spends entire lifecycle as plankton Ex. Jellyfish, copepods

Meroplankton- spend part of lifecycle as plankton Ex. fish and crab larvae, eggs

Nutritional modes of zooplankton:

Herbivores: feed primarily on phytoplankton •

Carnivores: feed primarily on other zooplankton (animals)

Detrivores: feed primarily on dead organic matter (detritus)

Omnivores: feed on mixed diet of plants and animals and detritus

DIRECTION

Zooplanktons are always dominated by two major groups of animals such as protozoa, metazoan Ecologically important protozoan zooplankton groups include the foraminiferans, radiolarians and dinoflagellates.

Important metazoan zooplankton include cnidarians such as jellyfish and the Portuguese Man o' War

- Crustaceans such as copepods and krill;
- Molluscs such as pteropods; and
- Chordates such as salps and juvenile fish

DIRECTION

Copepods are important food sources for many fish, whales, seabirds, crustaceans, and a variety of other sea-life. Copepods are crustaceans. sometimes called the **insects of the sea** because there are so many of them, about 10,000 species.

They can be found in fresh and salt water. Copepods are very small, usually not more than a few millimeters long. The largest copepod, the Pennella balaenopterae, lives on the finback whale and can grow to be over a foot long! They have two antenna, a shell and segmented bodies. They graze on phytoplankton and zooplankton. **Copepods are the largest source of protein in the ocean.**

Copepod-Cyclops

Nektons

Nektons are the assemblage of pelagic animals that swim freely, independent of water motion or wind. Only three phyla are represented by adult forms.

Chordate nekton include numerous species of bony fishes, the cartilaginous fishes such as the sharks, several species of reptiles (turtles, snakes, and saltwater crocodiles), and mammals such as the whales, porpoises, and seals.

Molluscan nekton include the squids and octopods.

The only arthropod nekton are decapods, including shrimps, crabs, and lobsters.

DIRECTION

Nektonic feeding types

Herbivorous nekton are not very common, although a few nearshore and shallow-water species subsist by grazing on plants.

Of the nektonic feeding types, zooplankton feeders are the most abundant and include, in addition to many bony fishes, such as the sardines and mackerel, some of the largest nekton, the baleen whales.

The molluscs, sharks, and many of the larger bony fishes consume animals bigger than zooplankton.

Other fishes and most of the crustaceans are scavengers

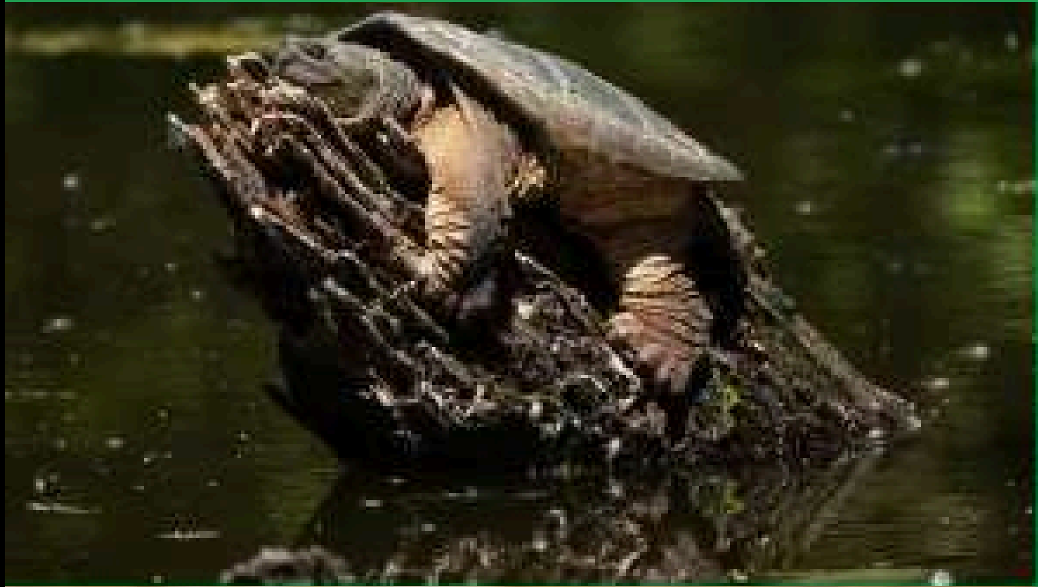
Marine Iguana

Salt Water Crocodile

Leather Back Turtle

Sea Krait

Common Snapping Turtle



Yellow Bellied Slider

American Alligator

Northern Water Snake

DIRECTION

Benthos

Benthos The term benthos comes from the Greek for "depths of the sea". Benthic organisms live on, in, or near the seabed, also known as the benthic zone. Unlike the drifting plankton and swimming nekton, benthic organisms – commonly referred to as benthos – live on or near the ocean bottom A benthic habitat may be shallow or deep.

Most benthic organisms are sessile (immobile) and anchored to the benthic environment; others crawl or swim over the ocean bottom Benthic organisms, such as sea stars, oysters, clams, sea cucumbers, brittle stars and sea anemones, play an important role as a food source for fish and humans.

Benthos is also used in freshwater biology to refer to organisms at the bottom of freshwater bodies of water, such as lakes, rivers, and streams.

DIRECTION

The main food sources for benthos are plankton and organic runoff from land. The depth of water, temperature and salinity, and type of local substrate all affect what benthos is present.

In coastal waters and other places where light reaches the bottom, benthic photosynthesizing diatoms can proliferate. Filter feeders, such as sponges and pelecypods, dominate hard, sandy bottoms.

Deposit eaters, such as polychaetes, populate softer bottoms.

Fish, starfish, snails, cephalopods, and crustaceans are important predators and scavengers.

DIRECTION

The **benthic zone of the ocean** is varied. There is a wide variety of life that makes its home on the ocean floor. Some organisms live in the mud, some crawl or swim along the bottom and some anchor themselves to the ocean floor.

Life in the benthos region is organized by size.

Macrobenthos are organisms that are larger than one millimeter like oysters, starfish, lobsters, sea urchins, shrimp, crabs and coral.

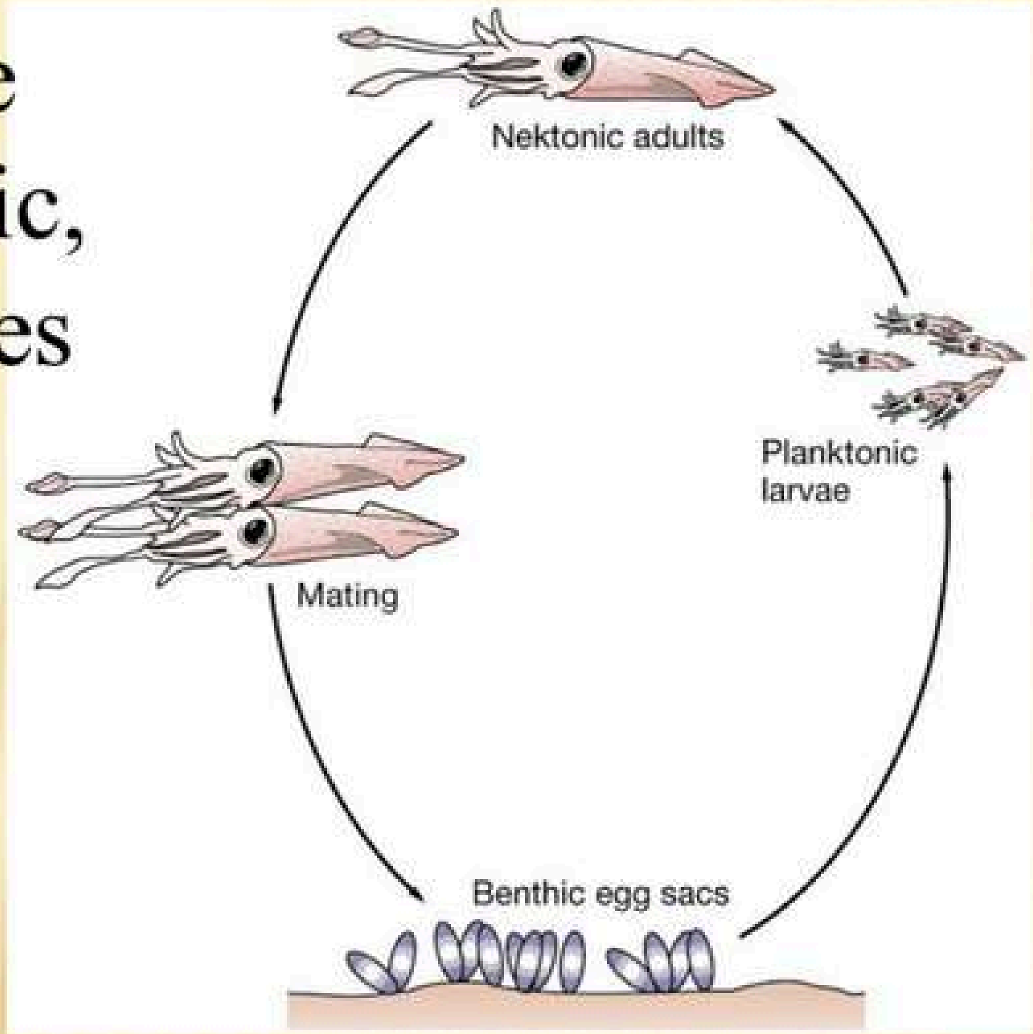
Meiobenthos are between one tenth and one millimeter in size. Organisms in this group include diatoms and sea worms.

Microbenthos are very tiny organisms like diatoms, ciliates and bacteria. They are smaller than one tenth of a millimeter.

DIRECTION

Life cycle of a squid

- Squids experience benthic, planktonic, and nektonic stages
- Squids are considered **meroplankton** (opposite = **holoplankton**)



DECOMPOSERS

In the ocean, the most abundant decomposers are bacteria, marine worms, Echinoderms, Crustaceans and Mollusks. They all get their energy by breaking down dead organic matter that float around or fall to the bottom of the sea. Different decomposers are adapted to survive in different marine ecosystems that are a result of the different conditions in different oceans and different parts (niches) of each ocean.

It includes - Micro Decomposers &Marine Worms

Micro Decomposers Micro decomposers in the ocean include bacteria and fungi and are the most important group of decomposers. Microscopic animals called protists or zooplankton can also be decomposers

These microorganisms can be found in all marine ecosystems and feed on a wide variety of organic material.

Marine Worms

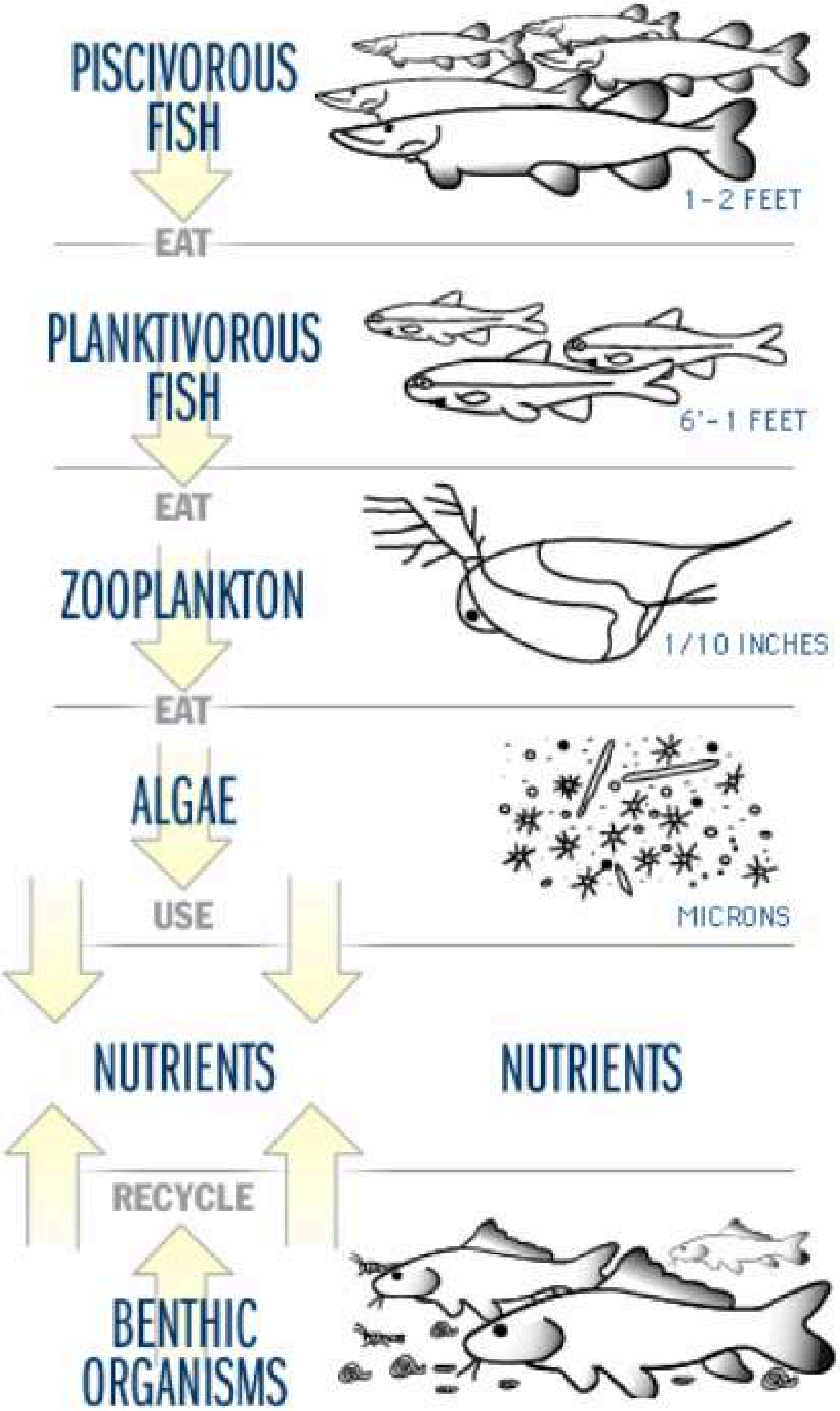
Marine worms are a diverse group of organisms, including decomposers like Christmas tree worms and feather duster worms.

They are sedentary filter feeders with appendages that spread out and catch small organic particles suspended in the water. They can be found in coral reefs and intertidal rock pools.

DIRECTION

Echinoderms Unlike the sedentary marine worms, echinoderms, such as starfish, brittle stars, sea urchins and sea cucumbers, actively seek out dead organic matter on rocks and other surfaces. Many echinoderms are opportunistic detritivores. Echinoderms are mostly found in shallow waters, like coral reefs and intertidal rock pools, but can also be found in deeper waters

DIRECTION


PISCIVOROUS FISH
1-2 FEET
EAT
PLANKTIVOROUS FISH
6'-1 FEET
EAT
ZOOPLANKTON
1/10 INCHES
EAT
ALGAE
MICRONS
USE
NUTRIENTS
NUTRIENTS
RECYCLE
BENTHIC ORGANISMS

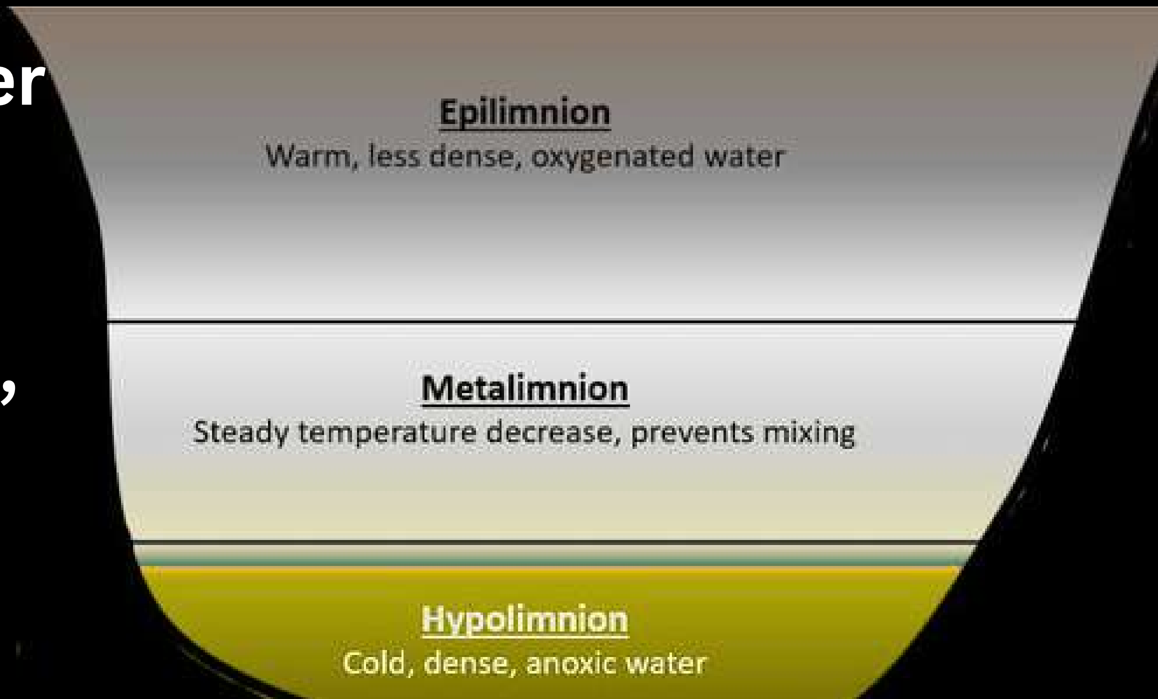
DIRECTION

Fresh Water Ecosystems

Lake Ecology

Thermal Stratification of a Lake

the epilimnion is the warm, well-mixed top layer exposed to sunlight, the metalimnion (or thermocline) is the middle layer with a rapid temperature decrease with depth, and the hypolimnion is the cold, dense, and stable bottom layer



DIRECTION

Thermal stratification is the process of dividing the water in the lakes into layers with each stratum having unique characteristics like changes in water temperatures and density.
Using this classification, lakes can be divided into three main categories: holomictic lakes, meromictic lakes, and amictic lakes

Holomictic Lakes

Holomictic lakes have with uniform density and temperature regardless of depth in a particular period of the year. The majority of the lakes in the world are holomictic. Holomictic lakes exist in three distinct types, and they include monomictic lakes, dimictic lakes, and polymictic lakes.

Monomictic lakes are holomictic and its water mixes from the top to bottom of the lake in one mixing period per year. Monomictic lakes can be further divided into two consisting of cold monomictic lakes and warm monomictic lakes. Some examples of monomictic lakes include; Lake Turkana, Sea of Galilee, Okanagan Lake, and Lake Titicaca.

Dimictic lakes are the type of holomictic lakes whose waters mix from top to bottom of the lake in two mixing periods of each year. Dimictic lakes are found in temperate regions and are covered by ice during winter. In the summer, the lakes are thermally stratified so that the warm surface water is separated from the relatively colder waters beneath. The waters mix during spring and autumn which results in the lakes being isothermal.

Polymictic lakes are holomictic and have shallow waters with the small depth preventing the development of thermal stratification in the lakes and therefore the waters mix regardless of the season. Polymictic lakes can be divided into two distinct types which are temperature-defined: warm polymictic lakes and cold polymictic lakes.

Meromictic Lake

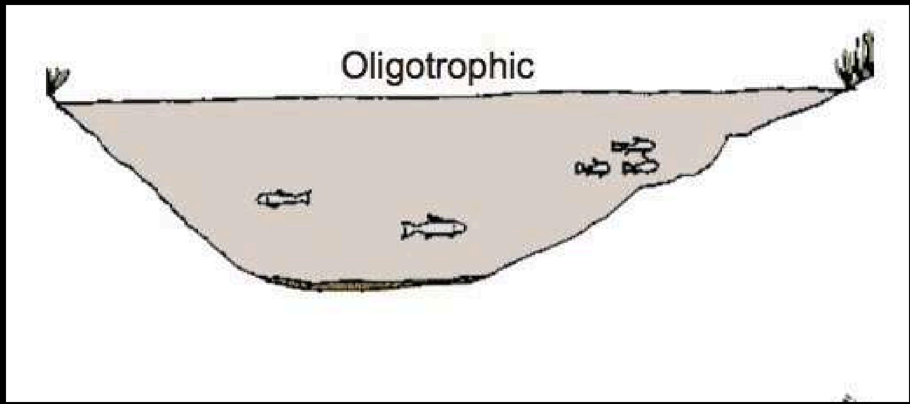
Meromictic lakes have layers of water that do not intermix. Due to the absence of intermixing of the water, the bottom layer of the lake contains no dissolved oxygen and is therefore largely devoid of life except for the purple sulfur bacteria. Also, due to the lack of any disturbance on the layer of sediment found on the bottom of such lakes leads to the formation of lacustrine varves. The waters of meromictic lakes are divided into three layers and the top layer being the mixolimnion while the bottom layer is known as the monimolimnion. The layer between the two is known as the chemocline. Meromictic lakes are few in the world compared to holomictic lakes with some examples being Lake Tanganyika (the deepest lake in Africa), Lake Kivu, Kaptai Lake, Jellyfish Lake, Lake Cadagno, the Great Salt Lake, and the Lower Mystic Lake.

Amictic Lakes

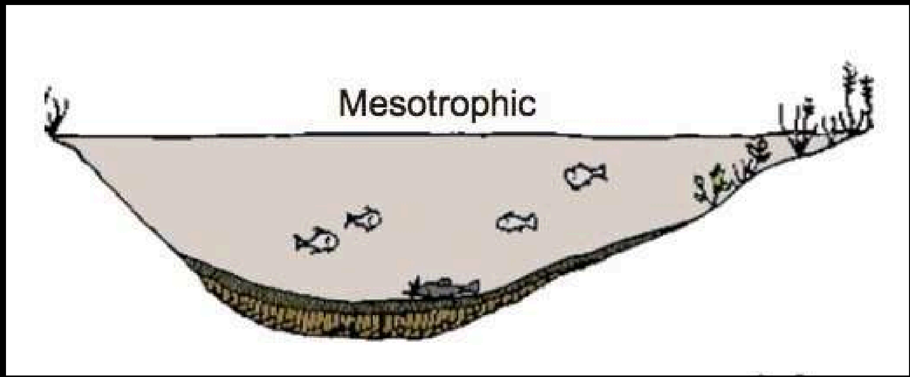
Amictic lakes have water whose surface is covered with ice throughout the year which prevents the mixing of the waters beneath, and therefore allowing such lakes to exhibit inverse cold water stratification where water temperature increases with the increase in depth. Due to the extreme cold temperatures which characterize amictic lakes, such lakes are only found in the polar regions both in the Arctic as well as in Antarctica. There are also a few amictic lakes found in Greenland. One example of an amictic lake is Lake Vanda found in Antarctica.

Trophic Classifications

Oligotrophic: An oligotrophic lake or water body is one which has a relatively low productivity due to the low nutrient content in the lake. The waters of these lakes are usually quite clear due to the limited growth of algae in the lake. The waters of such lakes are of high-drinking quality. Such lakes support aquatic species who require well-oxygenated, cold waters such as lake trout. Oligotrophic lakes are usually found in the cold regions of the world where mixing of nutrients is rare and slow due to the low temperatures of the lake waters.



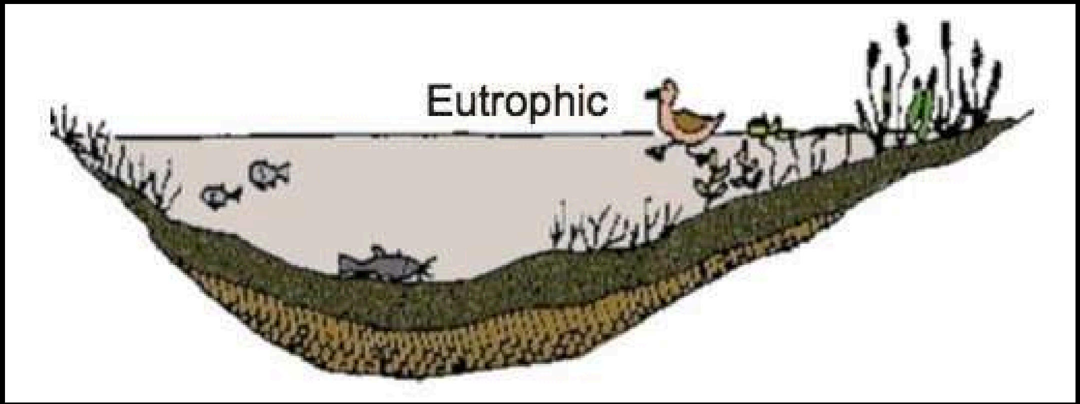
Mesotrophic: Lakes with an intermediate level of productivity are called mesotrophic lakes. These lakes have medium-level nutrients and are usually clear water with submerged aquatic plants.



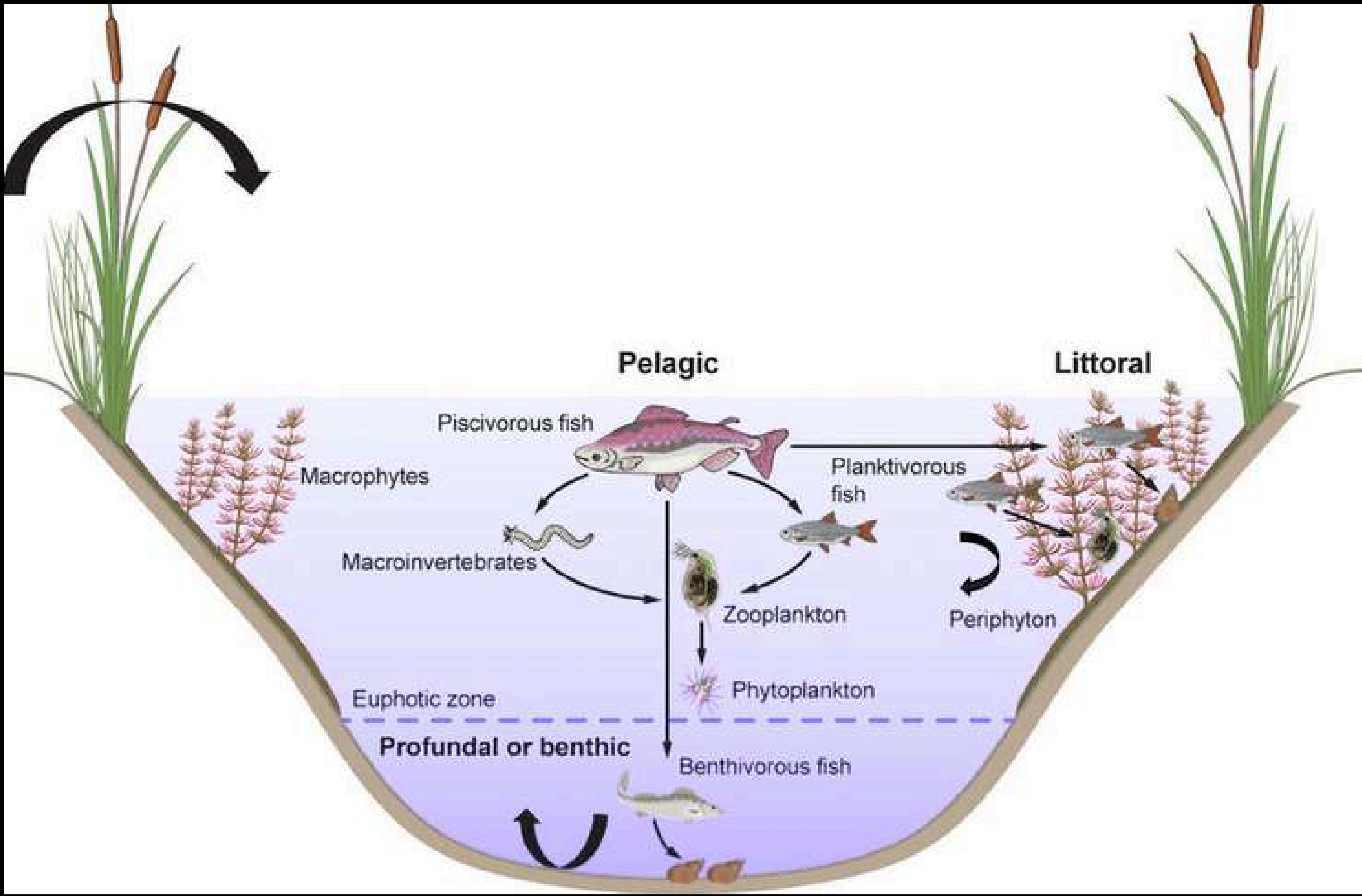
DIRECTION

Eutrophic: Lakes that are eutrophic in nature have high levels of biological productivity. An abundance of plants is supported by such lakes due to the rich nutrient constitution, especially nitrogen and phosphorus. Initially, eutrophic lakes accelerate multiplication and growth of lake fauna due to the high levels of oxygen provided by a large number of plants growing in the lake. However, when things cross limits and plants or algal blooms overcrowd the lake, the lake fauna suffers due to the high levels of respiration by the living vegetative matter. Eutrophication might occur naturally or due to human impact on the environment.

Hypereutrophic: These lakes suffer from problems arising due to excessive plant and algal growth due to a high supply of growth nutrients. These lakes have little transparency due to the dense overgrowth of algae or aquatic flora. These lakes usually have visibility limited to lower than 3 feet. Hypereutrophic lakes also have more than 100 micrograms/liter of phosphorus and more than 40 micrograms/liter of total chlorophyll. The overgrowth of algae often suffocates the fauna below the water depths and this might create dead zones beneath the water surface.



Habitat complexity in shallow lakes and ponds. Three major within-lake habitats are recognized: the pelagic, the benthic, and the littoral zone, all interacting with the adjacent terrestrial ecosystem through the riparian zone. Each lake habitat is characterised by different assemblages of organisms and different levels of complexity.



DIRECTION

River Ecology

Rivers have three distinct habitat areas:

- River beds, or the water channel itself.
- River banks, called the “riparian zone.” These include the land, trees, and water-loving animals and plants along the channel.
- Floodplains, or the low, flat land spreading out from the channel. This area periodically floods during heavy rains and snow melt. Sometimes floodplains stay soggy for a long time, creating rich wetland habitat.

River ecosystems have:

- flowing water that is mostly unidirectional
- a state of continuous physical change
- many different (and changing) microhabitats
- variability in the flow rates of water
- plants and animals that have adapted to live within water flow conditions.

DIRECTION

A variety of plants can be found growing within a river system. Some plants are free-floating while others are rooted in areas of reduced current. Plants such as cattails, water lilies, and submerged plants filter pollutants and provide habitat and food for other creatures

Algae are the most significant source of primary food in most rivers or streams. Most float freely and are therefore unable to maintain large populations in fast-flowing water.

DIRECTION

Invertebrates

Invertebrates have no backbone or spinal column and include crayfish, snails, limpets, clams and mussels found in rivers. A large number of the invertebrates in river systems are insects. They can be found in almost every available habitat – on the water surface, on and under stones, in or below the substrate or adrift in the current. Some avoid high currents by living in the substrate area, while others have adapted by living on the sheltered downstream side of rocks. Invertebrates rely on the current to bring them food and oxygen. They are both consumers and prey in river systems.

Native White-clawed Crayfish

Medicinal Leech

Banded Damoiselle

DIRECTION

Fish

Freshwater species: Fish like bass, perch, and catfish are common in many river habitats.

Migratory species: Salmon and trout travel to rivers to spawn, while others, like river herring, swim in these waters before heading to the ocean.

Amphibians and Reptiles

Amphibians: Frogs and salamanders use rivers and their banks for spawning, hunting, and as a drinking source.

Reptiles: Turtles, snakes, and alligators inhabit rivers, preying on fish and other small animals.

Birds

Wading birds: Herons and other wading birds rely on rivers for food, such as fish and eels.

Diving birds: Kingfishers catch fish from the surface of the water.

Mammals

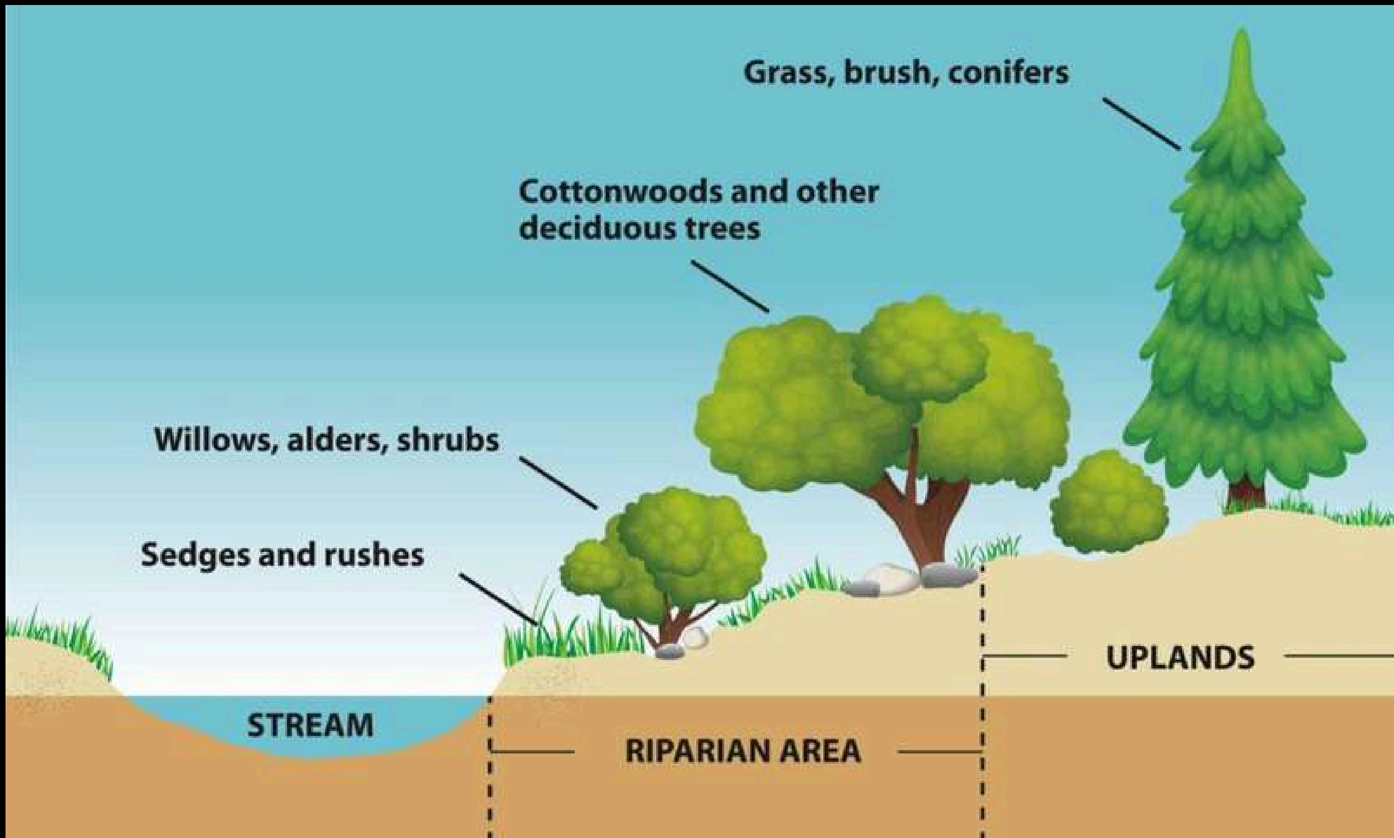
Semi-aquatic mammals: Animals like otters and beavers live in and around rivers, fishing and sheltering in riverbanks.

River dolphins: These unique aquatic mammals are found in some large freshwater river systems, such as the Amazon River.

DIRECTION

A riparian ecosystem is a transitional zone where terrestrial and aquatic environments meet, such as along river banks, floodplains, and wetlands

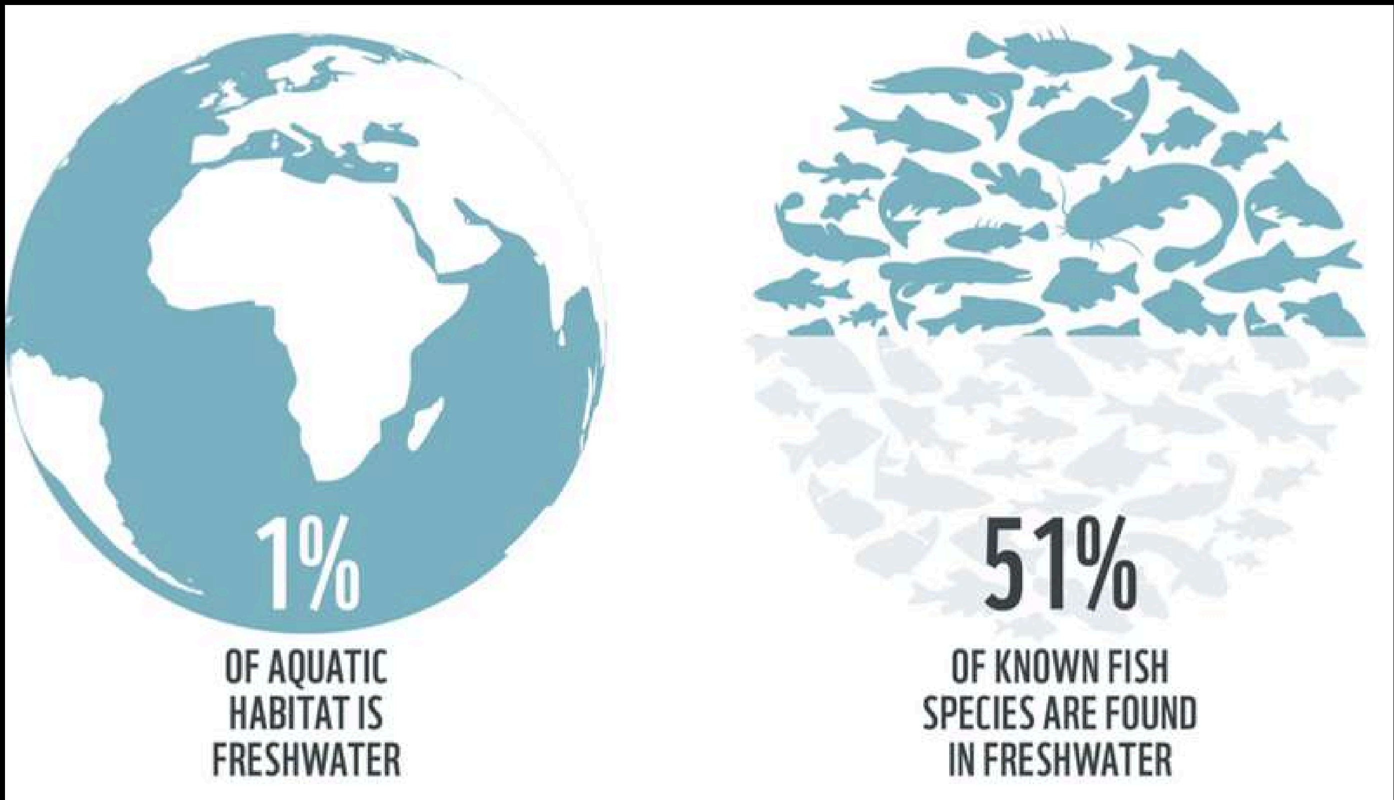
- Vegetation: Features water-loving plants like rushes, willows, and cottonwoods, and can include trees, shrubs, and grasses.
- Biodiversity: High levels of biodiversity, supporting a wide variety of insects, crustaceans, fish, and other wildlife.



DIRECTION

Fish

The ability of fish to live in a river system depends on their speed and duration of that speed – it takes enormous energy to swim against a current. This ability varies and is related to the area of habitat the fish may occupy in the river. Most fish tend to remain close to the bottom, the banks or behind obstacles, swimming in the current only to feed or change location. Some species never go into the current. Most river systems are typically connected to other lotic systems (springs, wetlands, waterways, streams, oceans), and many fish have life cycles that require stages in other systems. Eels, for example, move between freshwater and saltwater. Fish are important consumers and prey species.



DIRECTION

Freshwater fishes are extremely diverse. They include some of the smallest vertebrates on earth, such as the minnow, Paedocypris progenetica, that lives in peat swamps in Indonesia and is just 8mm long and weighs in at 0.004g, and giant fish such as the Mekong giant catfish, Pangasianodon gigas, Mekong giant freshwater stingray, Himantura chaophraya, and beluga sturgeon, Huso huso, all of which can reach more than 3m in length and weigh more than more than 300kg.

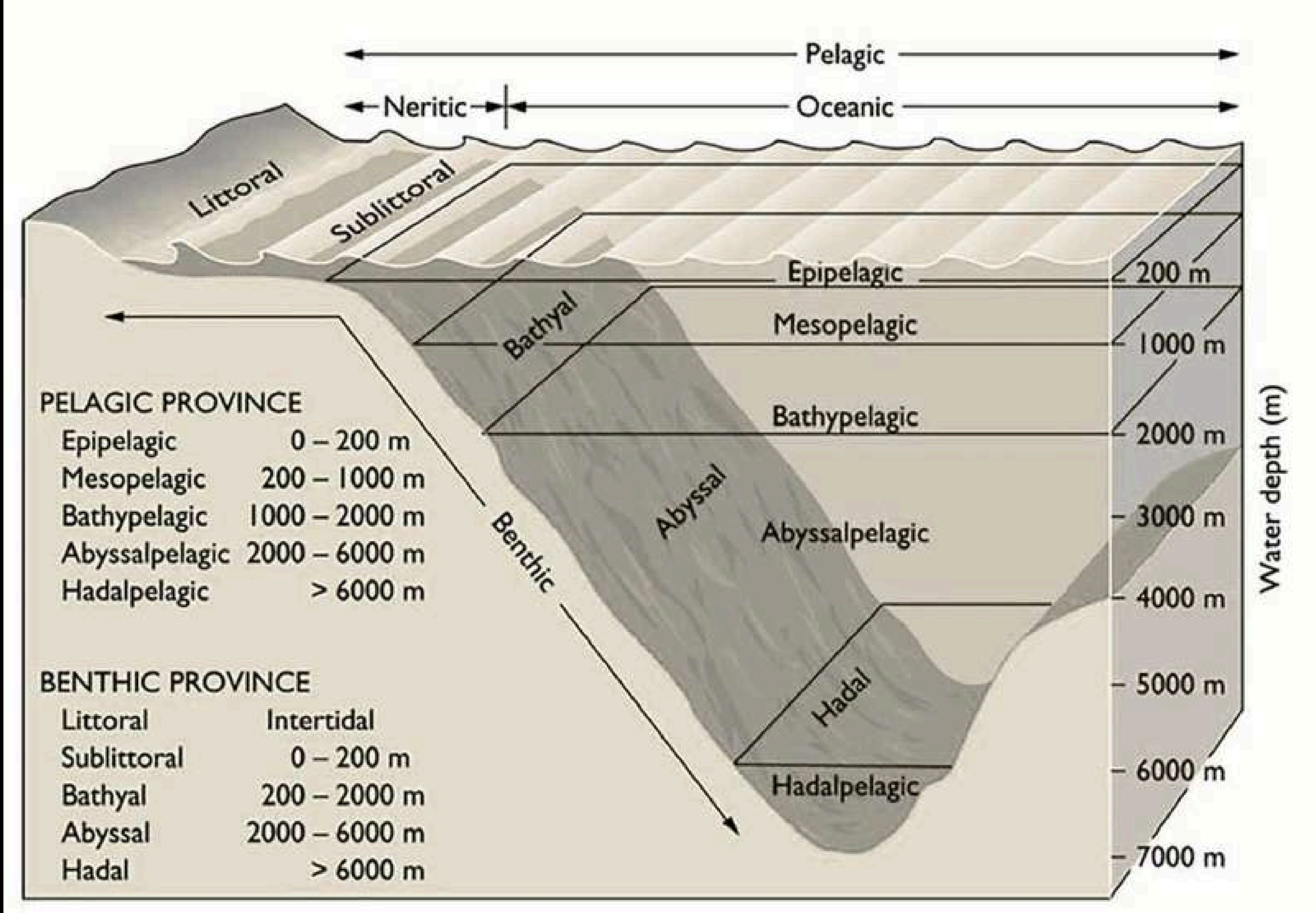
While diverse at the species level, freshwater fishes are less diverse at higher taxonomic levels that marine fishes. Almost 90% of freshwater fish species are found in just eight orders: carps, minnows and loaches (Cypriniformes), catfishes (Siluriformes),characins and tetras (Characiformes), cichlids (Cichliformes), toothcarps and killifishes (Cyprinodontiformes), gobies (Gobiiformes), perch-like fishes (Perciformes), and bettas and gouramis (Anabantiformes).

DIRECTION

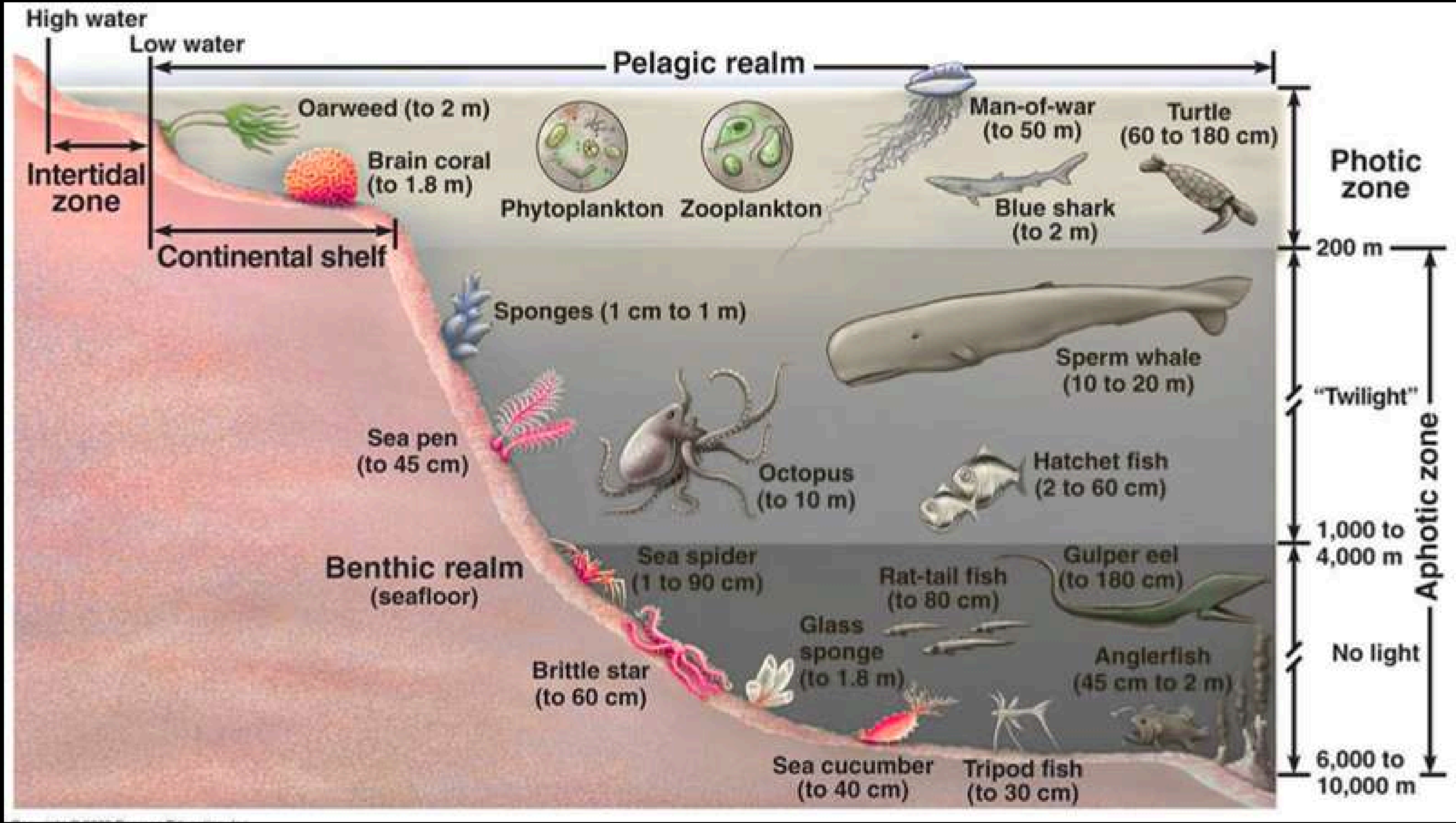
Salt Water Ecosystems

Saltwater ecosystems contain an array of aquatic and subaquatic organisms. The larger of the aquatic ecosystems, saltwater ecosystems have several different zones, or habitats, which include the intertidal zone, pelagic zone, benthic zone, and abyssal zone.

- The intertidal zone is a shallow region where the tide meets the land. Organisms such as crabs, mussels, seaweed, and barnacles live in the intertidal zone.
- The pelagic zone is part of the open ocean upper region, which is where most swimming fish, or nektons, live. Turtles, whales, and sharks also live in this zone.
- The benthic and abyssal zones are part of the open ocean lower region, which is the darkest, coldest area of the ocean. The benthic zone is populated by benthos, or bottom dwellers, such as eels, shrimp, and lobster. Other organisms found in the benthic zone include bacteria, fungi, sponges, sea anemones, and worms. Bottom dwellers eat algae and decayed matter off the ocean floor.
- Just beneath the benthic zone is the abyssal zone, the deepest region of the ocean. The water in this zone is only around three degrees Celsius and highly pressurized. Unlike the benthic zone, the abyssal zone is nutrient-deficient, so very few organisms live there.


Pelagic
Neritic
Oceanic
Littoral
Sublittoral
Epipelagic
200 m
Mesopelagic
1000 m
Bathyal
Bathypelagic
2000 m
Abyssal
Abyssalpelagic
3000 m
Benthic
4000 m
Hadal
5000 m
6000 m
Hadalpelagic
7000 m
Water depth (m)
PELAGIC PROVINCE
Epipelagic 0 – 200 m
Mesopelagic 200 – 1000 m
Bathypelagic 1000 – 2000 m
Abyssalpelagic 2000 – 6000 m
Hadalpelagic > 6000 m
BENTHIC PROVINCE
Littoral Intertidal
Sublittoral 0 – 200 m
Bathyal 200 – 2000 m
Abyssal 2000 – 6000 m
Hadal > 6000 m

DIRECTION



High water
Low water
Pelagic realm
Intertidal zone
Continental shelf
Oarweed (to 2 m)
Brain coral (to 1.8 m)
Phytoplankton
Zooplankton
Man-of-war (to 50 m)
Turtle (60 to 180 cm)
Blue shark (to 2 m)
Photic zone
200 m
Sponges (1 cm to 1 m)
Sperm whale (10 to 20 m)
"Twilight"
Sea pen (to 45 cm)
Octopus (to 10 m)
Hatchet fish (2 to 60 cm)
Aphotic zone
1,000 to 4,000 m
Benthic realm (seafloor)
Sea spider (1 to 90 cm)
Rat-tail fish (to 80 cm)
Gulper eel (to 180 cm)
Glass sponge (to 1.8 m)
Brittle star (to 60 cm)
Anglerfish (45 cm to 2 m)
No light
Sea cucumber (to 40 cm)
Tripod fish (to 30 cm)
6,000 to 10,000 m

DIRECTION

Hydrothermal vents

Hydrothermal vents are like geysers, or hot springs, on the ocean floor.Hydrothermal vent structures are characterized by different physical and chemical factors, including the minerals, temperatures, and flow levels of their plumes.

Black smokers emit the hottest, darkest plumes, which are high in sulfur content and form chimneys up to 18 stories tall, or 55 meters (180 feet).

The plumes of white smokers are lightly colored and rich in barium, calcium, and silicon. Compared to black smokers, white smokers usually emit cooler plumes and form smaller chimneys.

Vents with even cooler, weaker flows are often called seeps. They appear to shimmer because of differences in water temperatures or bubble because of the presence of gases, like carbon dioxide.

Hydrothermal bacteria are chemosynthetic microorganisms that thrive in the extreme, chemically rich environments of deep-sea hydrothermal vents, using chemical energy from compounds like hydrogen sulfide to produce organic matter instead of relying on sunlight

- Epsilonproteobacteria: A dominant group found in the mixing zones where hydrothermal fluids meet seawater.

- Zetaproteobacteria: Iron-oxidizing bacteria frequently found at hydrothermal vents.

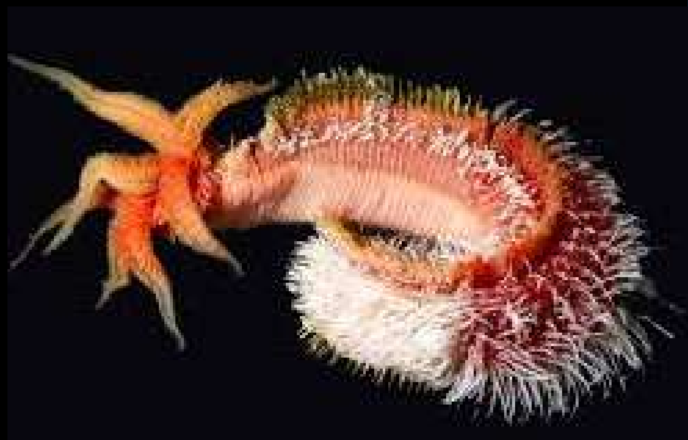
- Sulfur-oxidizing bacteria: These bacteria utilize the abundant sulfide from hydrothermal vents.

- Gammaproteobacteria: Another common group, often involved in iron oxidation.

- *Archaebacteria (now Archaea) are ancient, single-celled microorganisms adapted to extreme environments like hot springs and salt lakes*
- *Eubacteria (true bacteria) are a diverse group found in almost every environment*

DIRECTION

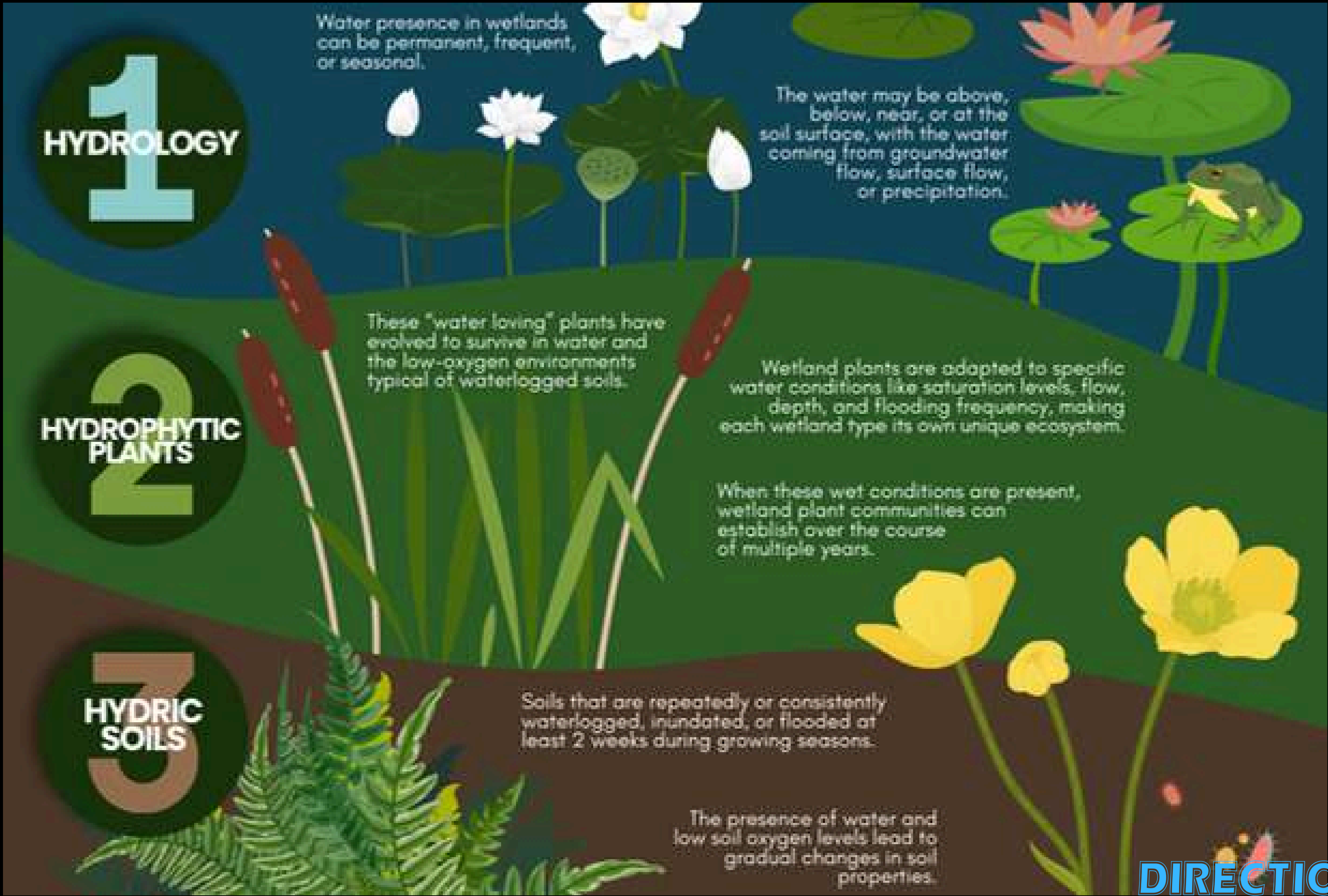
Hydrothermal vent ecosystems feature unique animals such as tube worms, mussels, shrimp, crabs, and fish, all adapted to extreme environments using chemosynthesis, a process where bacteria convert chemicals into energy. Examples include giant tube worms, Yeti crabs, and heat-tolerant Pompeii worms.



DIRECTION

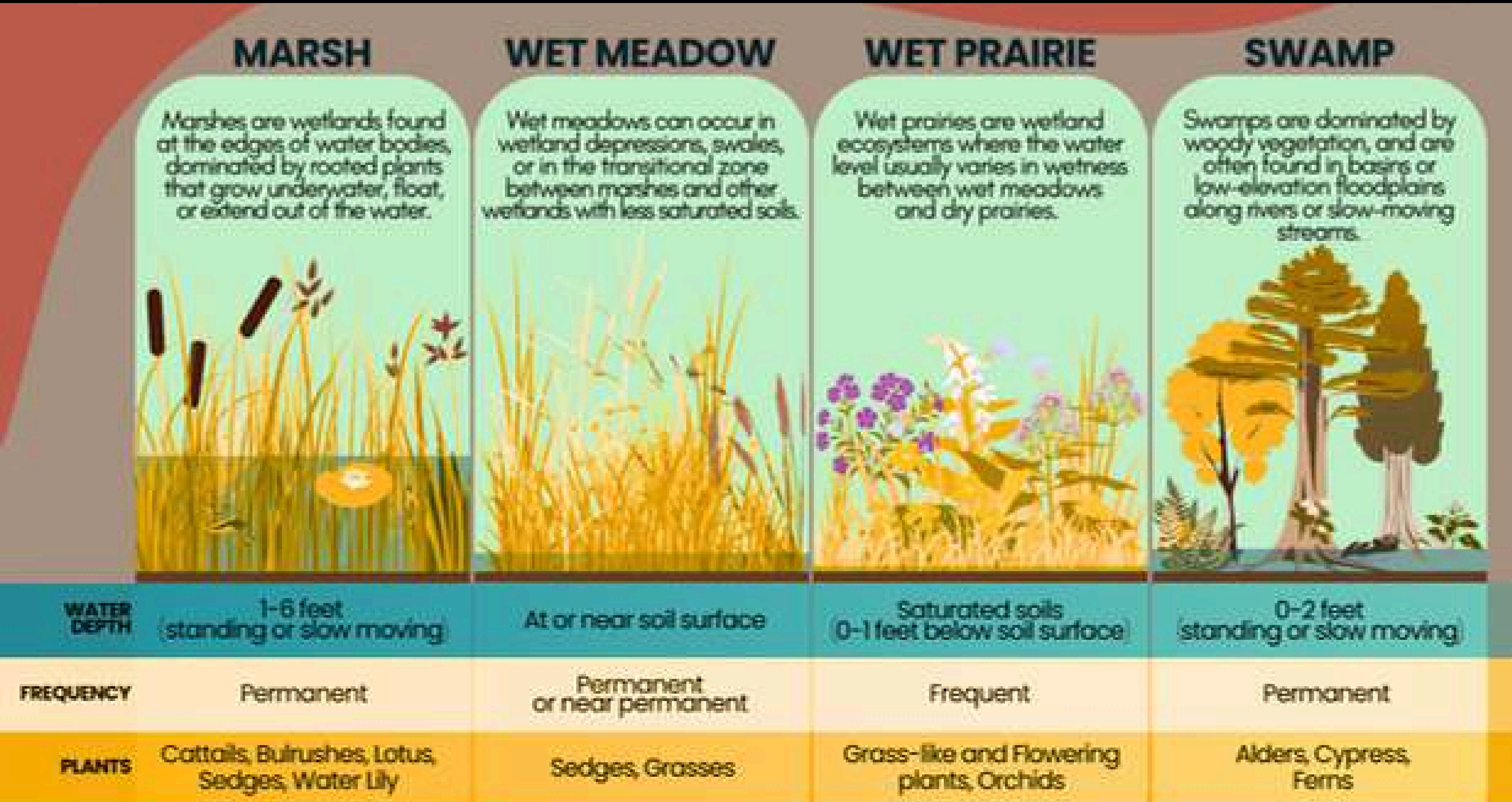
Locations of Hydrothermal Vents

Wet Lands



HYDROLOGY
Water presence in wetlands can be permanent, frequent, or seasonal.
The water may be above, below, near, or at the soil surface, with the water coming from groundwater flow, surface flow, or precipitation.
HYDROPHYTIC PLANTS
These "water loving" plants have evolved to survive in water and the low-oxygen environments typical of waterlogged soils.
Wetland plants are adapted to specific water conditions like saturation levels, flow, depth, and flooding frequency, making each wetland type its own unique ecosystem.
When these wet conditions are present, wetland plant communities can establish over the course of multiple years.
HYDRIC SOILS
Soils that are repeatedly or consistently waterlogged, inundated, or flooded at least 2 weeks during growing seasons.
The presence of water and low soil oxygen levels lead to gradual changes in soil properties.

Types of Wet Lands



DIRECTION

	BOG	FENS & SEEPS	VERNAL POOL	PRAIRIE POTHOLE
	Bogs are isolated basin wetlands characterized by spongy peat-rich soils. They have nutrient poor, acidic waters with floating mats of vegetation that are fed by rainfall and snow melt.	Fens are peatlands that are fed by a calcareous groundwater source, resulting in an alkaline water chemistry. Seeps, or springs, are areas where the groundwater naturally comes to the surface at the base of slopes.	Vernal pools are shallow, isolated depressions that are filled each spring by rain and snow melt, then dry up since they are not connected to other water bodies. They serve as an essential breeding habitat for frogs and salamanders.	Prairie potholes are water-holding depressions of glacial origin. These isolated wetlands provide essential food and resting places to migrating waterfowl.
WATER DEPTH	Shallow lake basins	Saturated soils	0.5–3 feet	1-4 feet
FREQUENCY	Seasonal to Permanent	Seasonal to Permanent	Seasonal (Spring)	Seasonal to Permanent
PLANTS	Sphagnum Moss, Pitcher Plant, Tamarack, Cranberry	Sedges, Grasses, Orchids, Marsh Marigolds	Ferns, Irises, Mosses, Marsh Purslane	Water Lilies, Pondweeds, Bulrushes, Arrowhead

DIRECTION

UPSC 2025

EXAM!

UPSC 2024

49. Consider the following statements :

I. No virus can survive in ocean waters.

II. No virus can infect bacteria.

III. No virus can change the cellular transcriptional activity in host cells.

How many of the statements given above are correct?

(a) Only one

(b) Only two

(c) All the three

(d) None

18. Consider the following :

1. Carabid beetles

2. Centipedes

3. Flies

4. Termites

5. Wasps

Parasitoid species are found in how many of the above kind of organisms ?

(a) Only two

(b) Only three

(c) Only four

(d) All five

DIRECTION

Terrestrial Biomes

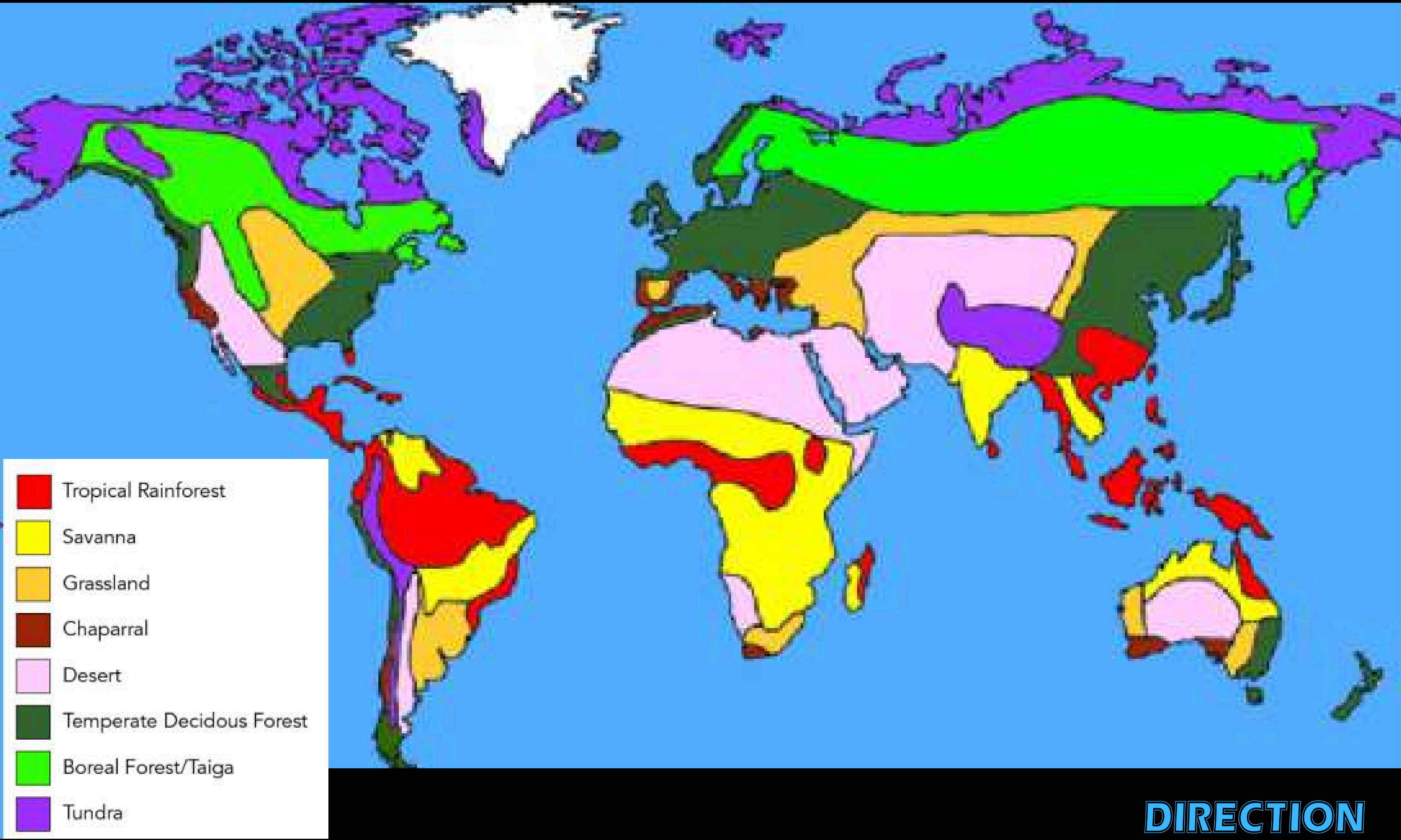
A terrestrial ecosystem is a land-based community of organisms and the interactions of biotic and abiotic components in a given area.

The type of terrestrial ecosystem found in a particular place is dependent on the temperature range, the average amount of precipitation received, the soil type, and amount of light it receives.

Examples of terrestrial ecosystems include the tundra, taigas, temperate deciduous forests, tropical rainforests, grasslands, and deserts.

DIRECTION

Examples of terrestrial ecosystems



DIRECTION

Tundra

The **Arctic tundra** is located between the north pole and the coniferous forests or taiga region. It is characterized by extremely cold temperatures and land that remains frozen year-round. Arctic tundra occurs in frigid mountaintop regions at exceptionally high elevations. **Alpine tundra** is found in high elevations worldwide, even in tropical regions. Although alpine tundra is not frozen year-round as in Arctic tundra areas, these lands are typically covered in snow for most of the year.

DIRECTION

Vegetation

Arctic tundra regions is limited due to dry conditions, poor soil quality, frigid temperatures, and permafrost. Arctic tundra plants must adapt to the cold, dark conditions of the tundra as the sun does not rise during the winter months.

In alpine tundra regions, unlike in the Arctic tundra, the sun remains in the sky for about the same amount of time throughout the year enabling vegetation to grow at a near-constant rate. Vegetation in these areas consists of short shrubs, grasses, and rosette perennials (i.e. lichens, mosses, sedges, perennial forbs, rosette, and dwarfed shrubs).

cotton grass of Alaska

DIRECTION

Lichen are non-destructive, living organisms composed of a fungus and algae living in a symbiotic relationship. In a symbiotic relationship, two organisms function in a way that is mutually beneficial. Because the algae derive nutrients through photosynthesis, and the fungi protect the algae from drying out, lichen can live and grow in extremely barren areas.

Mosses are non-vascular plants, able to colonize on hard, impervious surfaces such as bare rock and brick, as well as tree bark.

Moss and algae are primitive plants that derive nourishment through photosynthesis. Some algae may have a moist or slimy appearance. While they are both usually green, colors may range from blue-green to black.

Animals

DIRECTION

Large Arctic mammals, such as musk ox and caribou, are heavily insulated against the cold and migrate to warmer areas in the winter. Smaller mammals, like the Arctic ground squirrel, survive by burrowing and hibernating during the winter. Other Arctic tundra animals include snowy owls, reindeer, polar bears, white foxes, lemmings, Arctic hares, wolverines, caribou, migrating birds, mosquitoes, and black flies

Animals of the alpine tundra biome migrate to lower elevations in winter to escape the cold and find food. Animals in this biome include marmots, mountain goats, bighorn sheep, elk, grizzly bears, springtails, beetles, grasshoppers, and butterflies.

Only five amphibians and a single reptile species are found in the Arctic, as their cold-blooded nature makes it nearly impossible to survive in such low temperatures.

Arctic foxes

Caribou

Ptarmigans

Atlantic puffins

As temperatures drop and autumn gives way to the seemingly ceaseless snows of winter, some animals in northerly climes exchange their pelage or plumage of summer drab for the purest white

While camouflage is one evolutionary factor that has selected for seasonally white fur,pale coat may have better insulating properties—because melanin, the substance responsible for colored hair, is absent from white fur, leaving air spaces in the hair shaft.

Hares

Weasels

Peary Caribou

Siberian Hamsters

Ptarmigans

Collared Lemmings

Arctic Foxes

DIRECTION

Desert

1/5th of the earth’s land is covered with deserts. Every continent on this earth has a desert and every desert has its own ecosystem which is known as Desert ecosystem.

Deserts are extremely dry environments that are home to well-adapted plants and animals.

The main types of deserts include hot and dry deserts, semi-arid deserts, coastal deserts, and cold deserts.

Deserts usually get at most 50 centimeters (20 inches) of rainfall a year, and the organisms that live in deserts are adapted to this extremely dry climate.

DIRECTION

The four main types of desert include hot and dry deserts, semi-arid deserts, coastal deserts, and cold deserts.

In hot and dry deserts, also known as arid deserts, the temperatures are warm and dry year-round. Some famous arid deserts include the Sahara Desert that covers much of the African continent and the Mojave Desert located in the southwest of the United States.

Semi-arid deserts are a bit cooler than hot and dry deserts. The long, dry summers in semi-arid deserts are followed by winters with some rain. Semi-arid deserts are found in North America, Greenland, Europe, and Asia.

Coastal deserts are a bit more humid than other types of deserts. Although heavy fogs blow in from the coast, rainfall is still rare. The Atacama Desert of Chile in South America is an example of a coastal desert.

Cold deserts are still dry but have extremely low temperatures in comparison to the other types of deserts. The Antarctic is an example of a cold desert.

The plants can save water a few different ways: they can control the amount of water lost by transpiration, the amount they can get, or the amount they can store. If a plant has adaptations to help them deal with desert weather, we call them xerophytes, a word that means dry plants.

Cactus as Saguaros, the large cacti and other plants that store lots of water to help them through the dry seasons are called succulents. During even light rains, these plants soak up as much water as they can hold, storing the water in large storage areas in roots, leaves, or plant stems.

The sharp spines that you see on cactus and some other plants help shade the plant from the sun, keeping it cool. Certain plants like mesquite trees grow very long tap roots, reaching down over 100 feet to reach the groundwater, water stored deep

For some plants, one way to make sure to get enough water is to get rid of the competition—that is, nearby plants. A plant called creosote makes special chemicals, or toxins, that they release into nearby soil. These toxins make it difficult for other plants to grow in that soil. This trick is called allelopathy

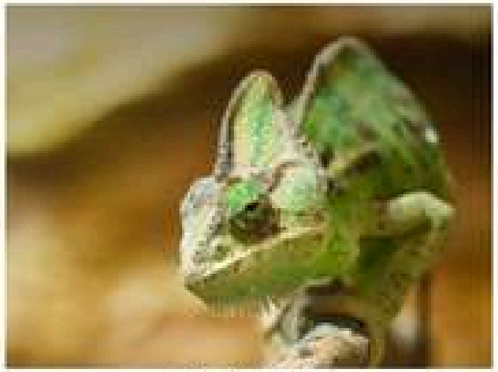
DIRECTION

Extreme temperatures create a challenge for the animals that live in the desert

In some deserts, animals depend on seasonal rain so they can store up enough water to last them through the dry seasons. The **Gila monster** and the **desert tortoise** both rest underground during much of the hot, dry summer and **they use their bladders to store water.**

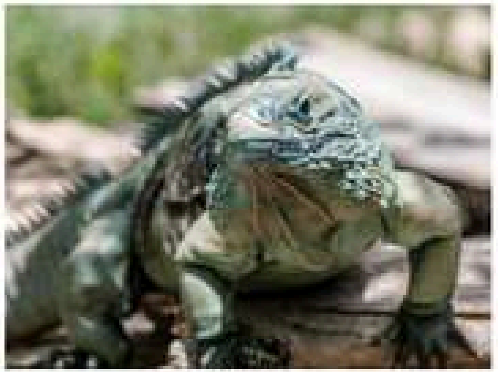
Reptiles

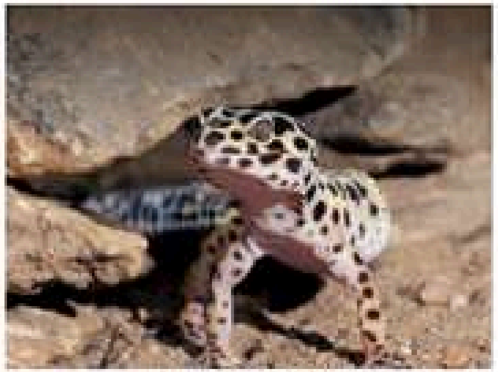

African Spurred Tortoise


Chameleon


Desert Tortoise

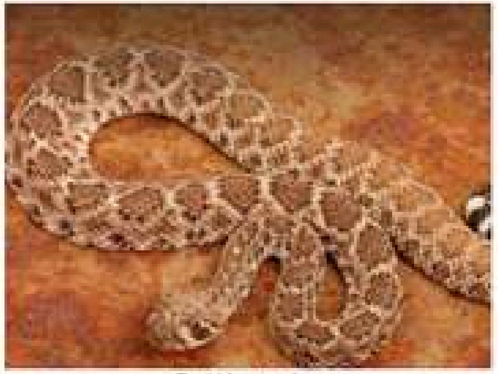

Gila Monster


Iguana

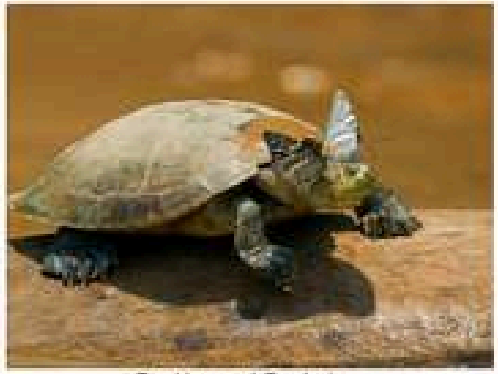

Leopard Gecko

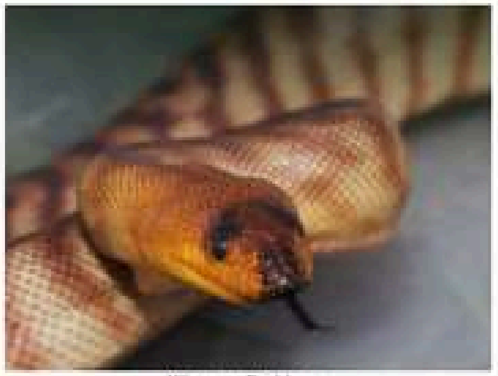

Lizard


Python


Rattlesnake

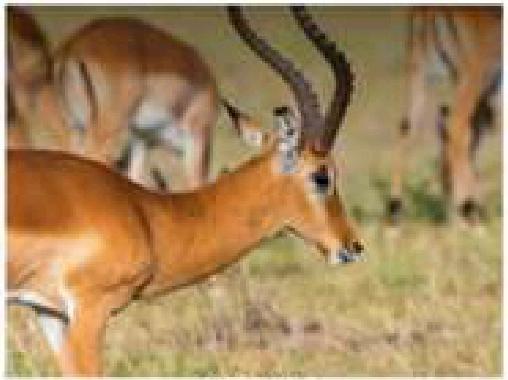

Snake

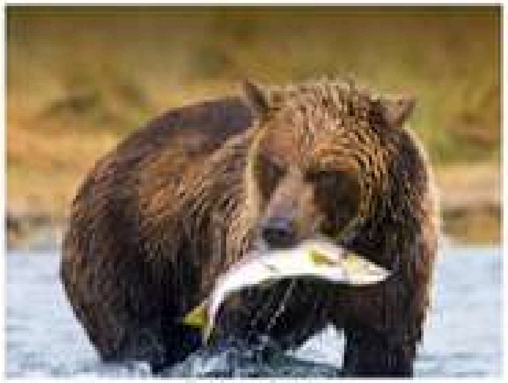

Turtle and Tortoise


Woma Python

DIRECTION

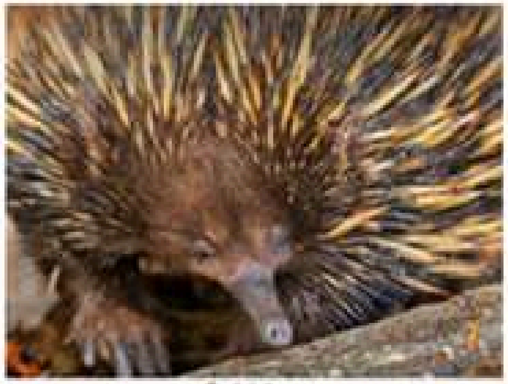
Mammals


Antelope


Brown Bear

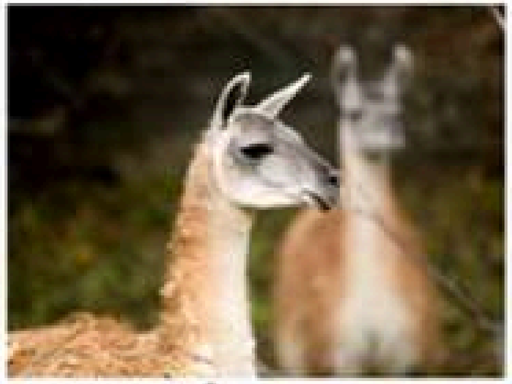

Camel


Caracal

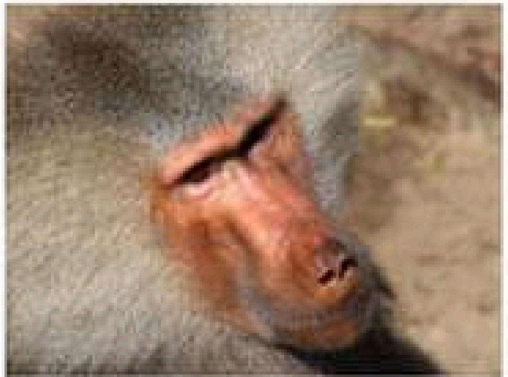

Echidna

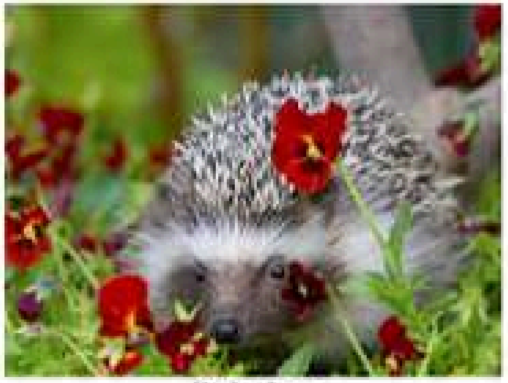

Fennec Fox

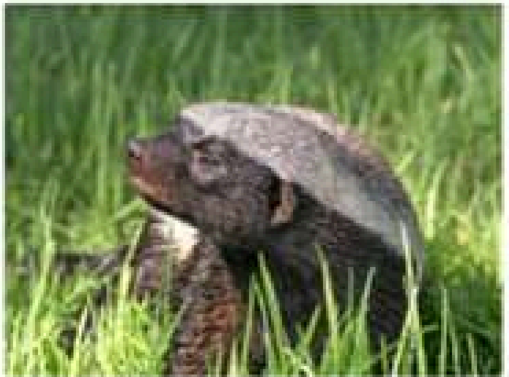

Goat and Sheep


Guanaco

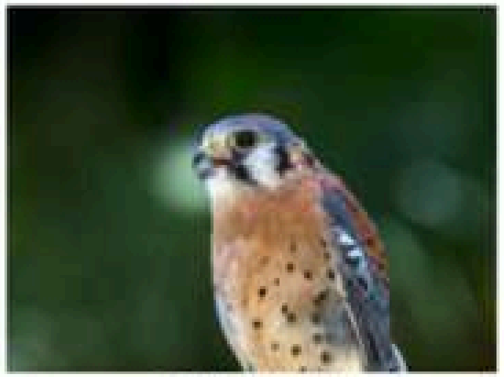

Gundi


Hamadryas Baboon

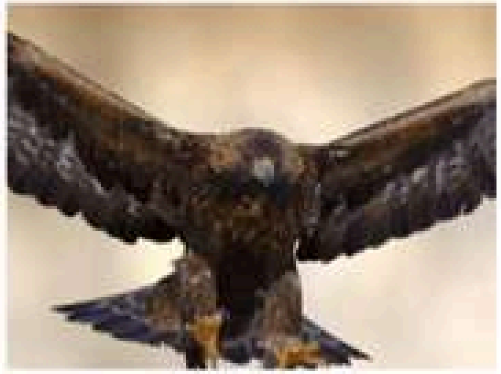

Hedgehog


Honey Badger (Ratel)

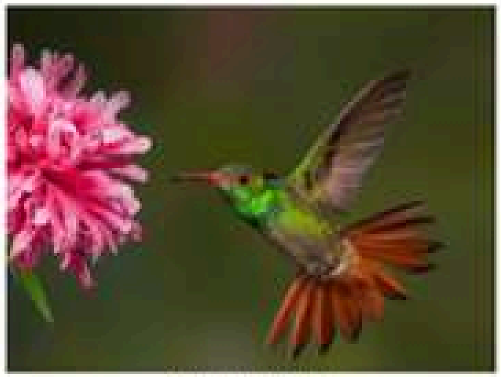
Birds



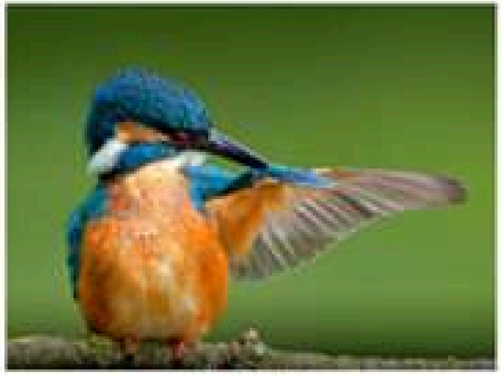
American Kestrel



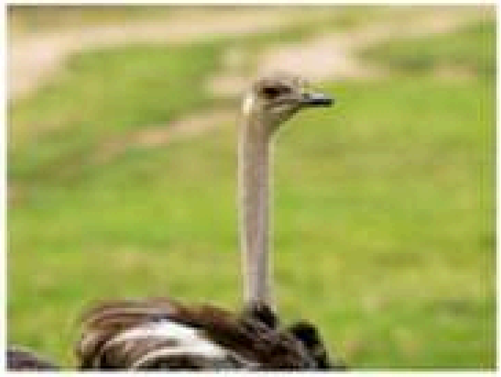
Golden Eagle



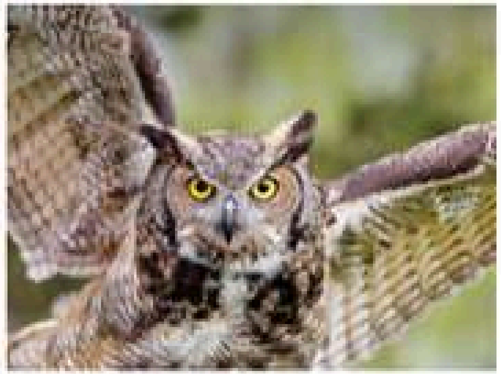
Hummingbird



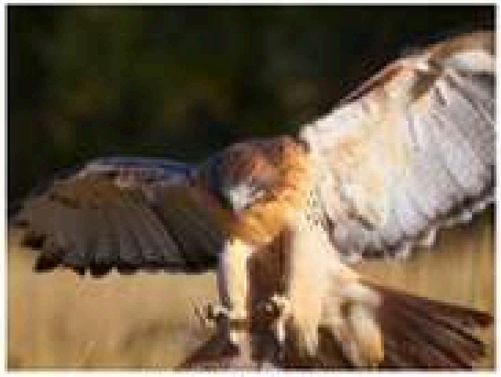
Kingfisher



Ostrich



Owl



Red-tailed Hawk

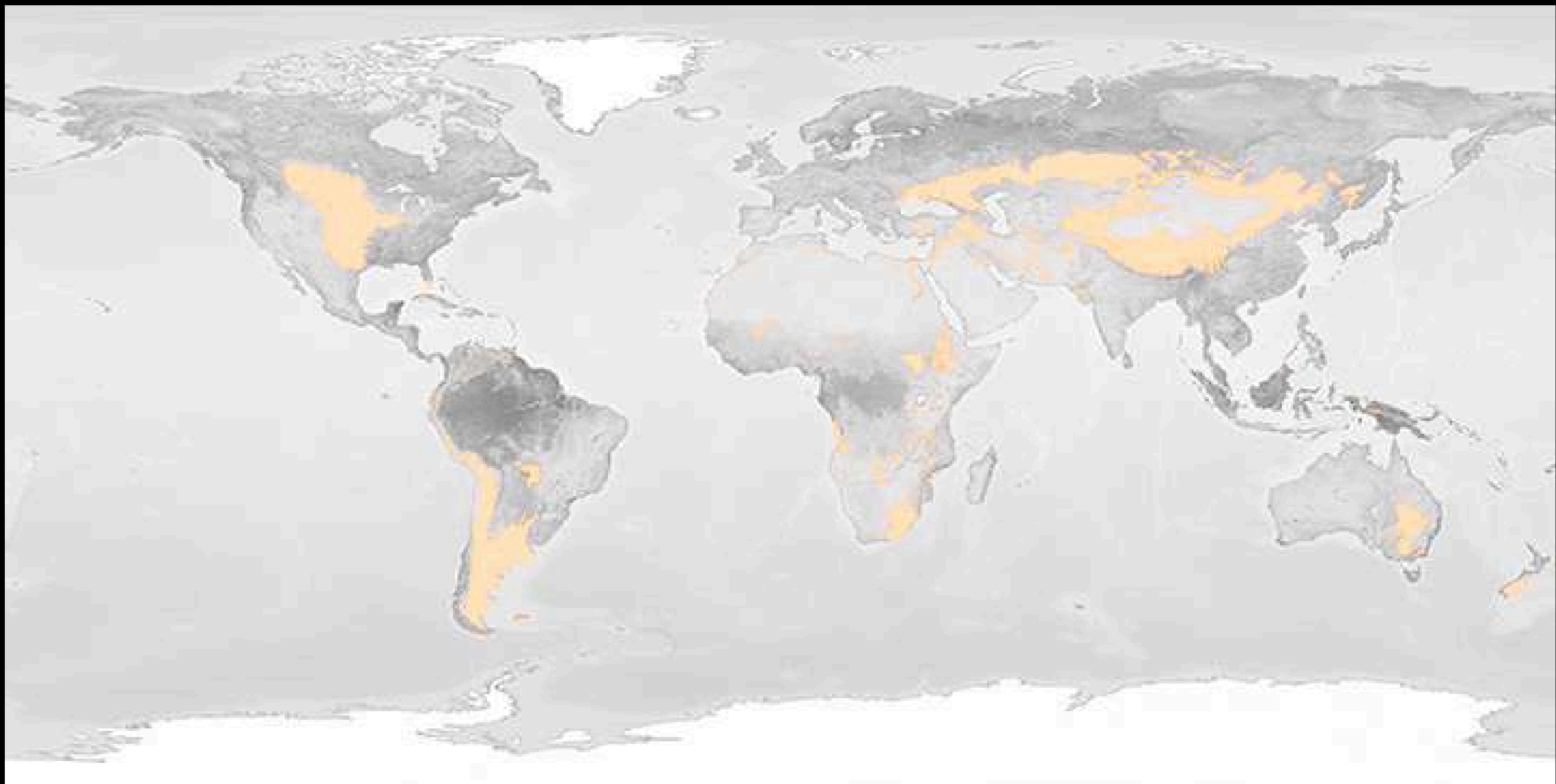
Sociable Weaver

DIRECTION

Grassland

Grasslands are found where there is not enough regular rainfall to support the growth of a forest, but not so little that a desert forms. In fact, grasslands often lie between forests and deserts.

Grasslands go by many names. In the United States Midwest, they're often called prairies. In South America, they're known as pampas. Central Eurasian grasslands are referred to as steppes, while African grasslands are savannas.



Location

There are Savannas around the world. There are five different types of savannas:

Tropical and subtropical savannas are near the equator. Tropical rainforests and deserts can be found around them (e.g., the Serengeti in Africa).

Temperate savannas are in mid-latitude regions (e.g., temperate savanna of Southeast Australia).

Mediterranean savannas are also in mid-latitude regions. Specifically in the Mediterranean (e.g., the Alentejo region in Portugal).

Flooded savannas are in the tropics (e.g., the Pantantal in South America).

Montane savannas are in high altitude regions (e.g., the mountains of Angola in equatorial Africa).

Plants

Most of the plants are tall and short grasses. There are also low-lying shrubs and some trees. Savannas are usually a transitional zone between a forest and a grassland. This means that savannas have trees, like in a forest. But unlike in a forest, in a savanna, grasses cover the ground.

Acacia Tree

Grass Types

- Red Oat Grass: (Themeda triandra): A common and conspicuous grass in African savannas.
- Rhodes Grass: (Chloris gayana): Another prevalent grass in tropical savannas.
- Star Grass: Found in the tropical savanna.
- Bermuda Grass: A common understory grass in African savannas.
- Spear Grass: (Heteropogon): A tall, dominant grass in Australian savannas.
- Kangaroo Grass: (Themeda triandra): A shorter grass that dominates Australian moist savannas.
- Spinifex: (Plectrachne, Triodia): Drought-resistant grasses found in more arid Australian savanna regions.
- Sehima: and Dichanthium: These grasses, along with thorny trees, are common in the Indian savanna.

Red Oat Grass:

Kangaroo Grass

Animals

Many types of grazing mammals are found in the savanna. Grazing animals are animals that eat grass.

Grazing animals live there because large amounts of grass covers the land. Zebras, wildebeests, elephants, giraffes, ostriches, gazelles and buffalo are all grazing animals. It is common to see groups, or herds, of grazing animals in the African savanna.

Hoofed animals, known as ungulates, are common. Ungulates include rhinoceroses, giraffes, camels, hippopotamuses and elephants. The biome of sub-Saharan Africa has the most ungulates on Earth.

gazelles

Meerkats

Wildebeests

DIRECTION

Marsupials dominate among the animals in this area of Australia. The animals include the Echidna, Eastern Gray Kangaroo, the Koala Agile and Whiptale Wallabies, Walaroos, Possums, Gliders, the Northern Qoull, and the Golden Bandicoot.

In the other parts of the tropical savanna, the reptiles dominate. The saltwater Crocodile, which is found here, is the world's largest reptile. It can grow to be from 7 to 8 meters long.

The vegetation in Australia differs from that of other Savannas. The acacia, part of the 1,200 members of the pea family, is the most common tree in other savannas. The acacia tree does grow in Australia but only in tropical and subtropical areas so, it's not the most common. Acacia's produce a gum called gum arabic, this is used in drugs, foods and others. The acacia's flowers are yellow or white and they grow in bundles.

The most common tree in Australia is the eucalyptus. They are famous for their oil, gum, and timber. The eucalyptus grows in warm climates and they are the most important tree for timber in Australia. The bark of some of these trees furnishes tannin, which is used in medicine

Brazilian Cerrado

The Cerrado is the world's most biologically rich savanna. It has over 10,000 species of plants, of which 45% are exclusive to the Cerrado, and it stretches across nearly 500 million acres of Brazil

The Brazilian Cerrado is home to diverse wildlife, including mammals like the Maned Wolf, Giant Anteater, Giant Armadillo, Jaguar, and Capybara; numerous bird species such as the Crested Caracara and various owls; various reptiles and amphibians, with many endemic species; and a high diversity of insects, like butterflies and termites

Black Jaguar

Giant Anteater

Tapir

Temperate grasslands

Temperate grasslands are characterized as having grasses as the dominant vegetation.
Trees and large shrubs are absent
The various species of grasses include purple needlegrass, blue grama, buffalo grass, and galleta. Flowers include asters, blazing stars, coneflowers, goldenrods, sunflowers, clovers, psoraleas, and wild indigos.
Temperate grasslands are home to many large herbivores. Some of these include bison, gazelles, zebras, rhinoceroses, and wild horses. Carnivores, like lions and wolves, are also found in temperate grasslands.
Other animals of this region include: deer, prairie dogs, mice, jack rabbits, skunks, coyotes, snakes, foxes, owls, badgers, blackbirds, grasshoppers, meadowlarks, sparrows, quails, and hawks.

American bison

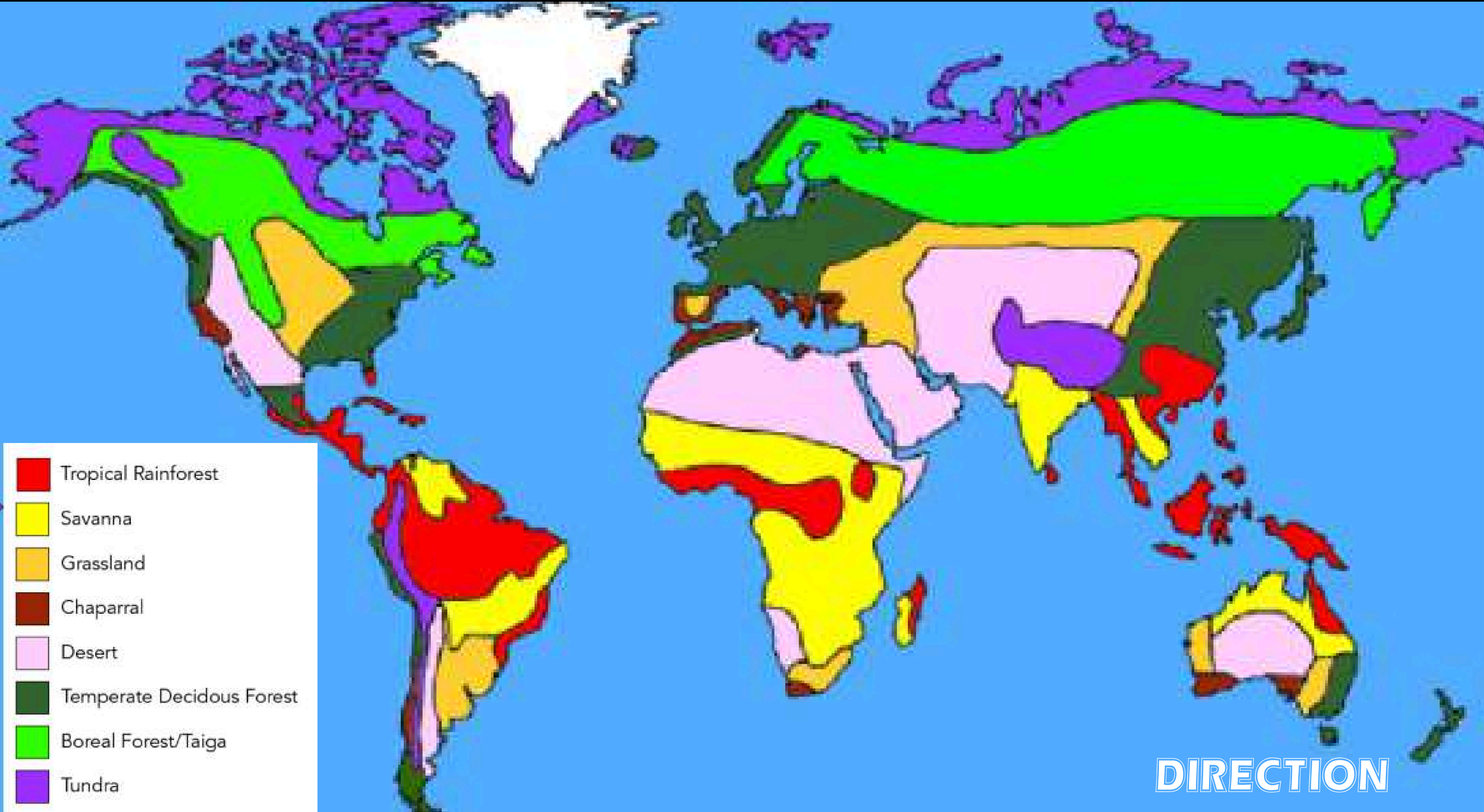
DIRECTION

Indian Bison, also known as Gaur (Bos gaurus), and are native to South and Southeast Asia, with about 85% of the global population residing in India. These large, wild bovines inhabit forests in regions like the Western Ghats, Eastern Ghats, Himalayan foothills, and Northeast India, and are a protected species under India's Wildlife (Protection) Act, 1972.

- **Largest Wild Cattle**: The Indian bison is the largest and tallest species of wild cattle in the world.
- Habitat: Gaurs prefer evergreen, semi-evergreen, and moist deciduous forests, particularly in hilly areas.
- Distribution in India: They are commonly found in the Western Ghats, such as in Nagarhole and Bandipur National Parks, and also in parts of the Eastern Ghats and Northeast India.

DIRECTION

forests occupy approximately **one-third of Earth's land area**, account for over two-thirds of the leaf area of land plants, and contain about **70% of carbon present in living things.**



The boreal forest covers about 11% of Earth's land mass. This makes it the world's largest terrestrial biome

Taigas are thick forests. Coniferous trees, such as spruce, pine, and fir, are common. Coniferous trees have needles instead of broad leaves, and their seeds grow inside protective, woody cones. While deciduous trees of temperate forests lose their leaves in winter, conifers never lose their needles. For this reason, conifers are also called "evergreens."

Plants in this biome have adaptations to the cold climate and poor soil. Many of the plants have shallow root systems. The roots work together with mycorrhizal fungi to get the most nutrients they can from the soil.

Southern boreal forests have a thick tree canopy . This is called a closed canopy forest. In the clearings between trees grow shrubs and wildflowers.

Northern boreal forests have trees which are more spread apart. This is called the lichen woodland. Here, lichens form most of the ground cover. There are also many kinds of mosses.

The boreal forest of the Eastern Siberian taiga is basically one large larch forest. Larch trees don't follow the common evergreen rule.

DIRECTION

Animals

The animal life in the boreal forest is adapted to the cold climate. There are large herbivores in Canadian boreal forests. This includes caribou, moose, elk and wood bison. Outside of North America, the name for caribou is reindeer. Wood bison are also called wood buffalo.

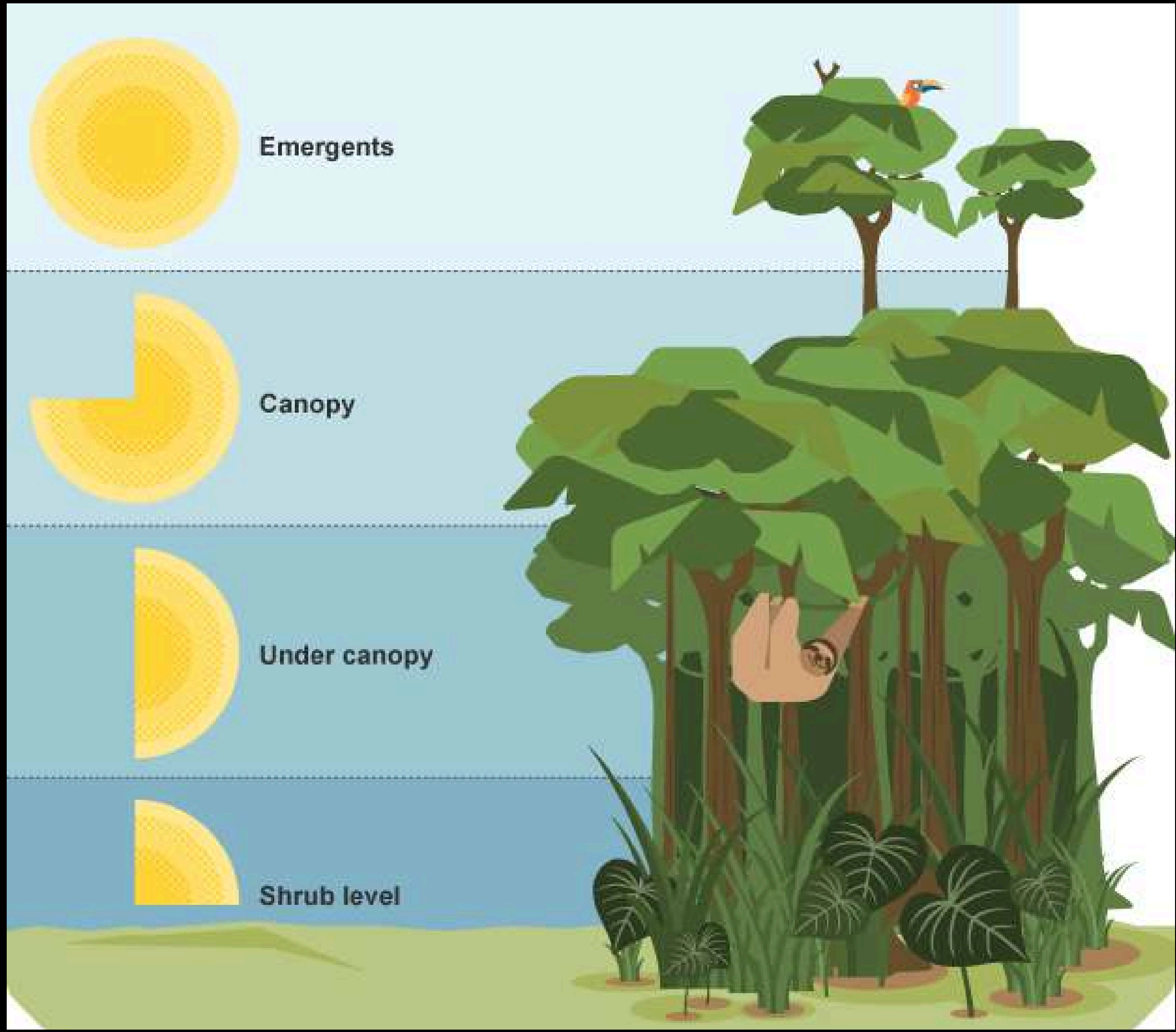
Woodland caribou have antlers for several reasons: male antlers are used to compete for mates during the fall breeding season, while female antlers serve as a defense mechanism to protect their food sources and young, especially in competitive winter environments. This makes caribou unique among deer species, as both males and females grow antlers.

DIRECTION

Large predators found here include the Canada lynx, gray wolf, black bear and brown bear.

DIRECTION

Equatorial rainforest ecology is defined by high biodiversity supported by a hot, wet climate that creates dense, layered forests with a dense canopy. These ecosystems are characterized by rich flora, including evergreen trees and epiphytes, and diverse fauna like primates, large mammals, and countless insects. A key ecological feature is the complex web of interdependence and a rapid but fragile nutrient cycle, where soils are nutrient-poor but are nourished by the fast decomposition of organic matter



DIRECTION

Equatorial rainforests contain an enormous variety of plants and animals – approximately 90 per cent of all of the world's species. Vegetation is dense and occurs in four main layers:

The forest floor/shrub layer. This area is dark as trees block out most of the sunlight. The forest floor is covered in a thick blanket of dead and decaying roots and leaves, known as humus. A little vegetation can grow between the trees if it is able to trap sunlight. This area is prone to flooding during torrential rainfall.

The under canopy is the layer above the forest floor. This area is shady and cooler. As there is very limited sunlight, seedlings lie dormant until larger plants and trees die. The gap that is left in the canopy is quickly filled as new plants grow into it. Lianas, or vines, take root in the ground and climb up trees to reach the sunlight.

The canopy is the continuous layer of tree tops that is more sheltered. The trees are normally 20 to 40 metres tall. This leafy location with fruit all year round is the habitat for most wildlife including insects, tree snakes, birds and some mammals, eg howler monkey, jaguar and sloth.

The emergent layer consists of the tallest trees in the rainforest and they can grow up to 60 metres. They are higher because they are able to trap more sunlight to help them make more food to grow. Emergent trees are supported by buttress roots which prevent them from blowing over in high winds.

Each one has adapted to rainforest conditions in a different way.
Fan palms have large, fan-shaped leaves. This feature is good for trapping sunlight and water. The leaves have segments, so excess water can drain away preventing its weight from breaking them.
Many tropical rainforest trees have developed huge buttress roots. These extend from the forest floor to two metres or more up the trunk and help to anchor the tree to the ground.
Buttress roots are essential as rainforests have a shallow layer of fertile soil, so trees only need shallow roots to reach the nutrients. However, shallow roots can't support huge rainforest trees, so they have grown buttress roots to support them.
Lianas are vines that grow up from the forest floor and use trees to climb up to the canopy, where they spread from tree to tree to get as much sunlight as possible.
Strangler figs start at the top of a tree and work their way down. The seed is dropped in a nook at the top of a tree and starts to grow, using the debris collected there as nourishment. Gradually the fig sends aerial roots down the trunk of the host tree, until they reach the ground and take root.
As it grows, the fig tree will slowly surround the host, criss-cross its roots around the trunk and start to strangle it. The fig's branches will grow taller to catch the sunlight and hostile roots deprive the host tree of nutrients. Eventually the original tree will die and decompose leaving the hollow but robust trunk of the strangler fig.

River Animals

DIRECTION

Who Lives on the Forest Floor?

DIRECTION

Who Lives in the Understory?

Who Lives in the Canopy Layer?

DIRECTION

Who Lives in the Emergent Layer?

BLUE MORPHO BUTTERFLY


Camouflage
Mimicry
Limited Diet
Poisonous
TOP 7 TROPICAL RAINFOREST ANIMAL ADAPTATIONS
Reduction In Size
Nocturnality
Changing of habitats
DIRECTION

The first and most common animal adaptation in a tropical rainforest is camouflage. For an animal to successfully exhibit this adaptation, it needs not only to have a color that will help it blend into the environment but also a shape that is unrecognizable by its predator.

- One good example of an animal practicing camouflage is the Green-eyed tree frog (Litoria genimaculata). This frog has developed flaps of textured skin around its body to resemble the barks of trees on its life.
- Another similar example is the Leaf-tailed Gecko (Phyllurus cornutus), which exhibits camouflage by having skin similar to tree bark covered with moss.
- Another good example is the young Southern Cassowary (Casuarius casuarius) which has an overall plumage color of light brown with stripes of black. Such adaptation helps the cassowary to blend in with the vegetation it lives on. During adulthood, the cassowary becomes fully black.

DIRECTION

With the very dense vegetation and little amount of sunlight that can pass through the tree canopies, animals can easily hide in the rainforest. But instead of hiding, some animals resort to the adaptation called mimicry, where they tend to look like something that is intended to be seen (and not hidden like camouflage).

While seemingly alike at first glance, one major difference between camouflage and mimicry is that the latter does not only involve the resemblance to the physical appearance but also to the behavior of other larger and more fearful organisms.

An example of the animal exhibiting mimicry is a katydid (Aganacris pseudosphex), which not only appears like a stinging wasp but also behaves like it. Unlike the wasp with a venomous sting, the katydid is a harmless relative of grasshoppers and knows nothing about the venomous sting investments of a wasp.

DIRECTION

The rainforest is exceedingly full of natural resources, but the competition for these is also great. To avoid such competition, some animals have developed an adaptation wherein they reduce the choice of food they consume.

Most of the animals that have reduced their diet are the bird species. The Toucans only consume fruits that other animal and even bird species cannot access. Along with this adaptation, their beak had to become long and narrow to open these fruits.

Another example is the Leaf Cutter ants , which are known for their ability to carry objects that are multiple times heavier than their bodies. Every day, they carry pieces of leaves from the high trees to their habitats underground. They bury these underneath the ground and consume the fungi that arise as the leaves decompose.

DIRECTION

Aside from the production of poison per se, some tropical rainforest animals tend to have bright colors and distinct patterns to scare their predators.

Poison dart frogs come in very bright colors of yellow, red, green, and blue adorned with spots and swirl patterns. These bright colors indicate to predators that they need to stay away, or they will be poisoned. Interestingly, though, some dart frogs are not at all poisonous, but they remain unharmed because they look like their poisonous relatives.

Lobster moths also exhibit this adaptation by looking like venomous scorpions during their larval stage. They have patterns in their wings that look like eyes, keeping them unharmed.

DIRECTION

Despite being huge in terms of area, the tropical rainforest only favors smaller animals because its understory (the layer above the forest floor) is so dense that it makes large movements hard to execute. Hence, animals adapt to this by reducing their body size and stature.

In a tropical rainforest, the jaguar , the world's largest species of cat, tends to grow only less than six feet long and weighs just about 200 pounds. Such a small build allows it to acquire the speed needed to hunt for food.

However, snakes are an exception to this rule. Snakes in tropical rainforests can grow larger than anywhere else because they can fit in the spaces between trees and underground. Tropical rainforest snakes can grow up to 20 to 30 feet long

DIRECTION

Another adaptation developed by rainforest animals is nocturnality. Nocturnal (unlike diurnal) animals are active at night and usually asleep or resting during the day.

The bearded pig is a dark brown pig with a beard and somewhat resembles an Airedale terrier. While normally active during the day, pigs of these species resort to nocturnality when they migrate within the tropical rainforest. When they do this, they usually travel in groups (called herds) on the forest floor.

On the other hand, from a predator's point of view, nocturnalityprovides a great advantage for food that seems to be nowhere during daytime (i.e., other nocturnal worms and mammals). Also, nocturnality reduces competition, as most predators hunt during the day.

The tropical rainforest is home to numerous towering trees. Hence, to use this great advantage, some animals climb the canopies and live there.

One example of this adaptation is the spider monkeys that have chosen to live at the tree canopies to avoid great competition in the under-story. These monkeys have developed tails capable of grasping, allowing them to swing freely among trees. Sloths that live by hanging upside down from high branches of trees are also an example.

The rule of changing habitats is for animals to maximize their protection from predators and limit the competition for food.

DIRECTION

Deciduous forest, vegetation composed primarily of broad-leaved trees that shed all their leaves during one season.

Deciduous forest is found in three middle-latitude regions with a temperate climate characterized by a winter season and year-round precipitation: eastern North America, western Eurasia, and northeastern Asia. Deciduous forest also extends into more arid regions along stream banks and around bodies of water.

Oaks, beeches, birches, chestnuts, aspens, elms, maples, and basswoods (or lindens) are the dominant trees in mid-latitude deciduous forests.

They vary in shape and height and form dense growths that admit relatively little light through the leafy canopy.

Shrubs are found primarily near clearings and forest edges, where more light is available, and herbaceous flowering plants are abundant within the forest in the spring, before the trees come into full leaf.

Snails, slugs, insects, and spiders are common inhabitants of the deciduous forest, and many cold-blooded vertebrates, such as snakes, frogs, salamanders, and turtles, are also present.
Birds are represented by warblers, flycatchers, vireos, thrushes, woodpeckers, hawks, and owls. Prominent mammals include mice, moles, chipmunks, rabbits, weasels, foxes, bears, and deer.

CHAPARRAL BIOME:

The Chaparral biome is home to a diverse array of plant species, each uniquely adapted to the region’s Mediterranean climate and soil conditions.

Plant communities in the Chaparral biome consist of a variety of species adapted to the region’s Mediterranean climate and dry, nutrient-poor soils. Here are some examples of plant communities commonly found in the Chaparral biome:

Manzanita
Sagebrush
Scrub Oak
California Lilac

UPSC **PRELIMS**

Biodiversity

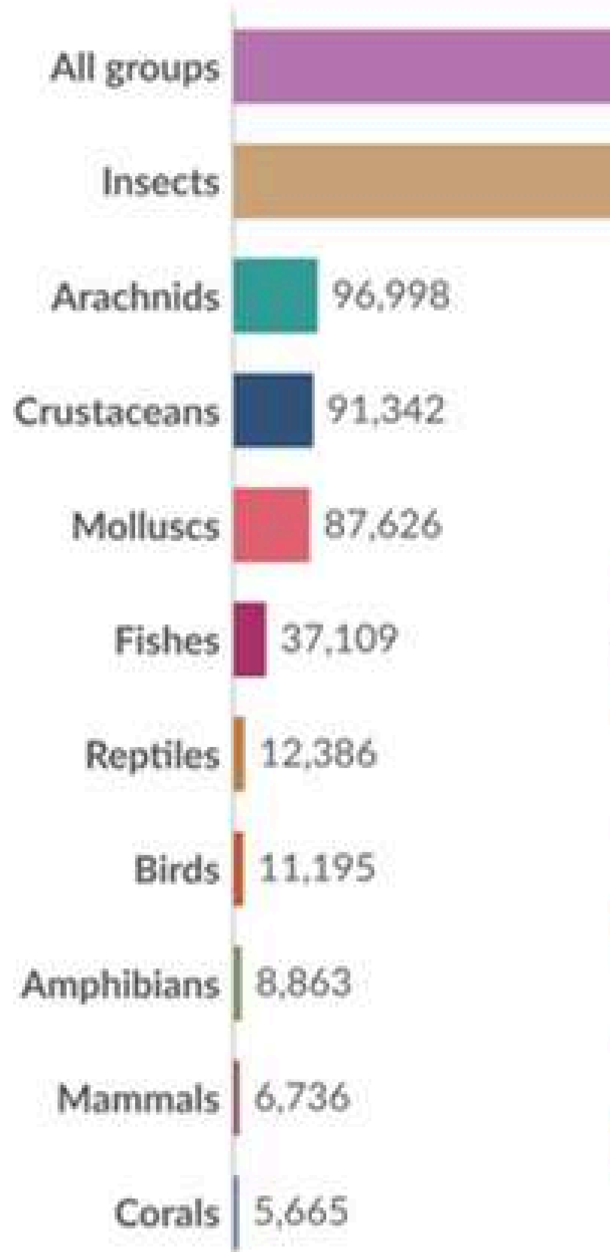
Biodiversity is the variety of life on Earth, encompassing the diversity of species, genetic variations within those species, and the ecosystems they form. It is a term that includes all living organisms, from plants and animals to microorganisms, and the complex interactions between them and their habitats.

- **Species diversity:**
  The variety of different species in a given area, from the number of species to their relative abundance.
- **Genetic diversity:**
  The variation of genes within a single species, which is crucial for adaptation and survival.
- **Ecosystem diversity:**
  The variety of different ecosystems in a geographical area, such as forests, wetlands, and deserts.

DIRECTION

Number of described species

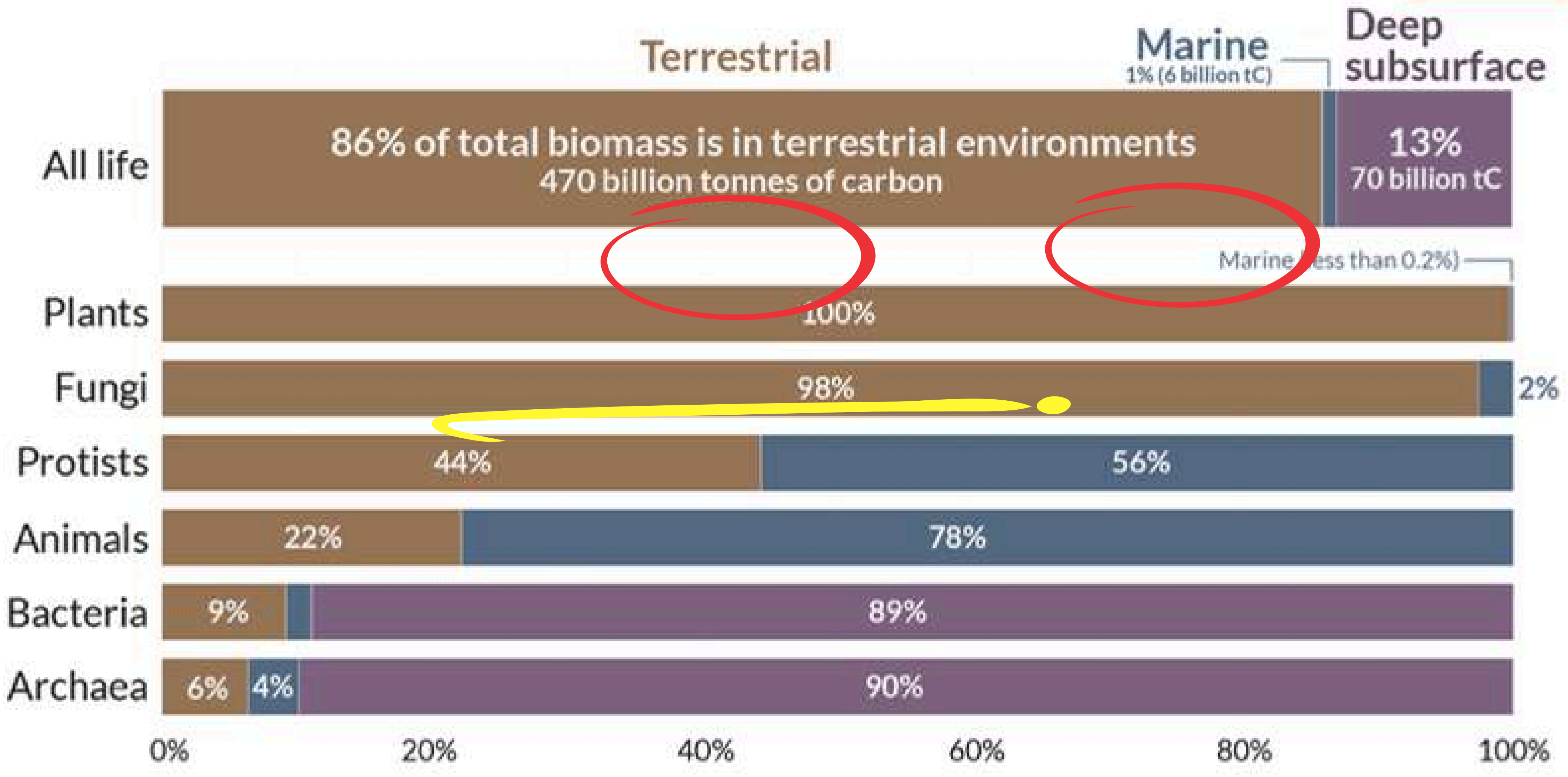
The number of identified and named species in each taxonomic group[1]. Since many species have not yet been described, this is a large underestimate of the total number of species in the world.



DIRECTION

There are an estimated 8.7 million species on Earth

86 Percent of Earth's Species Still Unknown?



Terrestrial
Marine
1% (6 billion tC)
Deep subsurface
All life
86% of total biomass is in terrestrial environments
470 billion tonnes of carbon
13%
70 billion tC
Marine (less than 0.2%)
Plants
100%
Fungi
98%
2%
Protists
44%
56%
Animals
22%
78%
Bacteria
9%
89%
Archaea
6%
4%
90%
0%
20%
40%
60%
80%
100%

DIRECTION

Most of life exists on land **86% of biomass.**

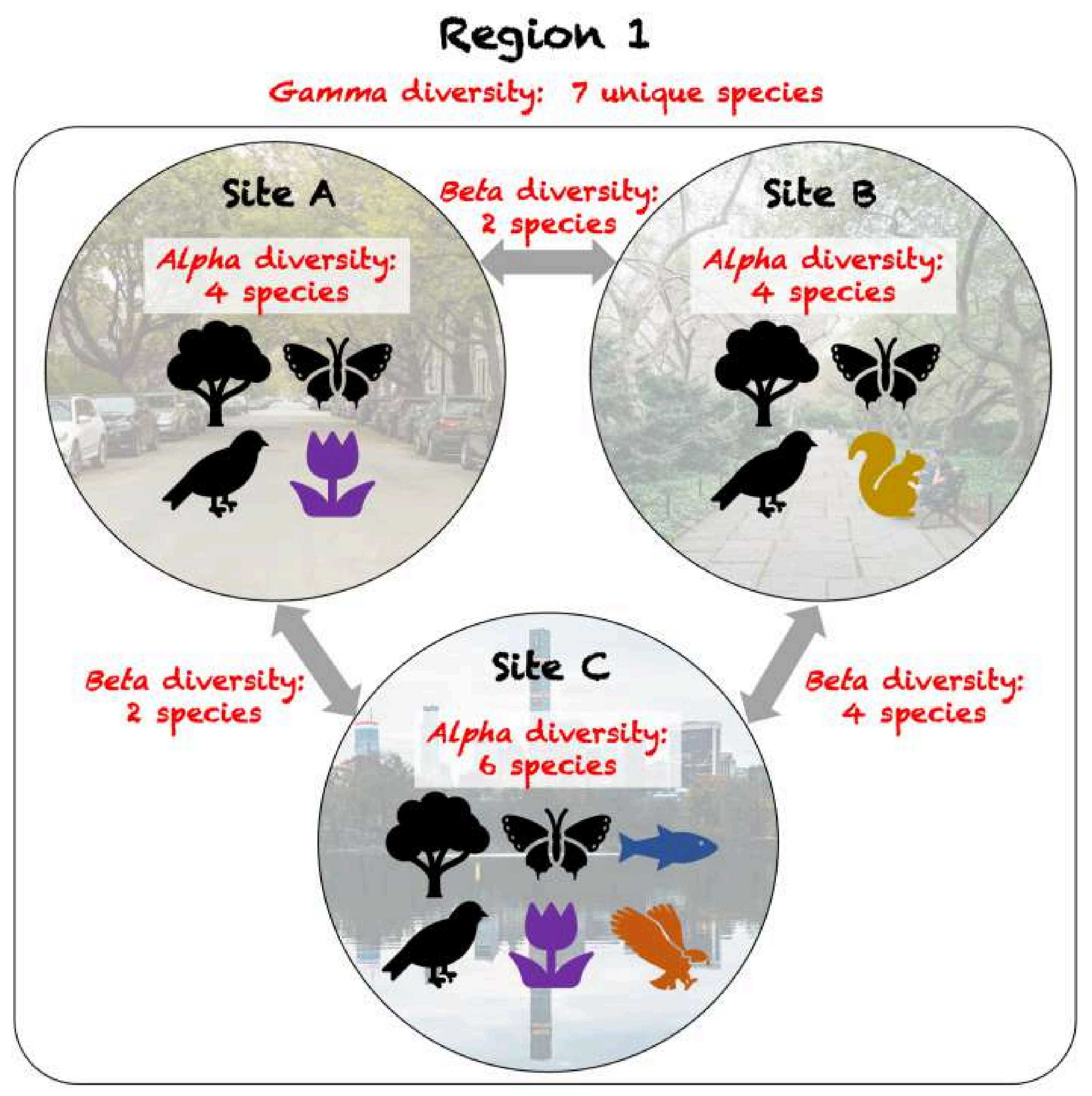
- This is because almost all plant life – mostly trees – is terrestrial. The marine plants, for example seaweed, make up less than 1 billion tonnes of carbon. This is less than 0.2% of total plant biomass.
- Most bacteria and archaea exists in the deep subsurface, meaning 13 percent of global biomass thrives in this environment.
- Despite dominating our planet in terms of area and volume – taking up more than 70% of global surface area – the oceans are home to just 1% of biomass.

But they do dominate the animal kingdom: 78% of animal biomass lives in the marine environment.

DIRECTION

Species diversity

Alpha, beta, and gamma diversity are measures of biodiversity across different scales:
alpha diversity is the species richness within a single habitat, **beta diversity** measures the change in species composition between different habitats, and **gamma diversity** is the total species richness across a larger region that includes multiple ecosystems



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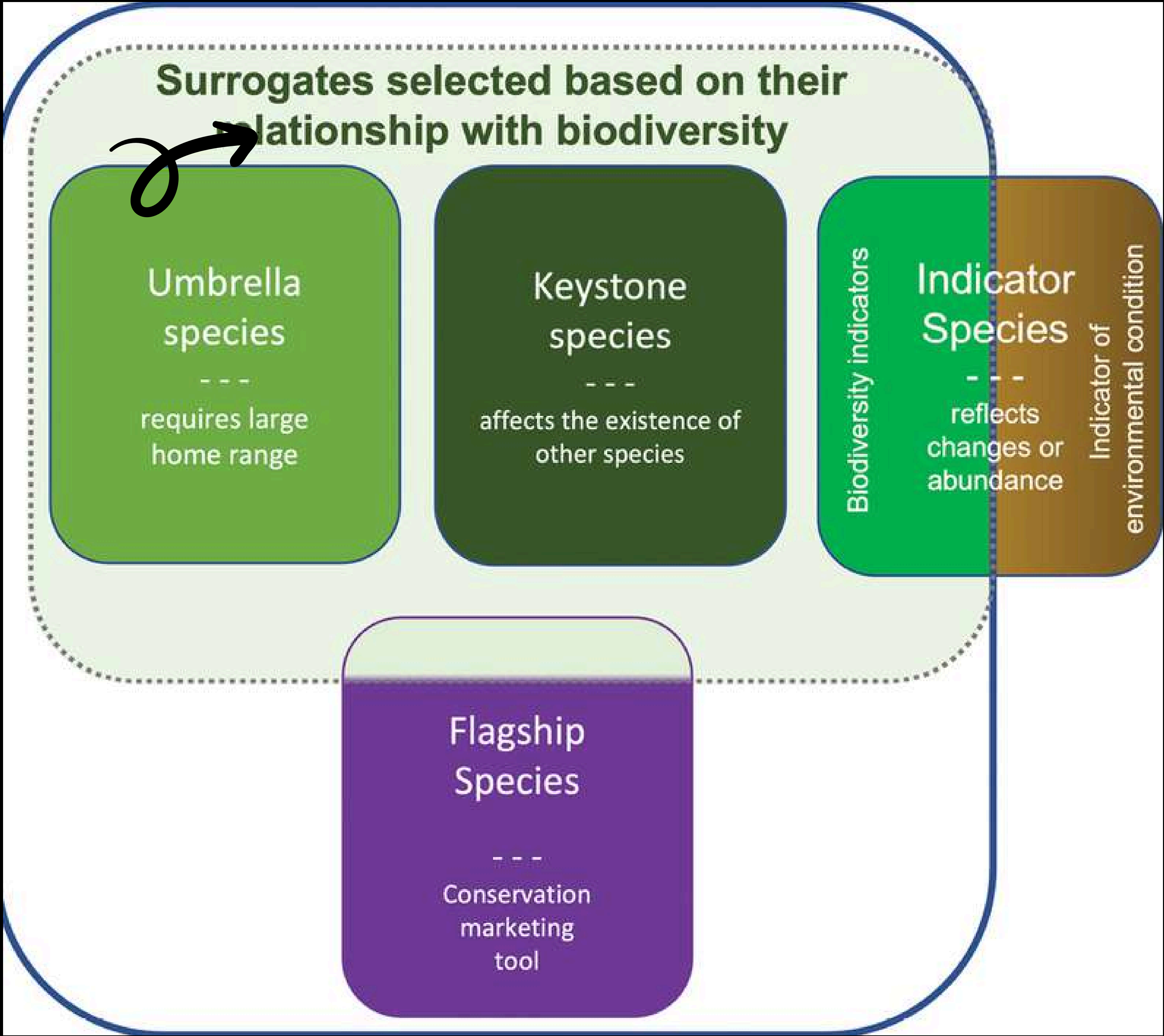

Surrogates selected based on their relationship with biodiversity
Umbrella species
- - -
requires large home range
Keystone species
- - -
affects the existence of other species
Biodiversity indicators
Indicator Species
- - -
reflects changes or abundance
Indicator of environmental condition
Flagship Species
- - -
Conservation marketing tool

DIRECTION

DIRECTION

A keystone species is a species that has a disproportionately large effect on its natural environment relative to its abundance. The concept was introduced in 1969 by the zoologist Robert T. Paine.

• **Predators**	Wolves - Apex Predators
• **Modifiers**	American Alligator
• **Prey**	Pacific Salmon
• **Mutualists**	Ruby throated humming bird
• **Hosts**	Aspen stands are habitat for many insects.

Keystone Species Examples In India

- **Fiddler crabs** are detritivores, which means they eat dead organic stuff. The ecosystem cannot function without it. These crabs provide an important service by removing leaf litter and delivering nutrients to the soil.
- **Cullenia exarillata tree (local name Veipla)** is native to India's Western Ghats, is home to a diverse range of species. This life-giving stationery guardian attracts insects, birds, and mammals alike.
- **Sloth bears i**n the wild serve critical roles in the ecology they dwell in, excavating termite, mounds, and hills with their enormous claws and munching on the morsels buried within. These are keystone species because their food, which consists primarily of termites, fruits, and tubers, contributes to forest health. Ramdurga ecosystem protection in Karnataka has recovered to its former glory! Sloth bears, leopards, and the uncommon pangolin have all made a comeback.
- **Elephants** are a keystone Engineers in the southern part of India including Karnataka, kerala and Tamil nadu. Elephants consume small trees and shrubs that thrive in the area. Elephants can topple and uproot the acacia tree, even if it reaches a height of a yard or more. Because of their grazing habits, the area remains a grassland instead of a forest.
- The mutually beneficial relationships that **bees have with plants** make them an excellent example of keystone species of arch. They increase plant growth and fertilisation potential, for instance, when they gather nectar and pollen, which are their main food sources.

Indicators species An indicator species can be any organism that is abundant and sensitive to changes in the environment.

Around 50% of indicator species are animals, and 70% are invertebrates! These are creatures without a backbone such as starfish, earthworms, jellyfish, spiders, snails, etc.

- **Amphibians:** Freshwater frogs and toads have exceptionally permeable skin, which enables these amphibious species to provide an early warning of decreased water quality and changes in environmental conditions.
- **Crustaceans:** Ecologists test fish and shellfish for heavy metals, pesticides, and plastics to gauge the effects of agricultural runoff and other water pollution issues. Crustaceans can also provide researchers with indications of the alkalinity or acidity of large bodies of water.
- **Lichens:** Mosses and lichens in old-growth forests—for example, in the Pacific Northwest region of North America—can be some of the best ecological indicators of water and air pollution in temperate forest ecoregions.

DIRECTION

- **Macroinvertebrates:** Very small animals like microorganisms and macroinvertebrates can provide researchers with a detailed picture of ecosystem health in waterways and sediment. These organisms can provide researchers with extensive data if several species cohabitate in a compact biosphere.
- **Wetland mammals:** Manatees, river otters, and beavers are examples of species that typically live in fragile wetland ecosystems, which have some of the best biodiversity on the planet. The population size, reproduction rates, and general health of bioindicator species in wetland areas can provide scientists with a clear picture of degenerating habitats.

Bioindicator vs. Biomonitor

A bioindicator is an organism that is used to qualitatively assess an environmental change. A biomonitor, on the other hand, is used to quantitatively measure responses and changes in the environment that indicate pollution. For example, if the amount of chlorophyll in a lichen decreases, scientists know that air pollution is present.

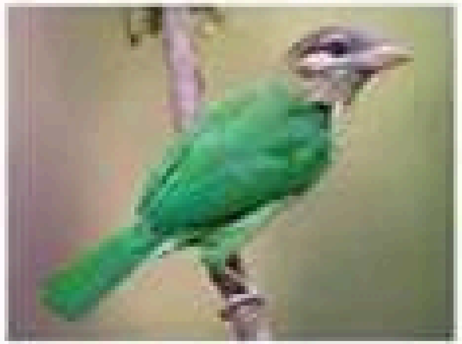
An **endemic species** is native to and found only in a specific geographic area, while a **precinctive species** is a rarer, interchangeable term for this concept, referring to species restricted to a defined, exclusive area

India has many endemic species, such as

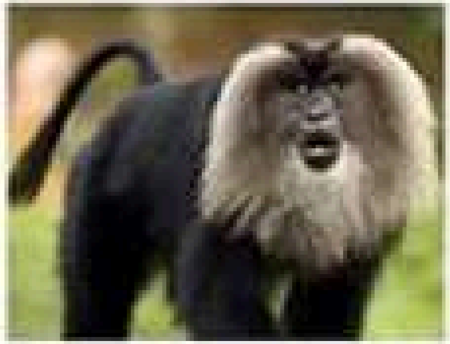
- the Asiatic Lion in Gir Forest,
- the Lion-Tailed Macaque and
- Purple Frog in the Western Ghats,
- the Nilgiri Tahr in the Nilgiri Hills, and
- the Sangai Deer in Manipur.

Other examples include the Kashmir Stag (Hangul) in the Kashmir Valley and the Pygmy Hog in Assam

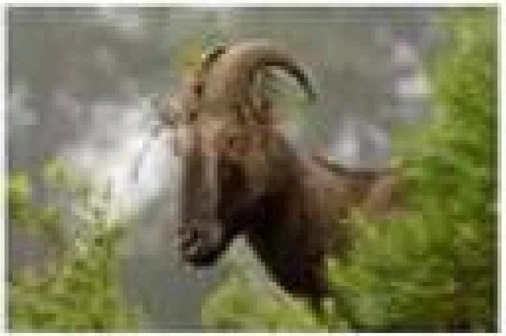
DIRECTION



White cheeked barbet



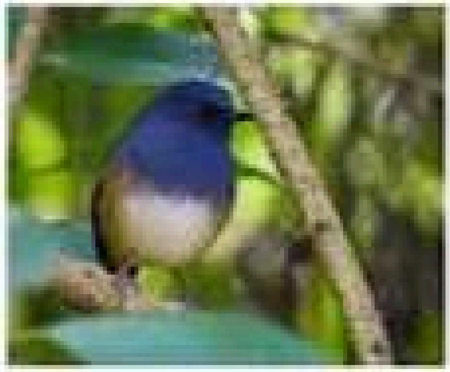
Lion tailed macaque



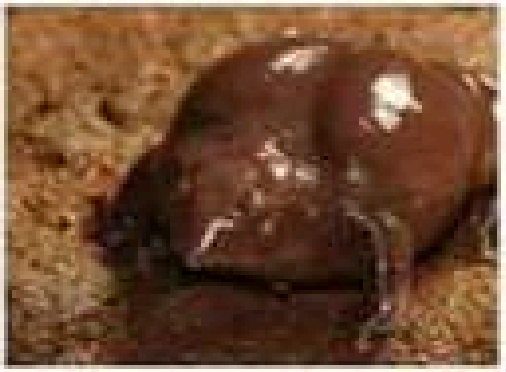
Nilgiri Tahr

Malabar large spotted civet

Pygmy hog



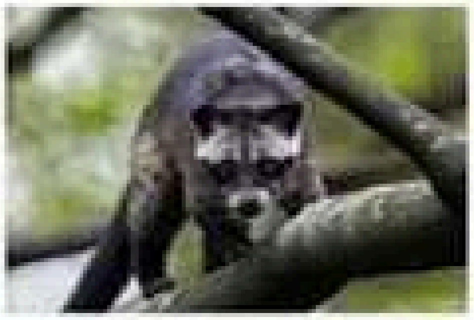
Nilgiri blue robin



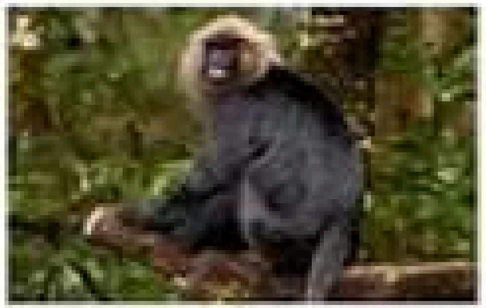
purple frog

malabar gliding frog

DIRECTION



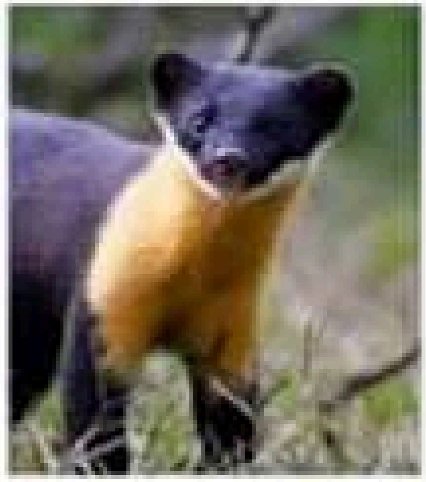
Brown palm civet



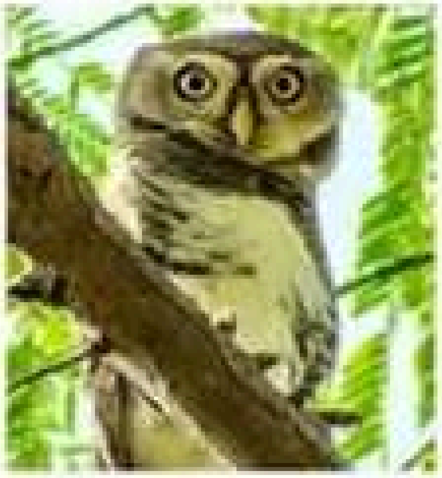
Nilgiri languar

Saara hardawicki

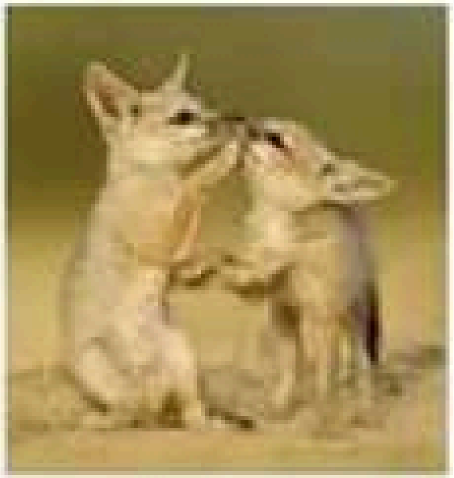
Nilgiri Flycatcher



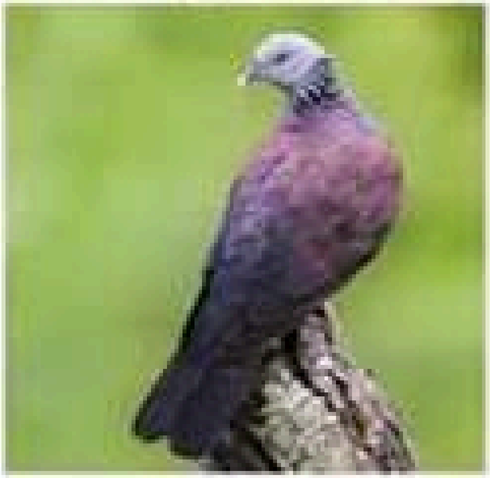
nilgiri marten



Forest owlet



Bengal fox



Nilgiri wood pigeon

An invasive species is an organism that is not indigenous, or native, to a particular area. Invasive species can cause great economic and environmental harm to the new area.

Not all non-native species are invasive.

To be invasive-

- a species must adapt to the new area easily.
- It must reproduce quickly.
- It must harm property, the economy, or the native plants and animals of the region.

Invasive animals

African catfish : Introduced for aquaculture, it has spread to many river systems and lakes, threatening native fish populations.

Red-eared slider: This North American turtle is popular as a pet but is often abandoned in local water bodies, where it outcompetes native freshwater species for food and habitat.

Invasive plants

- **Lantana camara:** Introduced as an ornamental plant, it now clogs forests and protected areas.
- **Water hyacinth** (\(Eichhorniacrassipes\)): Originally introduced in the early 1900s, it forms dense mats on water bodies, disrupting aquatic ecosystems.
- **Parthenium hysterophorus:** Also known as Congress grass, this weed spreads quickly in disturbed land and agricultural fields, potentially causing health issues and reducing crop yields.
- **Prosopis juliflora:** Also called the kiker tree, it was introduced for afforestation and now dominates arid regions, degrading native ecosystems.
- **Chromolaena odorata:** Commonly known as Siam weed, it can outcompete native vegetation.

A flagship species/ Umbrella species is an organism, often charismatic or iconic, chosen to represent and raise public attention and support for conservation efforts, habitat preservation, and broader environmental causes.

Examples include the Giant Panda, a symbol for conservation in China

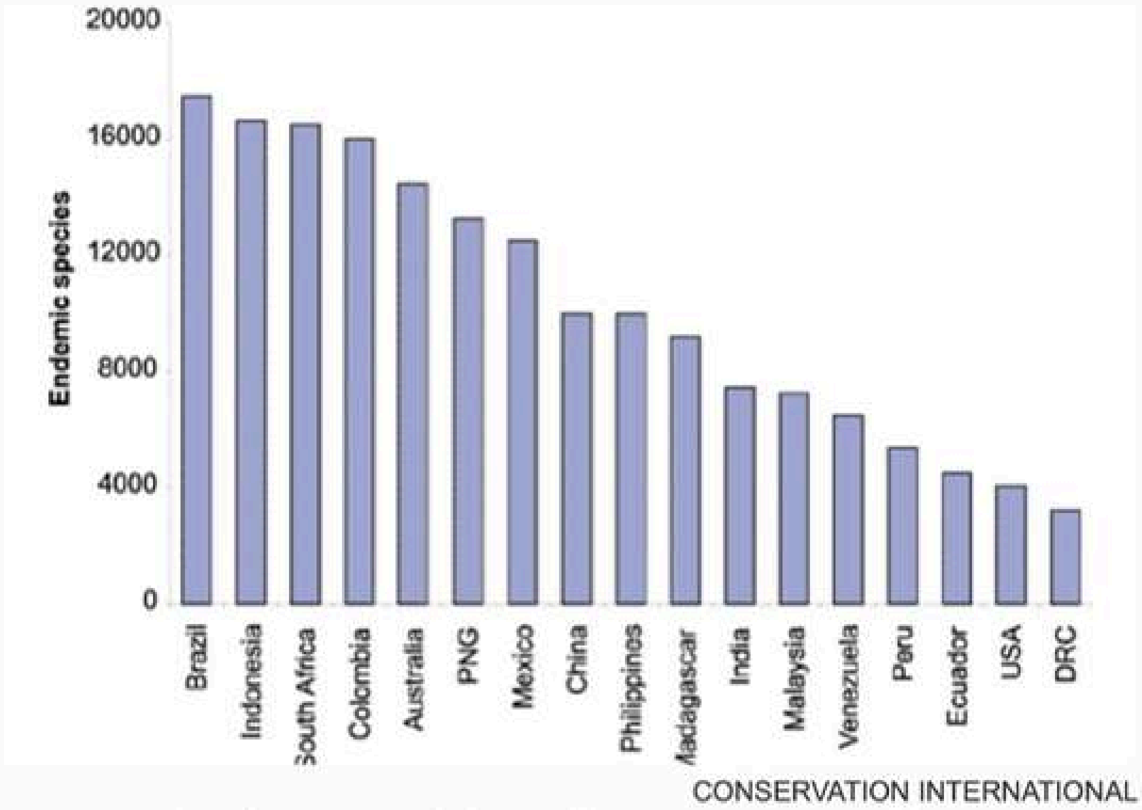
India's main flagship species include the Bengal tiger, Indian elephant, and one-horned rhinoceros, which represent major conservation efforts like Project Tiger and Project Elephant.

Other key flagship species include the snow leopard, Asiatic lion, and Ganges river dolphin.

What is megadiversity

The identification of "megadiverse" countries comes from organizations like the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and Conservation International. It's a term for a country or region with a high level of biodiversity or different species, including a significant percentage of endemic species.

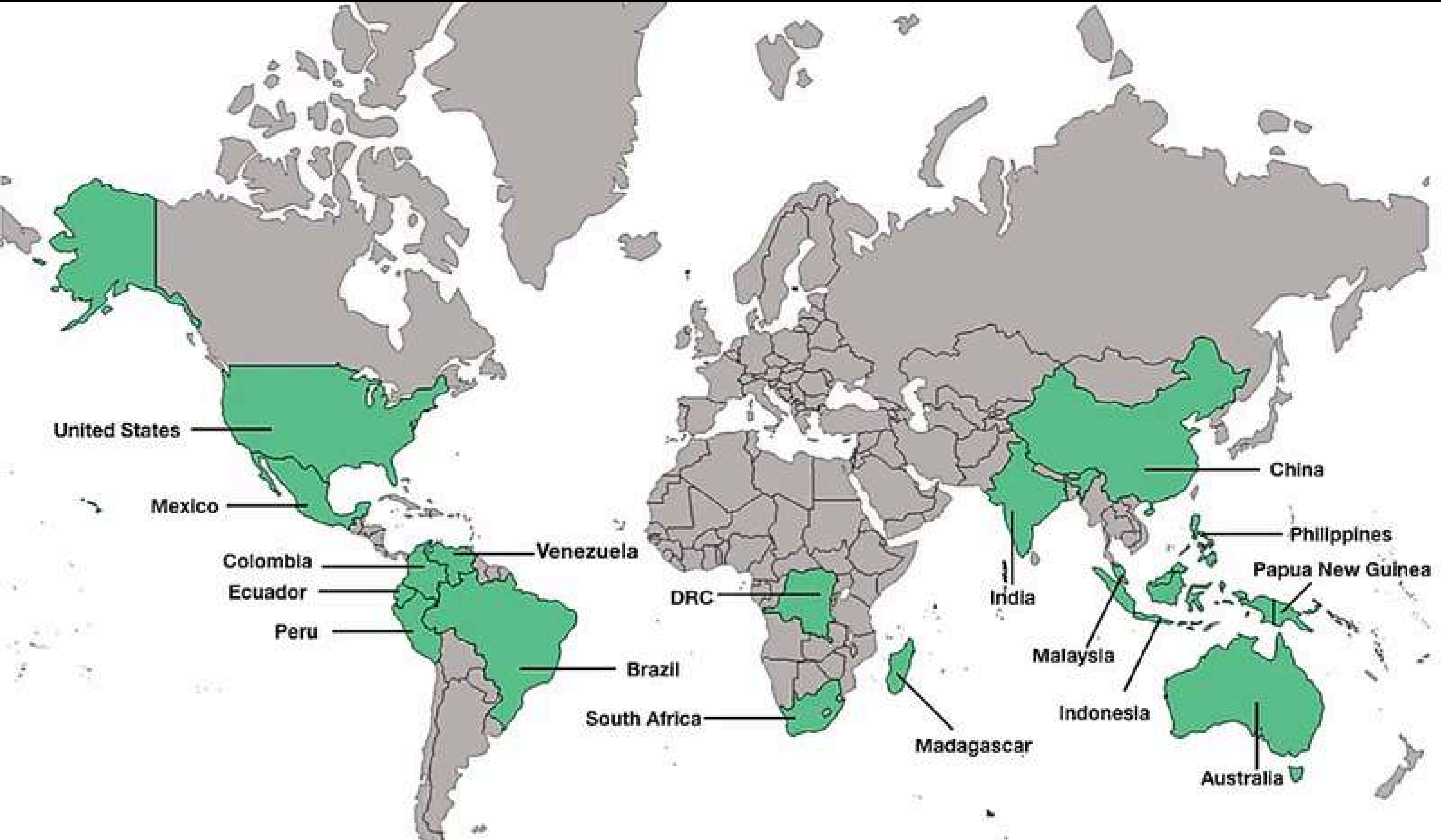
To be classified as megadiverse, a nation must have at least 5,000 plants that occur naturally only within its borders, as well as a marine ecosystem.



No. of endemic non-fish vertebrate species in each country

The 17 megadiverse countries comprise approximately 70% of the world's biodiversity and have their own organization, the Like-Minded Megadiverse Countries.

DIRECTION

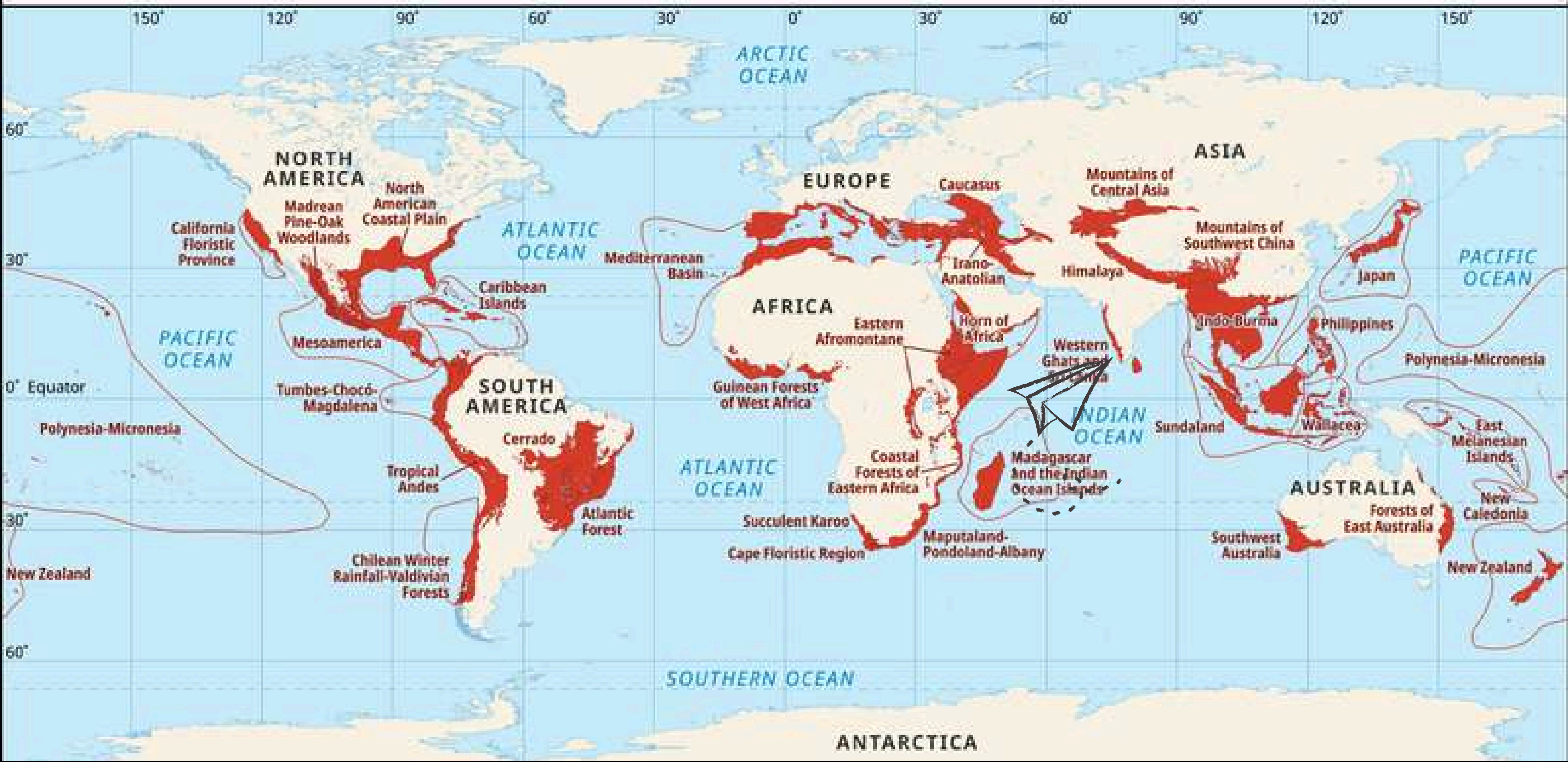

United States
Mexico
Colombia
Venezuela
Ecuador
Peru
Brazil
DRC
South Africa
Madagascar
India
China
Philippines
Papua New Guinea
Malaysia
Indonesia
Australia

To qualify as a **biodiversity hotspot,** a region must meet two strict criteria:

- It must have at least 1,500 vascular plants as endemics — which is to say, it must have a high percentage of plant life found nowhere else on the planet. A hotspot, in other words, is irreplaceable.
- It must have 30% or less of its original natural vegetation. In other words, it must be threatened.

Around the world, 36 areas qualify as hotspots. Their intact habitats represent just 2.5% of Earth's land surface, but they support more than half of the world's plant species as endemics — i.e., species found no place else — and nearly 43% of bird, mammal, reptile and amphibian species as endemics.

EARTH'S TERRESTRIAL HOT SPOTS OF BIODIVERSITY



DIRECTION

The Himalaya is a global biodiversity hotspot covering parts of Nepal, Bhutan, China, and India's Northeast, renowned for its incredible plant and animal diversity, especially endemic species. This region features extreme elevation changes, creating diverse ecosystems from subtropical forests to alpine meadows and is home to threatened species like tigers, snow leopards, and the

Red Panda.

- Mammals: Home to iconic and endangered species such as Asian Elephants, Tigers, Snow Leopards, and the Red Panda.
- Birds: Includes the vulnerable Great Hornbill and White-bellied Heron.
- Plants: Hosts an estimated 9,000 plant species, with about 3,500 being endemic and holding medicinal properties.

DIRECTION

The Western Ghats form a part of Western Ghats-Sri Lanka global biodiversity hotspot.

They run parallel to the west coast of India and run across the states of Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. Locally they are also known as the Sahyadris.

They harbour 7388 species of flowering plants. Out of these 7388 species, 5584 species are indigenous.

Out of the 5584 indigenous species of plants, 2242 species are endemic to India and 1261 are endemic to the Western Ghats endemics.

The Western Ghats is also rich among the invertebrate groups.

DIRECTION

- About 350 ant species, 20% of which are endemic to this region.
- 330 butterfly species, 11% of which are endemic to this region.
- 174 odonate species that includes dragonflies and damselflies, 40% of which are endemic to this region.
- 269 mollusc species that includes land snails, 76% of which are endemic to this region.
- The fish fauna of the Western Ghats spans around 288 species, 41% of which are endemic to this region.
- The amphibian fauna of this region consists of 220 species, of which 78% are endemic.
- 62% of the 225 described species of reptiles found here, are endemic to this region.

Over 500 species of birds and 120 species of mammals are also known from this region.

- Key species: Home to endangered species like the Nilgiri Tahr and Lion-tailed Macaque.

The Western Ghats region harbours the largest global populations of the Asian elephants and possibly of other mammals such as the tiger, dhole and gaur.

Wild relatives of cultivated plants are also found here, including pepper, cardamom, mango, jackfruit and sandal.

The North-East forms a part of Indo-Burma global biodiversity hotspot.

Some parts of the north-eastern region of India, excluding the Himalayan region, form a part of the Indo-Burma biodiversity hotspot.

- It is centred on the Indo-Chinese Peninsula, and comprises of Cambodia, the Lao People's Democratic Republic, Myanmar, Thailand, Vietnam and parts of Southern China.
- More than 60% of the bird species found in India have been recorded in the North-East.
- It harbours 35 endemic reptilian species including two genera of lizards and two turtle species.
- Out of 341 Indian amphibian species, at least 68 species are known to occur in the North-East. 20 out of the 68 are endemic.
- It is enriched with 13,500 vascular plant species, of which about 7000 (52%) are endemic to North-East.
- 74 out of the 1277 bird species found in Indo-Burma are endemic to North-East.
- 71 of the 430 mammal species in the hotspot are endemic to this region.
- 189 of the 519 non-marine reptile species are endemic to this region.
- 139 of the 323 amphibian species are endemic to the hotspot.
- It also supports a high diversity of freshwater turtles.
- It also accounts for about 10% of the fish fauna in the world. 566 out of the 1262 documented fish fauna species are endemic to this region.

Nicobar Islands are a part of the Sundaland global biodiversity hotspot.

- Mangrove forests are found in these islands.
- 3500 plant species are found in the Andaman and Nicobar group of islands.
- Out of these 3500 species, 422 of floral genera and 648 species are endemic to the Nicobar Island.
- Out of the 120 pteridophyte species of the Andaman and Nicobar Islands, 50% are from Great Nicobar Island alone.
- A total of 110 wild orchids are reported from these islands, of which 19 genera, with 25 species, are endemic.
-

The Malayan box turtle, the Sunbeam snake, the Saltwater crocodile and the Reticulated python are found in the Southern Nicobar group, besides several species of Pit viper in the central Nicobars.

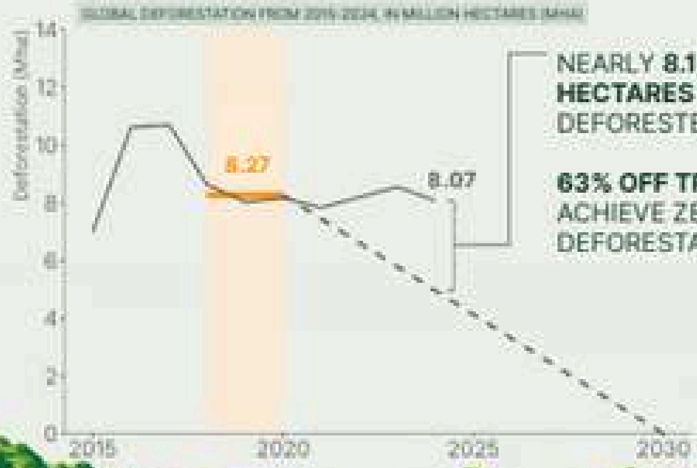
15 reptile species are reported to be endemic to the Nicobars.

Four species of marine turtle, the Leatherback turtle, Hawksbill turtle, Green sea turtle and the Olive ridley turtle feed and nest around the Andaman and Nicobars. The nesting population of Leatherbacks in the Nicobars is one of the last four colonies that exceed 1000 individuals in the Indo-Pacific and hence has global significance.

DIRECTION

The Forest Declaration Assessment

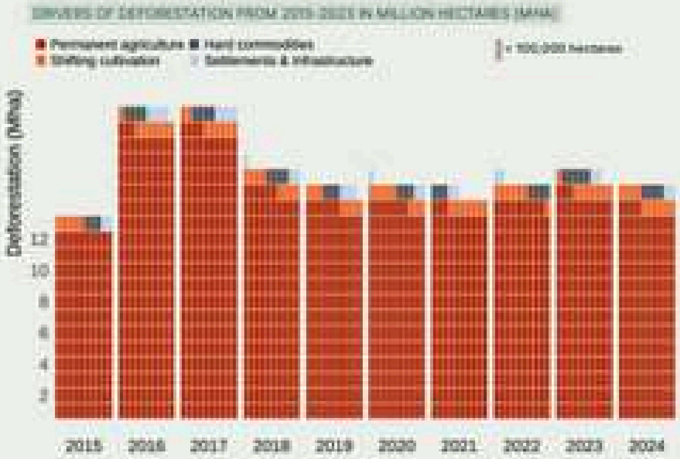
THE WORLD REMAINS OFF TRACK TO ELIMINATE DEFORESTATION BY 2030.



NEARLY **8.1 MILLION HECTARES** WERE DEFORESTED IN 2024:

63% OFF TRACK TO ACHIEVE ZERO DEFORESTATION BY 2030

IN THE PAST DECADE, 86% OF GLOBAL DEFORESTATION HAS BEEN CAUSED BY PERMANENT AGRICULTURE.



Agricultural expansion the dominant direct driver of deforestation worldwide, with mining projected to increase pressures on forest ecosystems.

Corruption, weak law enforcement, land speculation, and market forces - both from domestic and international consumers - form a complex web of indirect drivers that must be addressed.

FIRES IN THE AMAZON EMITTED MORE THAN MANY INDIVIDUAL COUNTRIES IN 2024

8.8 million hectares of tropical moist forests were degraded in 2024. A major driver of this was forest fires in tropical moist forests in the Amazon basin, which emitted:

791 MILLION METRIC TONS OF CO2eq IN 2024

– exceeding the GHG emissions of an industrialized country like Germany.

FORESTED KEY BIODIVERSITY AREAS ARE STILL UNDER THREAT

Protecting forest habitats is crucial for the forest dependent species and making progress toward global biodiversity targets.

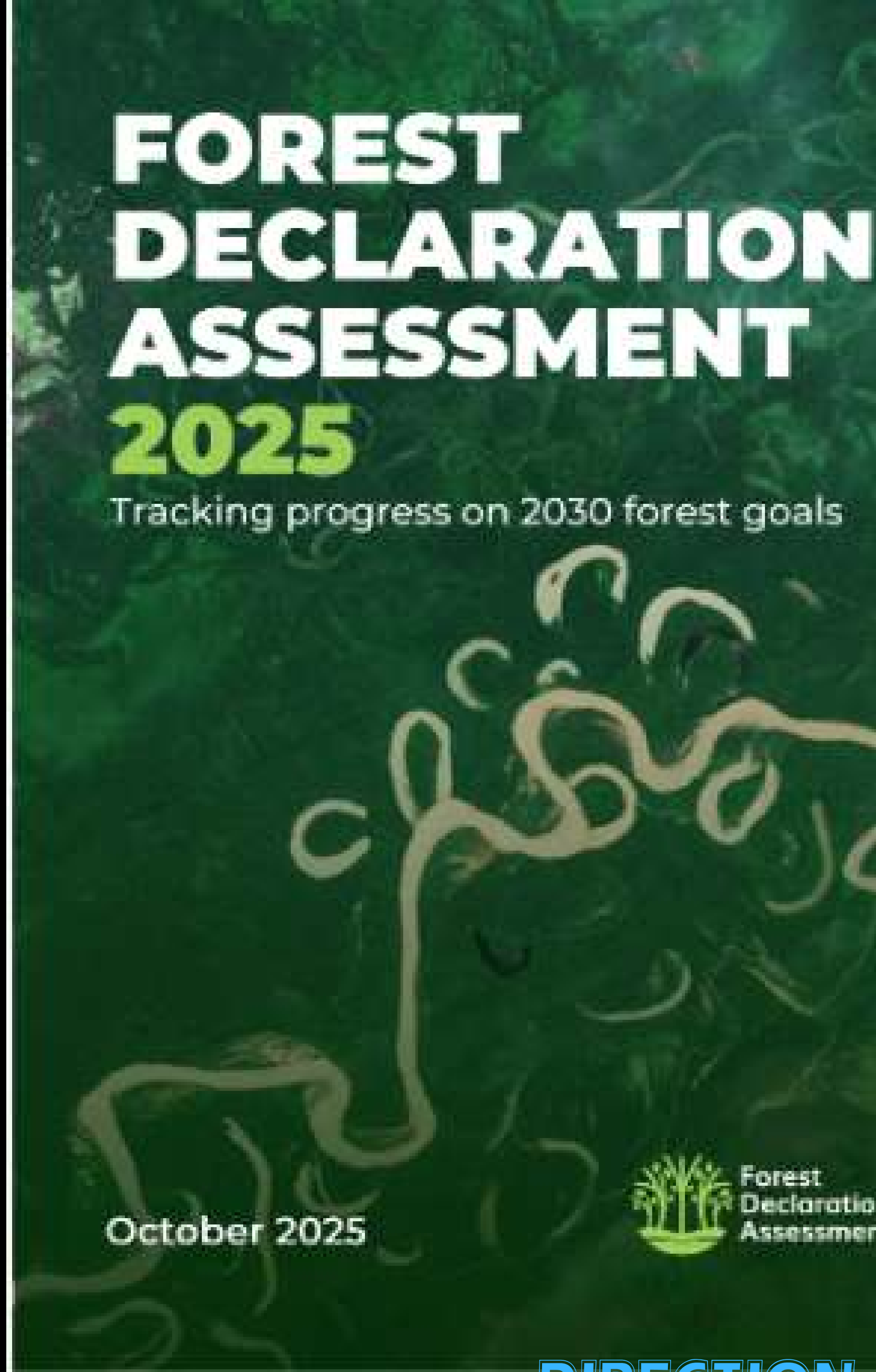
47% INCREASE IN FOREST LOSS IN fKBAs FROM 2023-2024

FOREST RESTORATION EFFORTS PROGRESS, BUT MONITORING REMAINS A CHALLENGE

An estimated 10.6 million hectares of global restoration activities (as of Sept. 2025) represents a small fraction of the global restoration potential. Fragmented data hinders complete estimates.

The Forest Declaration Assessment 2025 finds that:

- 8.1 million hectares of forest were lost in 2024, a level of destruction 63% higher than the trajectory needed to halt deforestation by 2030.
- Loss of humid primary tropical forests—the irreplaceable stores of carbon and biodiversity—spiked In 2024, largely due to climate change-induced increase of forest fires.
- Forest degradation affected 8.8 million hectares affected in 2024—eroding ecosystem integrity and climate resilience.



DIRECTION

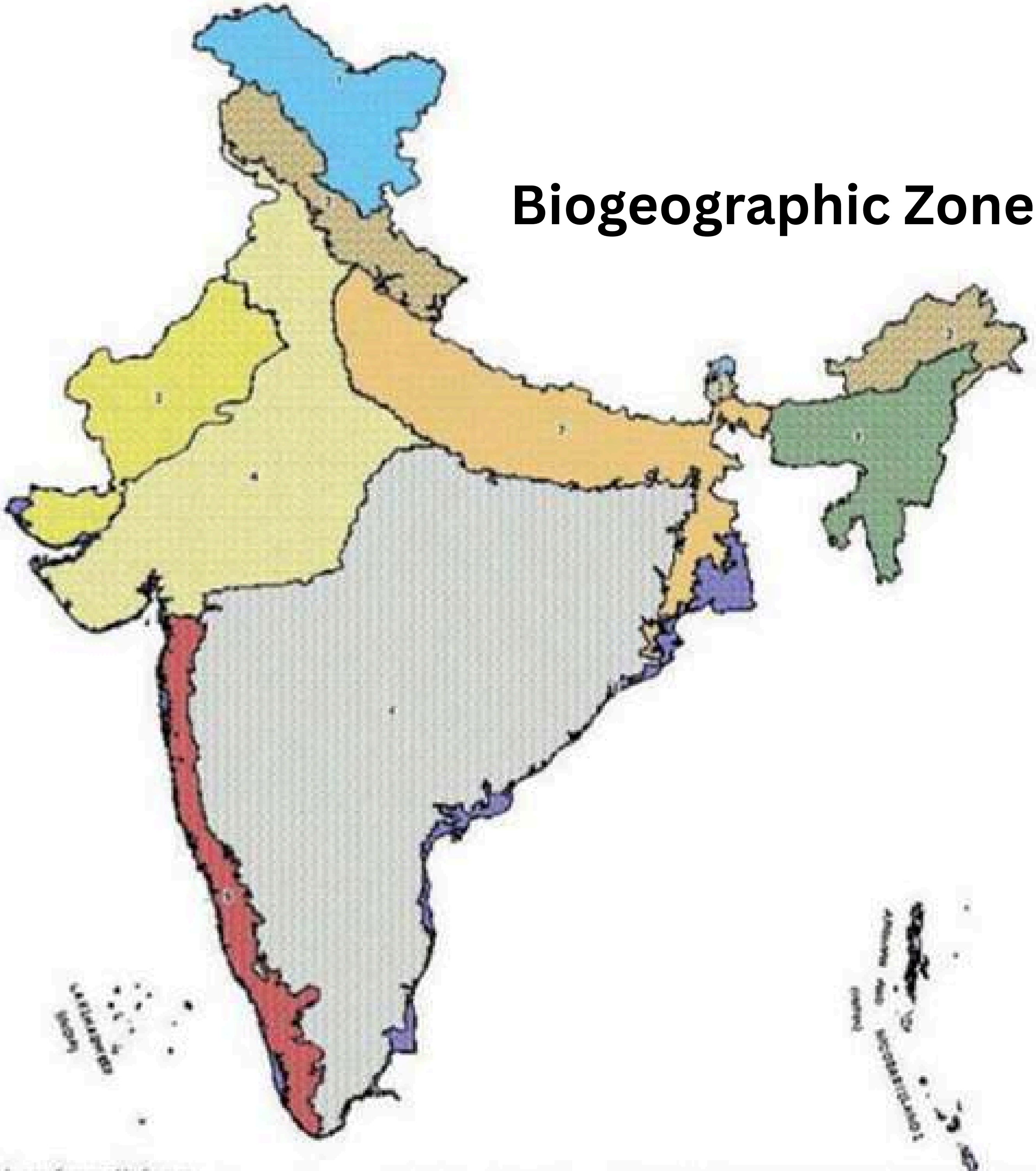
- Restoration efforts are expanding, with at least 10.6 million hectares hosting forest restoration projects worldwide. But global data remain too fragmented to determine whether the world is recovering forests at the scale required.
- Financial flows are still grossly misaligned with forest goals, with harmful subsidies outweighing green subsidies by over 200:1. Despite new pledges, the flow of funds to forest countries and local actors remains far below what's necessary to deliver on 2030 goals.
- Delivery on corporate and financial sector commitments is lagging, and transparency remains inconsistent.

At the halfway point to 2030, the world should be seeing a steep decline in deforestation. Instead, the global deforestation curve has not begun to bend.

India is considered a megadiverse country because it has a high level of biodiversity, with 8.1% of the world's recorded species despite occupying only 2.4% of the world's land area. This is supported by diverse ecosystems like forests, wetlands, and grasslands, along with various climatic conditions and geographical features.

India is home to a significant portion of global species and contains four major biodiversity hotspots: the Himalayas, Western Ghats, North-East, and Nicobar Islands

DIRECTION

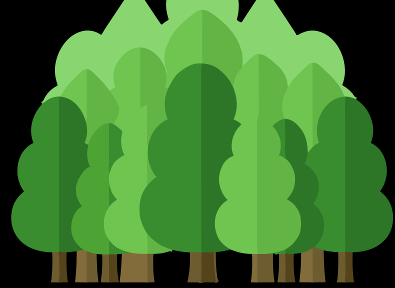


Biogeographic Zones

DIRECTION

- **Asiatic Lion: Gir, Gujarat**
- **Asian Elephant (Indian Elephant): Eastern Arunachal Pradesh, the Plains of Upper Assam, and the foothills of Nagaland**
- **Bengal Florican: Uttar Pradesh, Assam, and Arunachal Pradesh**
- **Bengal Tiger: Mangroves of the Sundarbans, West Bengal**
- **Blackbuck: Maharashtra, Odisha, Punjab, Rajasthan, Haryana, Gujarat, Andhra Pradesh, Tamil Nadu, and Karnataka**
- **Great Indian Bustard: Rajasthan, Gujarat, and Maharashtra**
- **Himalayan Monal (Pheasant): Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh**
- **Hoolock Gibbon: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura**
- **Jerdon's Courser: Eastern Ghats of Andhra Pradesh**
- **Leopard Cat: Foothills of the Himalayas**
- **Lion Tailed Macaque: Western Ghats of South India**
- **Malabar Civet: Western Ghats of South India**
- **Nilgiri Langur: Nilgiri Hills of the Western Ghats in South India**
- **Olive Ridley Sea Turtle: Gahirmatha, Odisha**
- **Pygmy Hog: Assam**
- **Sarus Crane: Haryana, Rajasthan, Uttar Pradesh, and Madhya Pradesh**
- **Wild Ass: Rann of Kutchchh, Gujarat**

Forest in India



Forest and Tree cover is 8,27,357sq km,

Forests are vital ecosystems that support environmental stability, economic growth, food security, and the well-being of people at all levels. They deliver tangible and non-tangible benefits such as storing carbon, protecting soil and water, regulating climate, and conserving biodiversity while supporting the livelihoods of millions, including Indigenous and forest-dependent communities.

Forests ecosystem and related activities are directly or indirectly linked to Sustainable Development Goals (SDGs), making them central to the global development agenda adopted by 196 countries, including India. International agreements, such as the United Nations Strategic Plan for Forests 2017-2030, highlight the importance of reversing forest loss, restoring degraded forests, and boosting cooperation and resources for long-term sustainability.

India is ranked third in the world for the highest net annual gain in forest area (2010-2020), due to large-scale restoration projects, strong community participation, and progressive agroforestry efforts, demonstrating the country's on-going commitment to forest conservation.

India supports a diverse range of forest types 16 broad groups spanning tropical, sub-tropical, temperate, alpine, and scrubby/evergreen forests found across various regions and climatic zones, reflecting the country's ecological richness and complexity. Forests and tree cover in I**ndia together account for 8.27 lakh sq. km, (25.17%) of the country's geographical area, according to the India State of Forest Report 2023. Forest cover alone is 7.15 lakh sq. km (21.76%), and tree cover is 1.12 lakh sq. km (3.41%). India is a signatory to the United Nations Strategic Plan for Forests 2017-2030**, which sets six Global Forest Goals and 26 voluntary targets, including reversing the loss of forest cover, enhancing forest benefits, expanding sustainable management, mobilizing increased financial resources and strengthening governance and cooperation.

India’s forests are classified into four major groups

Top four states showing maximum increase in forest and tree cover are Chhattisgarh (684 sq km) followed by Uttar Pradesh (559 sq km), Odisha (559 sq km) and Rajasthan (394 sq km).

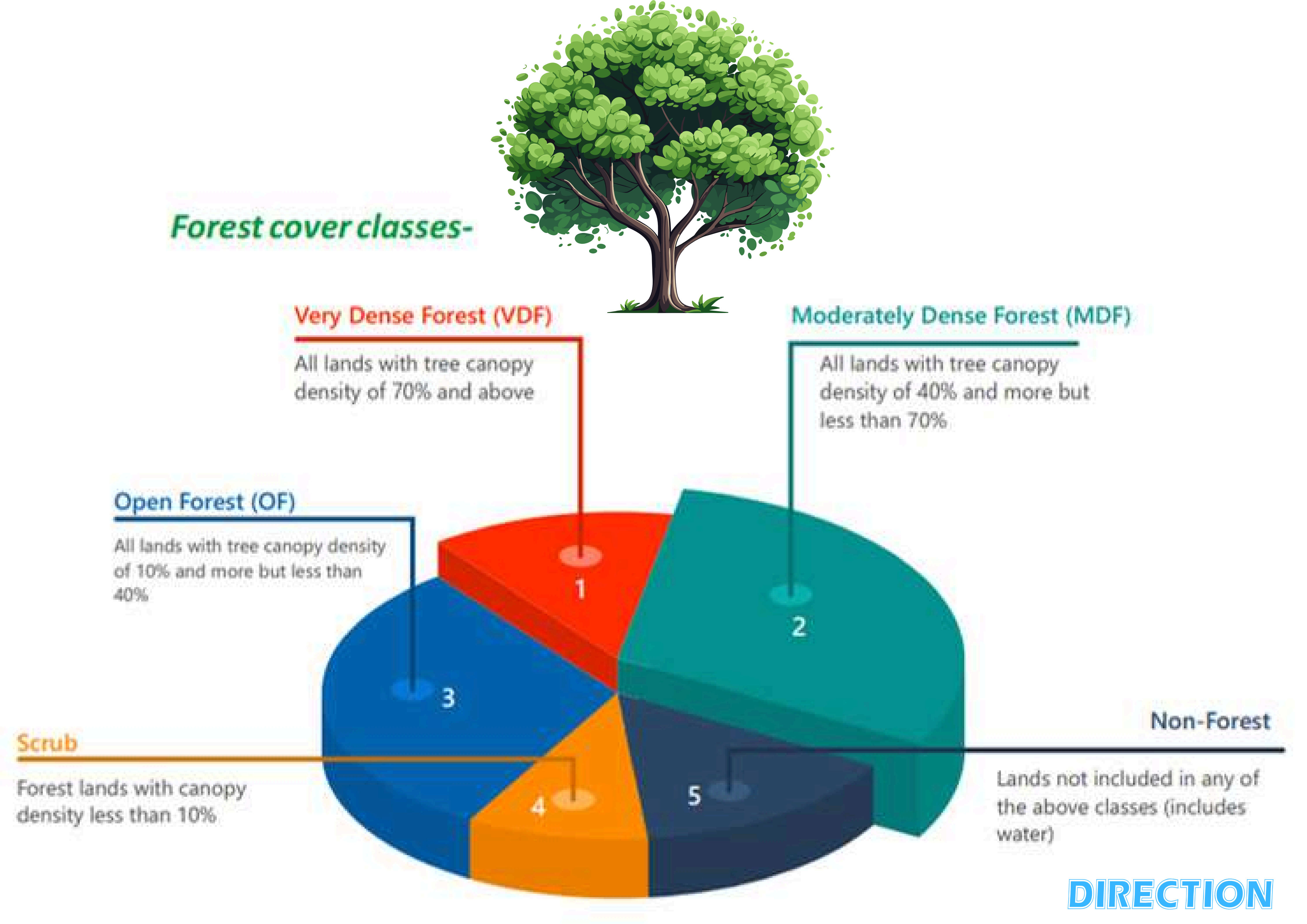
namely- tropical, sub-tropical, temperate and alpine. These four groups are further classified into 16 type groups . The landscape of Indian forests ranges from Tropical Wet Evergreen Forests in the Andaman & Nicobar Islands, the Western Ghats, and the north-eastern States, to Dry Alpine Scrub high in the Himalayas in the north. The country has Semi-Evergreen Forests, Deciduous Forests, Thorn Forests, and Subtropical Pine Forests in the lower montane zone and Temperate Montane Forests in the higher zones. At the other extreme, tropical dry deciduous and thorn forests predominate in the semi-arid areas of Rajasthan and Gujarat.

DIRECTION

According to the FAO's State of the World's Forests 2024 report, India ranked third globally in terms of average annual net gain in forest area between 2010 and 2020. During this period, India recorded an average annual increase of 266,000 hectares of forest area. Only China and Australia reported higher gains. The report also highlighted India's initiatives in restoring degraded lands and promoting agroforestry as key contributors to this positive trend.

Ranking	Country	Forest area	
		1000 ha / yr	Percentage
1	China	1937	0.93
2	Australia	446	0.34
3	India	266	0.38
4	Chile	149	0.85
5	Vietnam	126	0.90
6	Turkey	114	0.53
7	United States of America	108	0.03
8	France	83	0.50
9	Italy	54	0.58
10	Romania	41	0.62

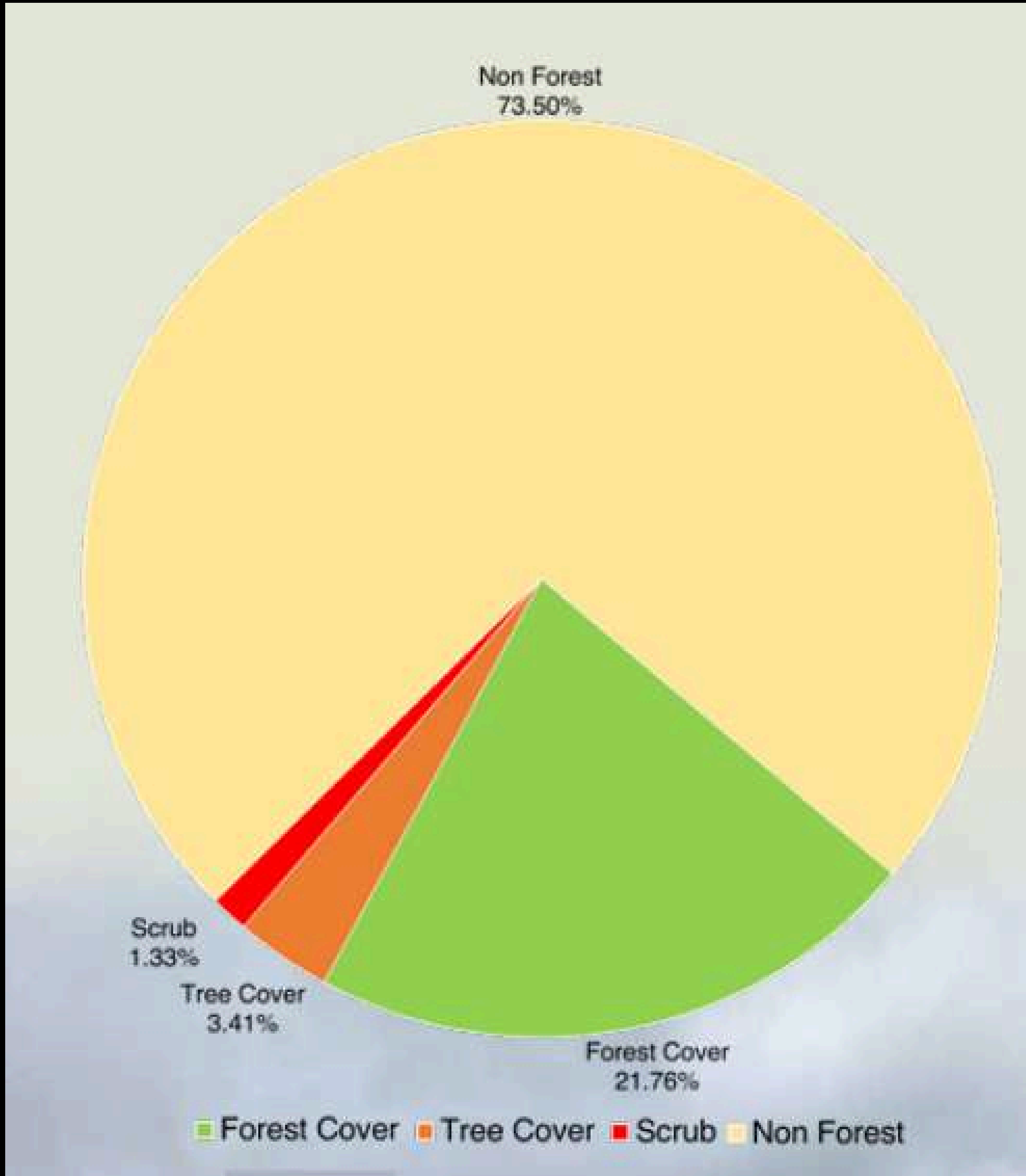
Source: *Global Forest resource assessment, 2020, FAO*



Forest cover classes-
Very Dense Forest (VDF)
All lands with tree canopy density of 70% and above
Moderately Dense Forest (MDF)
All lands with tree canopy density of 40% and more but less than 70%
Open Forest (OF)
All lands with tree canopy density of 10% and more but less than 40%
Scrub
Forest lands with canopy density less than 10%
Non-Forest
Lands not included in any of the above classes (includes water)
1
2
3
4
5
DIRECTION

Forest Cover is defined as follows: “All areas with tree cover having canopy density of greater than or equal to 10% and having an area greater or equal to 1 hectare.” It may be situated in recorded forest, or on other Government, private or Institutional lands.

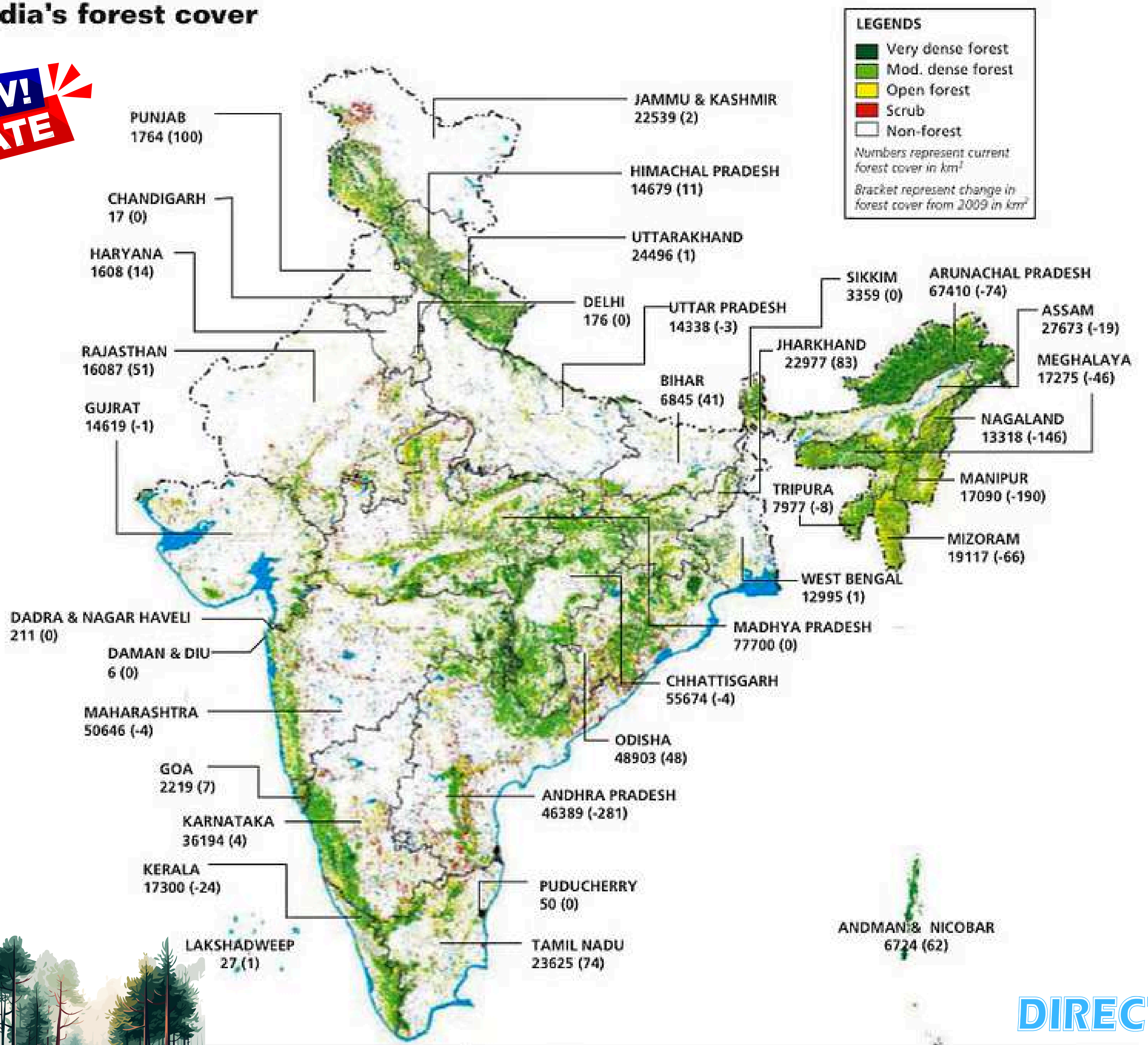
Tree Cover is defined as follows: “Tree Cover includes Woody vegetation Resources in patches and individual trees outside the RFA on blocks of less than one hectare.”



DIRECTION

India's forest cover

NEW! UPDATE



DIRECTION

Regional Distribution of Forest Type as per Champion and Seth (1968) Classification-

S.no	Forest Type Group	General Composition	Regional Occurrence (States of India)
1	Tropical Wet Evergreen Forest (TWEF)	Dense tall forests, entirely evergreen or nearly so	NER excluding Meghalaya , Karnataka, Kerala, Tamil Nadu, Andaman & Nicobar Islands and Goa. Arunachal Pradesh, Assam, Nagaland
2	Tropical Semi-Evergreen Forests (TSEF)	Dominants includes deciduous species but evergreens predominant	Assam, Karnataka, Kerala, Maharashtra, Nagaland, Odisha, Tamil Nadu, Andaman & Nicobar Islands and Goa. Arunachal Pradesh, Bihar, Manipur, Meghalaya, Mizoram, Tripura, Uttar Pradesh, West Bengal
3	Tropical Moist Deciduous Forests (TMDF)	Dominants are mainly deciduous but sub-dominants and lower story largely evergreen top canopy even and dense but 25m high	Andhra Pradesh, NER excluding Arunachal Pradesh & Sikkim, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh, West Bengal, Andaman & Nicobar Islands, Goa , Himachal Pradesh, Assam, Chhattisgarh, Jharkhand, Manipur, Meghalaya, Mizoram, Nagaland, Telangana, Tripura, Uttarakhand, Dadar & Nagar Haveli and Daman & diu

4	Littoral and Swamp Forests (L&SF)	Mainly evergreens of varying density and height but always associated predominantly with wetness	Andhra Pradesh, Gujarat, Maharashtra, Odisha, Tamil Nadu, West Bengal and Andaman & Nicobar Islands. Assam, Bihar, Goa, Karnataka, Kerala, Madhya Pradesh, Uttar Pradesh, Uttarakhand, Dadar & Nagar Haveli and Daman & diu, Puducherry
5	Tropical Dry Deciduous Forests (TDDF)	Entirely deciduous or nearly so top canopy uneven rarely over 25 m high	Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Jammu & Kashmir, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal, Chhattisgarh, Delhi, Goa, Jharkhand, Kerala, Telangana, Uttarakhand, Chandigarh, Dadar & Nagar Haveli and Daman & diu
6	Tropical Thorn Forests (TTF)	Deciduous with low thorny trees and xerophytes predominant top canopy more or less broken, less than 10 m high	Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh, Delhi, Kerala, Telangana, Dadar & Nagar Haveli and Daman & diu

7	Tropical Dry Evergreen Forests (TDEF)	Hard leaved evergreen trees predominate with some deciduous emergent often dense but usually under 20 m high	Andhra Pradesh and Tamil Nadu
8	Sub-Tropical Broad-Leaved Hill Forests (STBLHF)	Broad-leaved largely evergreen high forests	Assam and Meghalaya Arunachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Manipur, Mizoram, Nagaland, Sikkim, Tamil Nadu, West Bengal
9	Sub-Tropical Pine Forests (STPF)	Pine associated predominates	Arunachal Pradesh, Haryana, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Nagaland, Punjab, Assam, Mizoram, Uttarakhand
10	Sub-Tropical Dry Evergreen Forests (STDEF)	Low xerophytic forest and scrubs	Jammu & Kashmir
11	Montane Wet Temperate Forests (MWTF)	Evergreen without coniferous species	Arunachal Pradesh, Manipur and Nagaland, Kerala, Sikkim, Tamil Nadu, West Bengal

12	Himalayan Moist Temperate Forest (HMTF)	Evergreen forests mainly sclerophyllous oak and coniferous species	Himachal Pradesh. Jammu & Kashmir, Arunachal Pradesh, Manipur, Nagaland, Sikkim, Uttarakhand, west Bengal, Ladakh
13	Himalayan Dry Temperate Forests (HDTF)	Coniferous forests with sparse xerophytic under-growth	Jammu & Kashmir and Himachal Pradesh Arunachal Pradesh, Uttarakhand, Ladakh
14	Sub-Alpine	Stunted deciduous or evergreen forests, usually close formation with or without conifers	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand, West Bengal, Ladakh
15	Moist Alpine Scrub	Low but often dense scrub of evergreen species	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand
16	Dry Alpine Scrub	Xerophytic scrub in open formation mostly of deciduous in nature	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Ladakh

DIRECTION

IMPORTANT

India State of Forest Report 2023 (ISFR 2023)

The ISFR is brought out by the Forest Survey of India (FSI) on a biennial basis since 1987.

- FSI carries out in-depth assessment of the forest and tree resources of the country based on interpretation of Remote Sensing satellite data and field based National Forest Inventory (NFI), and the results are published in the ISFR. The India State of Forest Report 2023 is 18th such report in the series.
- As per the present assessment, the total Forest and Tree cover is 8,27,357sq km, which is 25.17 percent of the geographical area of the country. The Forest Cover has an area of about 7,15,343sq km (21.76%) whereas the Tree Cover has an area of 1,12,014 sq km (3.41%)

India State of Forest Report 2023

DIRECTION

The total area covered is **8,27,357 sq km**, which constitutes **25.17% of India's geographical area**

This includes **7,15,343 sq km** of forest cover **(21.76%)** and **112,014 sq km** of tree cover **(3.41%)**

Increase of **1,445 sq km** in total forest and tree cover since last assessment in 2021

India State of Forest Report 2023

- Mangrove Cover: **4,992 sq km**
- Bamboo Bearing Area: **1,54,670 sq km** *(an increase of **5,227 sq km** in bamboo area from previous assessment)*
- Carbon Stock in Forests: **7,285.5 million tonnes** *(an increase of **81.5 million tonnes** in carbon stock from previous assessment)*

📌 **Top States with Maximum Increase :** Chhattisgarh had the highest additional forest area of 684 sq km adding to the list is Uttar Pradesh with 559 sq km Odisha with 559 sq km and Rajasthan with 394 sq km.

- **States with Largest Forest and Tree Cover:** Among the states, Madhya Pradesh has the largest area under forests and trees 85,724 sq km, Arunachal Pradesh(67,083 sq km), Maharashtra (65,383 sq km only).
- **States with Largest Forest Cover:** The highest forest cover in the country is reported by the Madhya Pradesh at 77,073 Sq km, second largest in Arunachal Pradesh at 65,882 Sq km and the third largest in Chhattisgarh at 55,812 sq km.
- **Forest Cover as Percentage of Geographical Area:** Among the states, Lakshadweep has the highest percentage of forest cover with 91.33%, second by Mizoram at 85.34% and third by Andaman & Nicobar Islands at 81.62%.

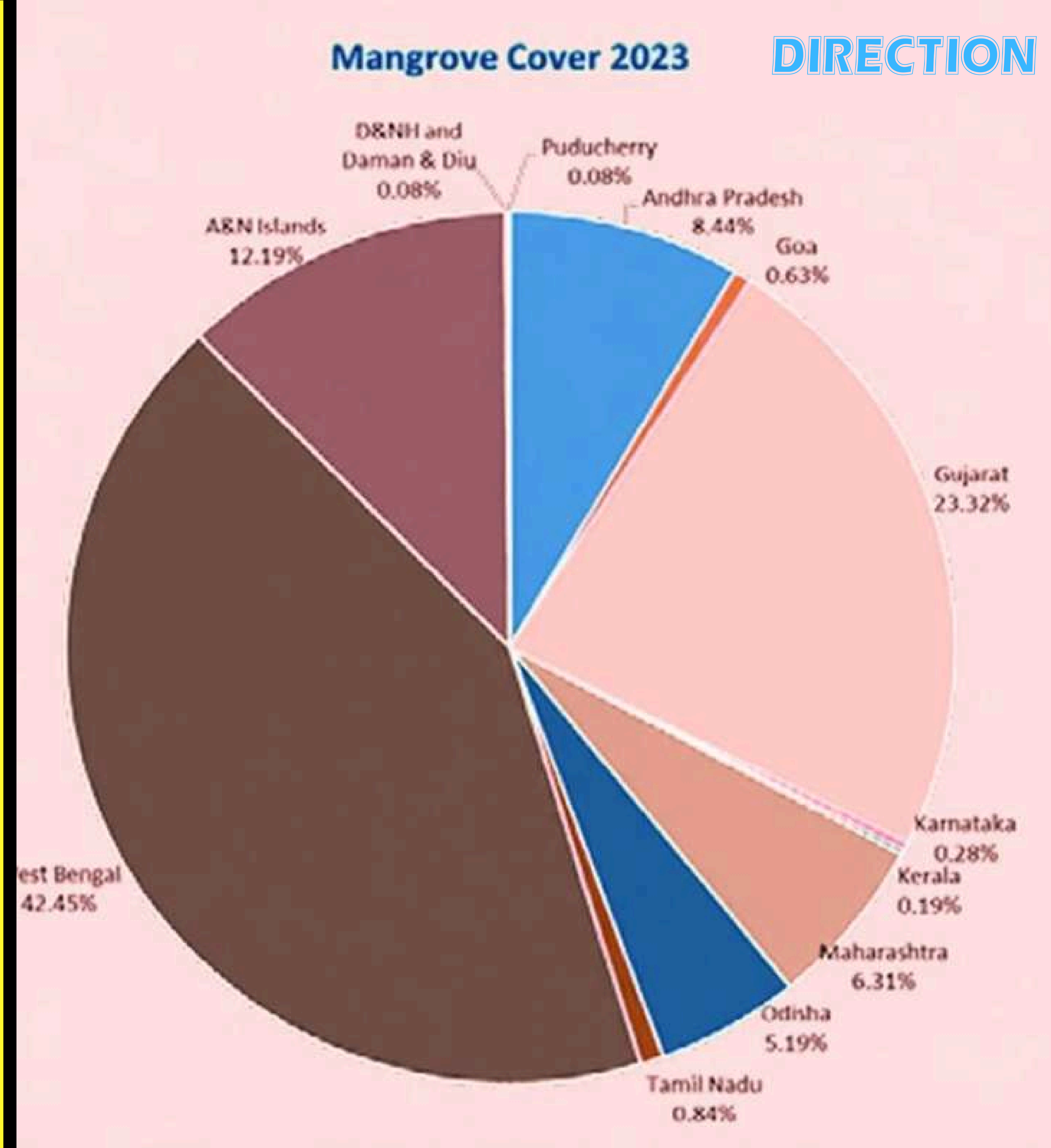
Mangrove Cover: Total Mangrove cover in India: 4,991.68 sq km or 0.15% of the geographical size of the country.

Breakdown of Mangrove cover: Very Dense Mangroves: 1,463.97km² of the total area with 29.33% of cover.

Moderately Dense Mangroves: 1,500.84 km² (30.07%).

Open Mangroves: 2,026.87 km² (40.60%).

Change in Mangrove cover: It is still lower by 7.43 KM² from the total area assessed in 2021.



Fire incidents have also decreased, with 203,544 fire hotspots recorded in 2023-24, down from 223,333 in 2021-22.

Forest and SDGs

Forests are important since they help in maintaining and upgrading the environment quality which is beyond quantification. But with more and more fragmentation in the forests, there is deterioration in the quality of the services provided by the forests. Owing to the importance of the forestry sector, the agreement on the first-ever United Nations Strategic Plan for Forests (2017-2030) was forged at a special session of the UN Forum on Forests in January 2017 and the Plan was adopted by the UN General Assembly on 27 April 2017. The Strategic Plan features a set of six Global Forest Goals and 26 associated targets to be archive by 2030, which are voluntary and universal.

Carbon Stock: The total carbon stocked in the forests is divided into five pools by Good Practice Guidance (GPG) of the Intergovernmental Panel for Climate Change (IPCC). The living portion of biomass carbon is classified as 'above ground biomass (AGB)' and 'below ground biomass (BGB)' and stores significant amount of carbon. The 'dead organic matter (DOM)' is classified as 'dead wood' and 'litter'. The fifth pool is 'soil organic matter' which contains substantial amount of organic carbon.

1

- **Global Forest Goal 1:** Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change.

2

- **Global Forest Goal 2:** Enhance forest-based economic, social and environmental benefits, including by improving the livelihoods of forest-dependent people.

3

- **Global Forest Goal 3:** Increase significantly the area of protected forests worldwide and other areas of sustainably managed forests, as well as the proportion of forest products from sustainably managed forests.

4

- **Global Forest Goal 4:** Mobilize significantly increased, new and additional financial resources from all sources for the implementation of sustainable forest management and strengthen scientific and technical cooperation and partnerships.

5

- **Global Forest Goal 5:** Promote governance frameworks to implement sustainable forest management, including through the UN Forest Instrument, and enhance the contribution of forests to the 2030 Agenda.

6

- **Global Forest Goal 6:** Enhance cooperation, coordination, coherence and synergies on forest-related issues at all levels, including within the UN System and across Collaborative Partnership on Forests member organizations, as well as across sectors and relevant stakeholders.

Indicators under Condition account of Forest Ecosystems

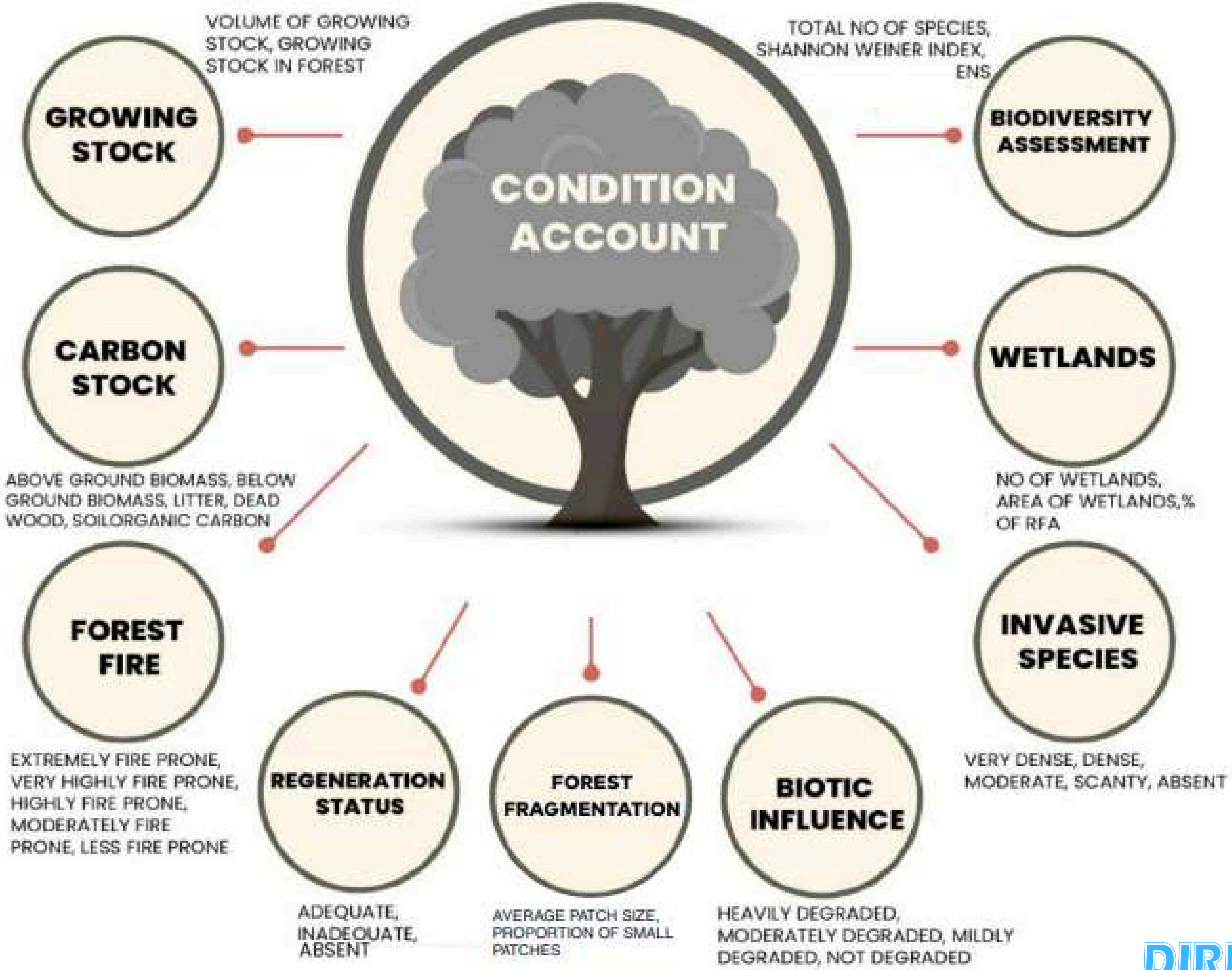


Table *Classification of carbon stock in forests under different carbon pools*

Pools		Description
Living Biomass	Above ground biomass (AGB)	All living biomass above the soil including stem, stump, branches, bark, seeds and foliage.
	Below ground biomass (BGB)	All living biomass of live roots. Fine roots of less than 2mm diameter (country specific) are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead Organic Matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing or lying on the ground. Dead wood also includes dead roots and stumps larger than or equal to 10cm in diameter or any other diameter used by the country.
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for FSI 5 cm), lying dead, in various states of decomposition above the mineral or organic soil.
Soil	Soil organic matter	Includes organic carbon in mineral and organic soils (including peat) to a specific depth chosen by the country (for FSI 30 cm) and applied consistently through the time series.

India's Integrated Vision for Forests, Food, and Sustainability

DIRECTION

DIRECTION

National Agroforestry Policy

Agroforestry is a sustainable land-use system that integrates trees and crops to enhance agricultural productivity, improve soil fertility, and provide an additional income source for farmers. Recognizing its potential, the Government of India introduced the National Agroforestry Policy in 2014 to promote tree plantation in farmland.

It is a combination of practicing agriculture and forestry together on same land

What are the components of agroforestry?

There are three main components of agroforestry — crops, trees and livestock.

What are the major agroforestry systems based on the type of component?

Agroforestry systems are classified into three categories based on the types of components: Agrisilviculture (crops + trees), silvopastoral (pasture/livestock + trees); and Agrosilvopastoral (crops + pasture + trees).

What are the major attributes that agroforestry systems should possess?

There are three attributes of agroforestry systems:

Productivity: Production of preferred goods and increasing productivity of land

Sustainability: Conserving the production potential

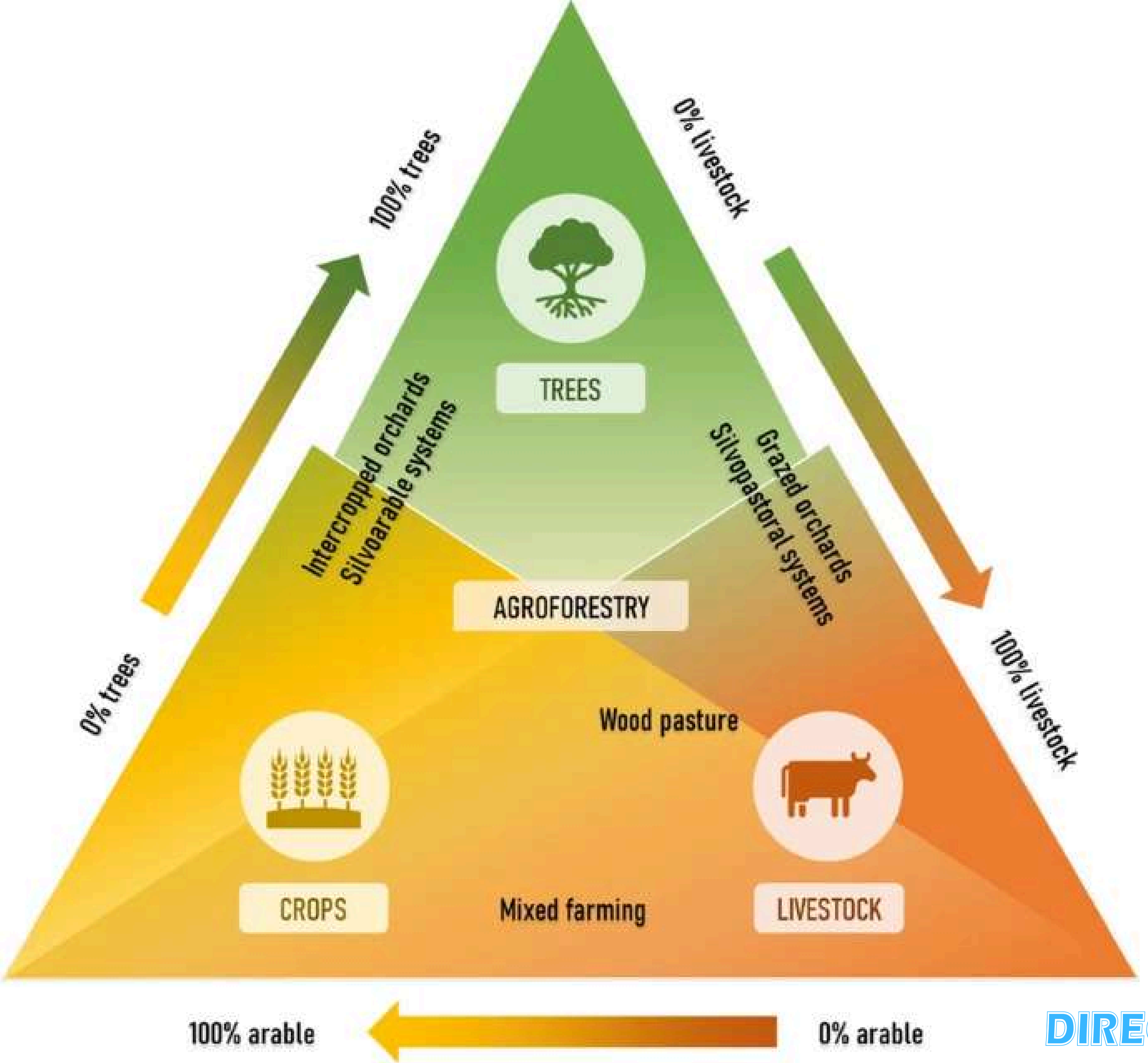
Adoptability: Acceptance of the prescribed practice

What are the trees suitable for rainfed areas?

Neem, Pongamia, Sandalwood and Anjan tree among others

What are the tree crops suited for saline / sodic lands?

Eucalyptus, Casuarina, Pongamia, Neem and Flame of Forest among others



100% trees
0% livestock
TREES
Intercropped orchards
Silvoarable systems
Grazed orchards
Silvopastoral systems
AGROFORESTRY
0% trees
100% livestock
Wood pasture
CROPS
Mixed farming
LIVESTOCK
100% arable
0% arable

DIRECTION

Key objectives

- Enhance farmer livelihoods:
- Improve productivity, employment, and income for rural households, especially smallholder farmers, by integrating trees with crops and livestock.
- Increase forest/tree cover:
- Boost the overall tree cover in the country by promoting plantation on agricultural lands.
- Promote environmental security:
- Protect ecosystems, increase carbon sinks, and make farming systems more resilient to climate change.
- Meet industrial demand:
- Supply timber and other products to wood-based industries, reducing the need for imports.
- Implementation and support

Sub-Mission on Agroforestry (SMAF):

Launched in 2016-17 under the National Mission for Sustainable Agriculture to promote tree plantations on farmland with the motto "Har Medh Par Ped" (A tree on every bund).

- Support for quality planting material: The program emphasizes the production and distribution of high-quality seedlings.
- Financial incentives: The SMAF scheme provides financial assistance for seedlings, planting, and protection.
- Coordination: The policy aims to coordinate efforts among various government departments related to agriculture, forestry, environment, and rural development.

Green India Mission

MISSION

The Green India Mission (GIM) also known as National Mission for a Green India, is a key part of India's National Action Plan on Climate Change (NAPCC). It is one of the eight missions under NAPCC. The mission aims to protect, restore, and enhance India's forest cover while tackling climate change. GIM focuses on improving biodiversity, water resources, and ecosystems like mangroves and wetlands, all while helping absorb carbon. The activities under GIM were started in the FY 2015-16.

Mission Goals:

Expand forest/tree cover by 5 million hectares (mha) and improve the quality of another 5 mha of forest and non-forest land.

Boost ecosystem services like carbon storage, water management, and biodiversity.

Improve livelihoods for 3 million households by increasing income from forest-based activities.

Sub-Missions:

GIM has five sub-missions, each focused on a different aspect of greening:

- Enhancing Forest Cover – Improving Forest quality and ecosystem services.
- Ecosystem Restoration – Reforesting and increasing forest cover.
- Urban Greening – Adding more trees in cities and nearby areas.
- Agro-Forestry & Social Forestry – Boosting biomass and creating carbon sinks.
- Wetland Restoration – Reviving critical wetlands.

National Action Plan on Forest Fire

The primary forest fire prevention and management scheme is a Centrally Sponsored Scheme (CSS) of the Ministry of Environment, Forest and Climate Change (MoEFCC) in India that provides financial and technical assistance to states and Union Territories. It is complemented by the National Action Plan on Forest Fires (2018), which provides a framework for states to develop their own action plans. Key elements include early warning systems, community participation, prevention measures like fire line creation, modern firefighting equipment, and capacity building for staff and communities.

Key components of the scheme

Financial assistance:

The MoEFCC provides funding to states, with a cost-sharing ratio of 90:10 for the Northeast and Western Himalayan regions and 60:40 for other states.

National Action Plan on Forest Fires:

This plan provides a comprehensive strategy, guiding states to create their own plans based on local needs.

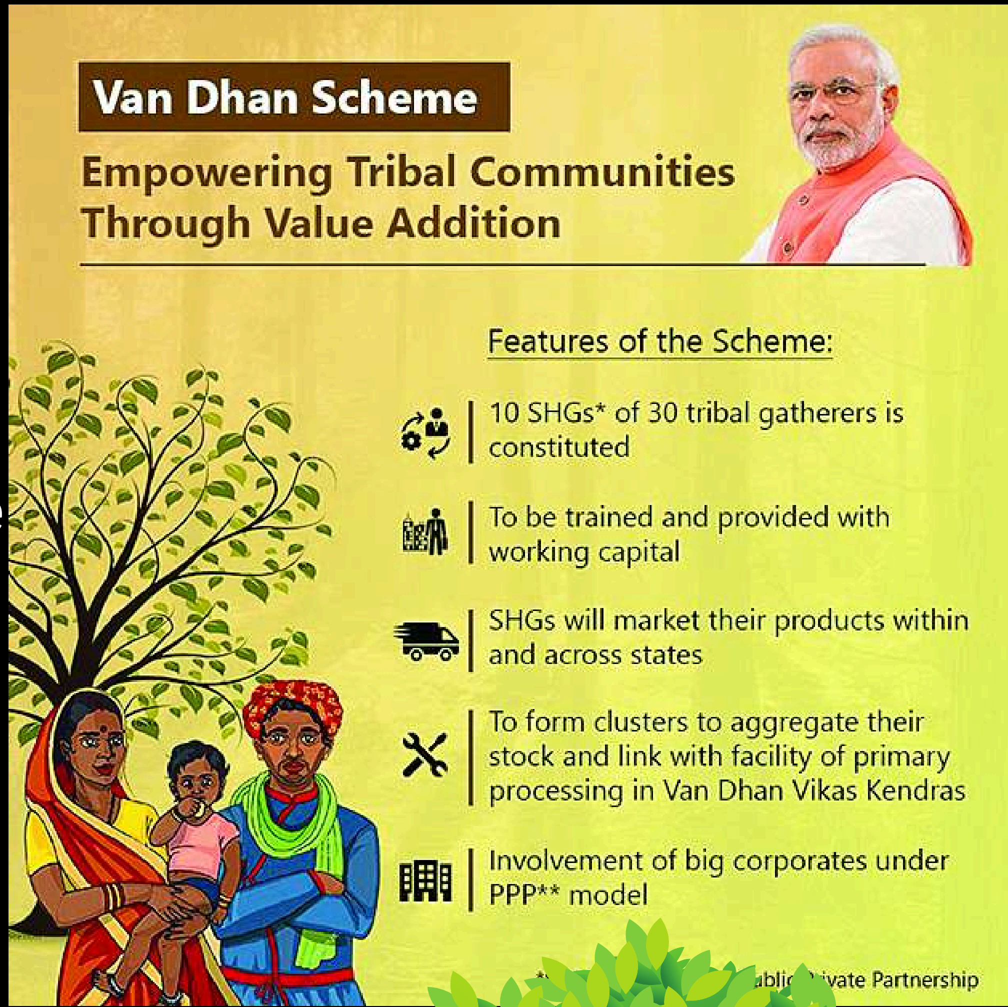
Early warning systems:

The Forest Survey of India (FSI) provides one-week advance and near real-time alerts through a satellite-based system via SMS and email.

Community participation:

The scheme emphasizes involving and empowering forest fringe communities and incentivizing their participation in prevention and control efforts.

Pradhan Mantri Van Dhan Yojana (PMVDY) or Van Dhan Vikas Yojana (VDVY) is a scheme launched by the Ministry of Tribal Affairs, Government of India, with the aim of improving the livelihood of tribal communities in India. The scheme focuses on developing value chains for forest-based products and enhancing the income of tribal communities by providing them with skill training and capacity building. The Van Dhan Vikas Yojana has the potential to transform the lives of tribal communities in India by providing them with alternative livelihood opportunities and improving their socio-economic status. The scheme not only promotes entrepreneurship but also helps in the conservation of forests and the protection of biodiversity.



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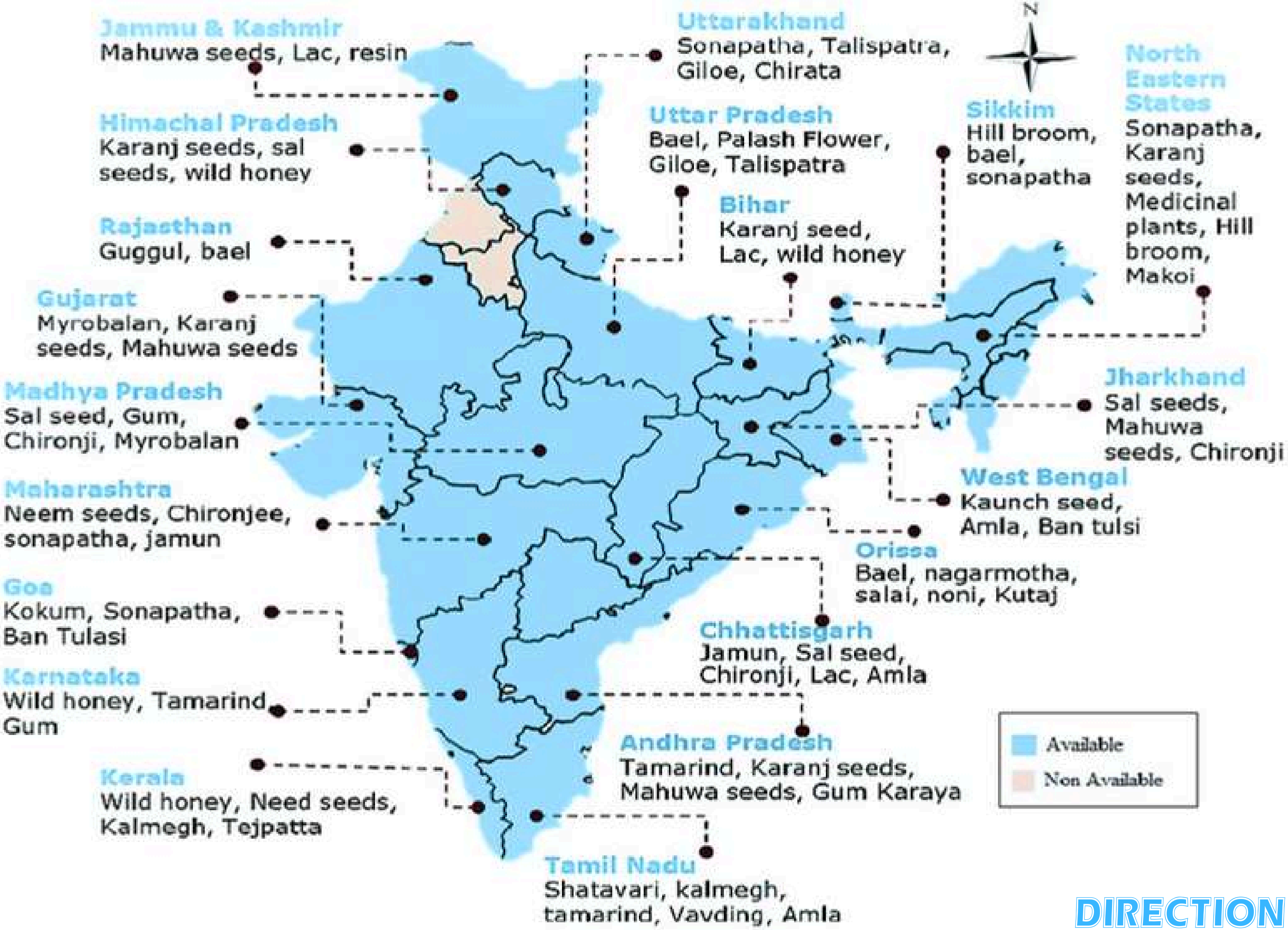

Jammu & Kashmir
Mahuwa seeds, Lac, resin
Himachal Pradesh
Karanj seeds, sal seeds, wild honey
Rajasthan
Guggul, bael
Gujarat
Myrobalan, Karanj seeds, Mahuwa seeds
Madhya Pradesh
Sal seed, Gum, Chironji, Myrobalan
Maharashtra
Neem seeds, Chironjee, sonapatha, jamun
Goa
Kokum, Sonapatha, Ban Tulasi
Karnataka
Wild honey, Tamarind, Gum
Kerala
Wild honey, Need seeds, Kalmegh, Tejpatta
Uttarakhand
Sonapatha, Talispatra, Giloe, Chirata
Uttar Pradesh
Bael, Palash Flower, Giloe, Talispatra
Bihar
Karanj seed, Lac, wild honey
N
Sikkim
Hill broom, bael, sonapatha
North Eastern States
Sonapatha, Karanj seeds, Medicinal plants, Hill broom, Makoi
Jharkhand
Sal seeds, Mahuwa seeds, Chironji
West Bengal
Kaunch seed, Amla, Ban tulsi
Orissa
Bael, nagarmotha, salai, noni, Kutaj
Chhattisgarh
Jamun, Sal seed, Chironji, Lac, Amla
Andhra Pradesh
Tamarind, Karanj seeds, Mahuwa seeds, Gum Karaya
Tamil Nadu
Shatavari, kalmegh, tamarind, Vavding, Amla
Available
Non Available

DIRECTION

The scheme, **Nagar Van Yojana (NVY)** has been launched during the year 2020, for creation of Nagar Vans in urban areas, which promotes urban forestry by involving local communities, NGOs, educational institutions, local bodies, etc.

Nagar Van Yojana envisages creating 1000 Nagar Van / Nagar Vatika in Cities having Municipal Corporation/Municipal council/Municipality/Urban Local Bodies (ULBs) for providing wholesome healthy living environment for the residents and thus contributing to growth of clean, green, healthy and sustainable cities. **The salient features of Nagar Van Yojana are:**

- Creating green space and aesthetic environment in an urban set up.
- Creating awareness about plants and biodiversity and developing environment stewardship.
- Facilitating in-situ conservation of important flora of the region.
- Contributing to environmental improvement of cities by pollution mitigation, providing cleaner air, noise reduction, water harvesting and reduction of heat islands effect.
- Extending health benefits to residents of the city and
- Helping cities become climate resilient.

MISHTI (Mangrove Initiative for Shoreline Habitats & Tangible Incomes)

The "Conservation and Management of Mangroves and Coral Reefs" program under **the National Coastal Mission** provides financial and technical assistance to coastal states and union territories for protecting and managing these ecosystems. It involves developing and implementing annual Management Action Plans (MAPs) for activities like survey, demarcation, and restoration, with a 60:40 cost-sharing model between the central and state governments.

It includes subset - **MISHTI India's main scheme for mangrove restoration**

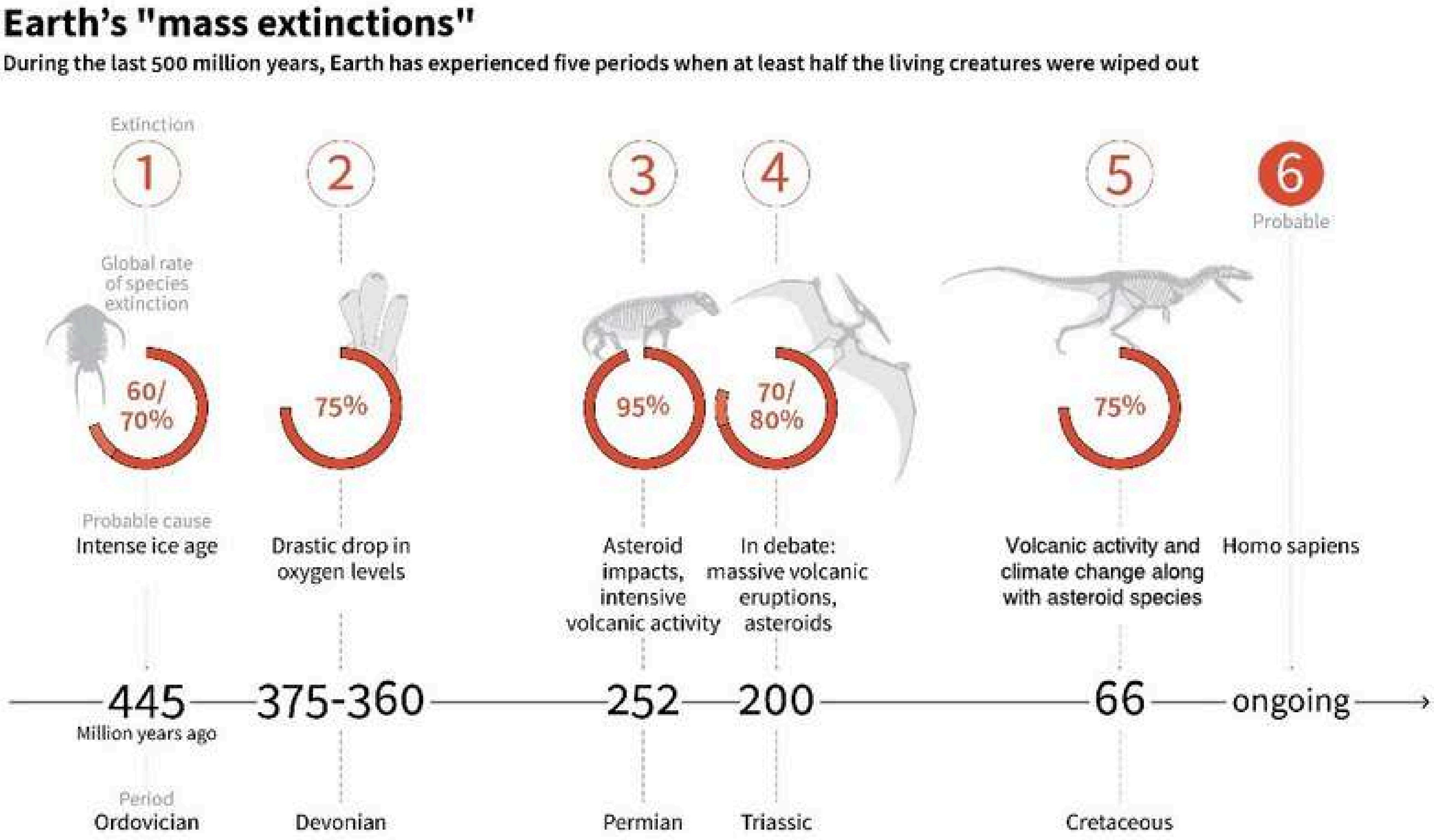
- Objective: To restore and afforest mangrove forests along India's coast.
- Scope: To restore approximately 540 sq. km of mangroves over a five-year period starting in 2023-24, across nine coastal states and three Union Territories.
- Funding: It is funded through a convergence of schemes, including the National Compensatory Afforestation Fund Management and Planning Authority (CAMPA) and the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS).

Compensatory Afforestation Fund Management and Planning Authority (CAMPA): This scheme compensates for the loss of forest cover and ecosystem services caused by the diversion of forest land for non-forestry purposes, in line with the Van Sanrakshan Evam Samvardhan Adhiniyam, 1980.

Joint Forest Management and Eco Development Committees: In line with the National Forest Policy of 1988, the Ministry has promoted community involvement through Joint Forest Management Committees (JFMCs) for better forest and wildlife protection, ensuring local participation in management and conservation activities.

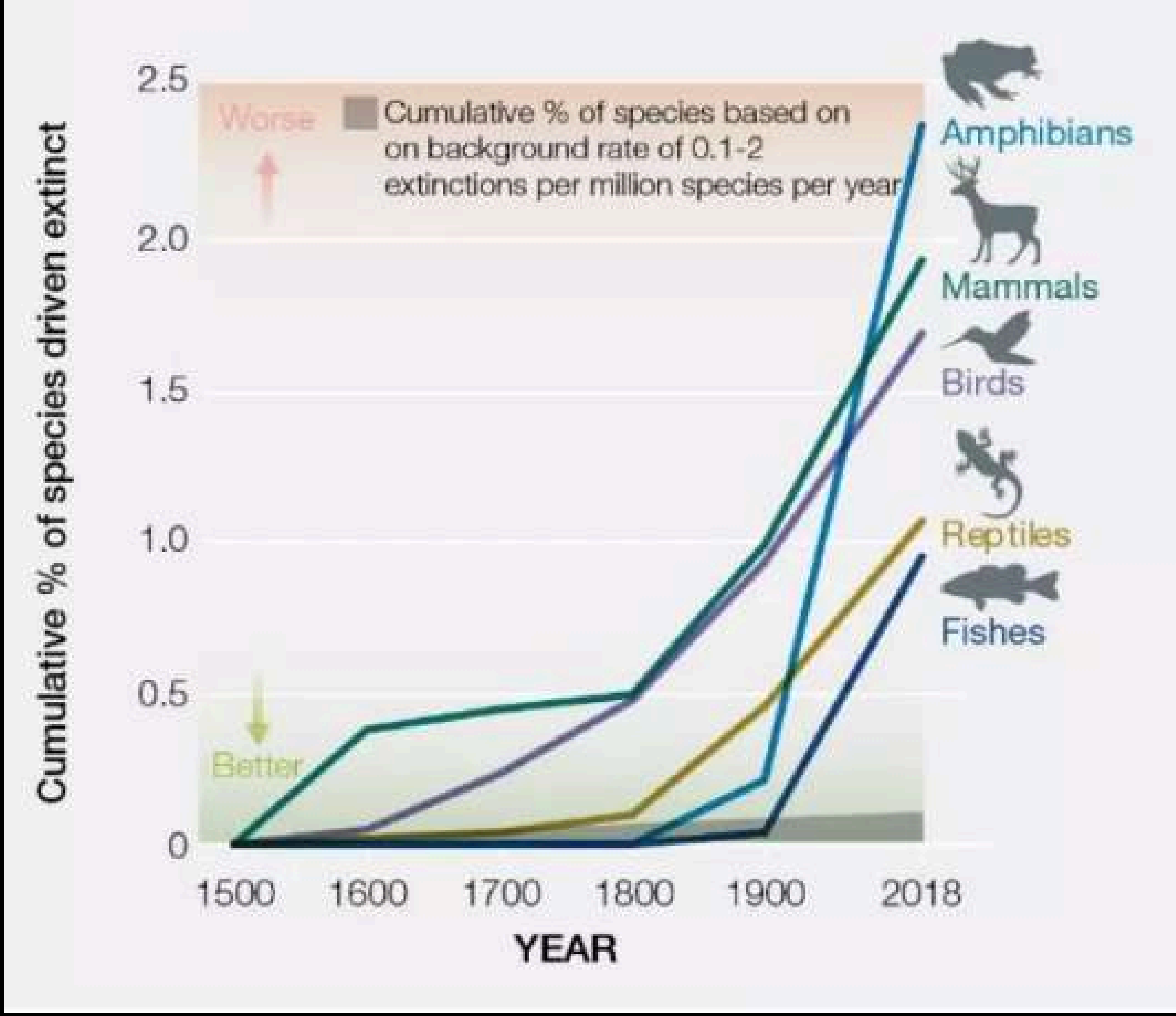
DIRECTION

Biodiversity Loss



Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Often described as the 'IPCC for Biodiversity', the IPBES is the independent international body which inform policy on biodiversity and ecosystems. provides decision-makers with the most comprehensive scientific information on nature-related issues.



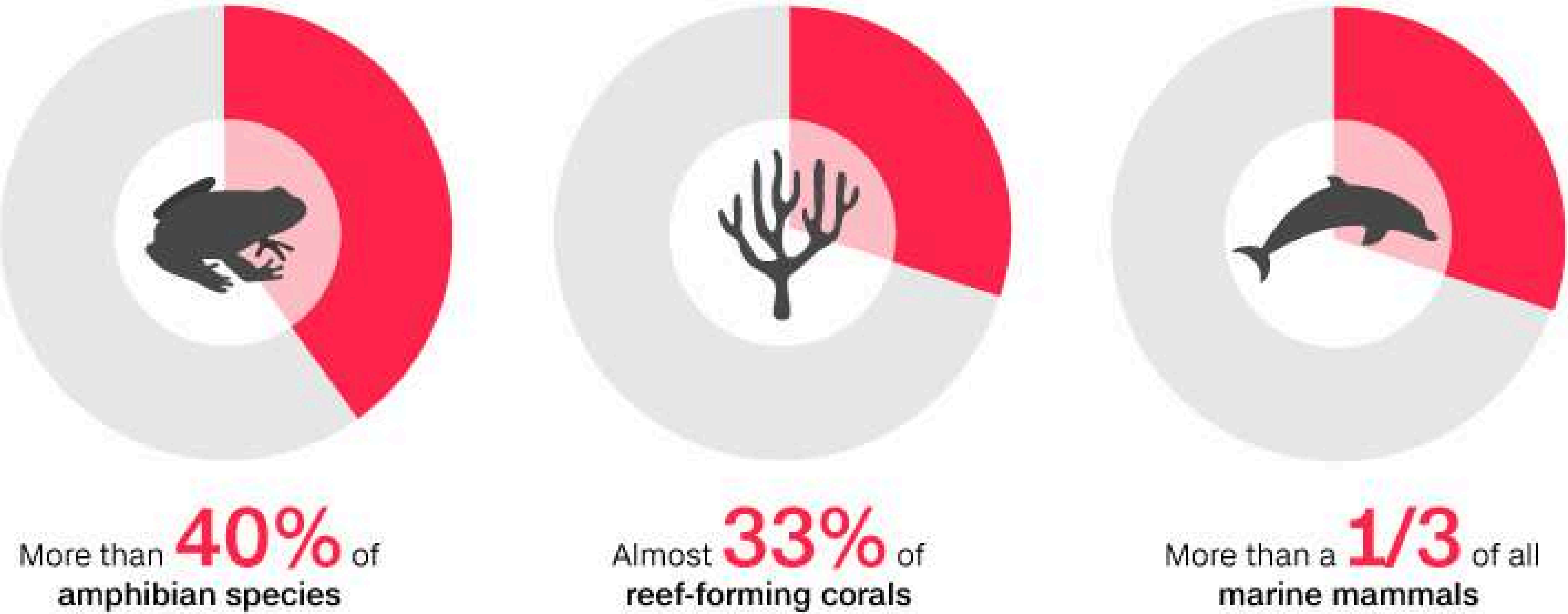
DIRECTION

RISKS

The report lists a number of key global threats, from humans' use of land and sea resources to challenges posed by climate change, pollution and invasive species.

- Loss of the natural world affects human societies.
- Disappearance of insects vital for pollinating food crops.
- Destruction of coral reefs that support fish populations that sustain coastal communities.
- Loss of medicinal plants.
- 40 per cent of the amphibian species are threatened with extinction.
- Almost 33 per cent of reef-forming corals and more than a third of all marine mammals are threatened.
- The average abundance of native species in most major land-based habitats has fallen by at least 20%, mostly since 1900.

RANGE OF RISKS



DIRECTION

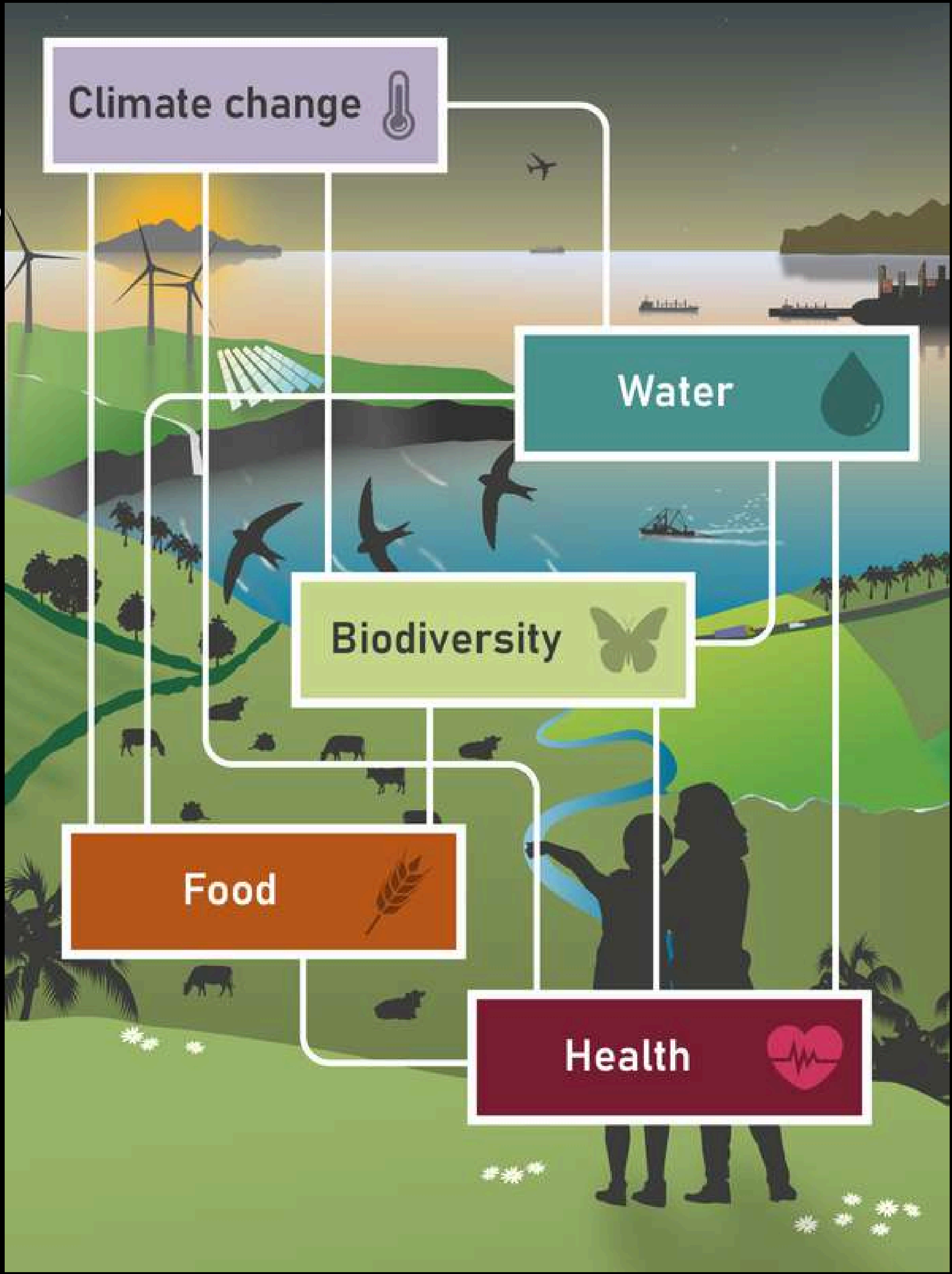
REPORT’S NOTABLE FINDINGS

- 75% of land environment and some 66% of the marine environment “have been significantly altered by human actions.”
- “More than a third of the world’s land surface and nearly 75% of freshwater resources” are used for crops or livestock.
- “Up to $577 billion in annual global crops are at risk from pollinator loss.”
- Between 100 million and 300 million people now face “increased risk of floods and hurricanes because of loss of coastal habitats and protection.”
- Since 1992, the world’s urban areas have more than doubled.
- “Plastic pollution has increased tenfold since 1980,” and from “300-400 million tons of heavy metals, solvents, toxic sludge” and other industrial waste are dumped into the world’s water systems.

DIRECTION

The Nexus Report-2024

Biodiversity loss, water scarcity, food security, human health, and climate change are not isolated issues. They are indivisible, interrelated and interdependent. As they are intricately linked when one falters, the others follow. The IPBES Nexus Assessment is the first comprehensive global assessment that looks at the interlinkages between these crises and identifies solutions



DIRECTION

According to IPBES assessments, the five main direct drivers of biodiversity loss are: land/sea-use change, direct exploitation of organisms, climate change, pollution, and invasive alien species. These direct drivers are exacerbated by indirect socioeconomic drivers like population growth, consumption patterns, and economic systems

The assessment emphasized that traditional, siloed approaches to these issues are insufficient and often worsen other problems. Integrated actions, on the other hand, can achieve mutually supportive benefits and offer significant cost savings.
Taken together, support the achievement of all 17 SDGs, all 23 targets of the Kunming-Montreal Global Biodiversity Framework and the long-term goals for climate change mitigation and adaptation of the Paris Agreement. Twenty-four of the response options advance more than five SDGs and over five of the Global Biodiversity Framework targets.

DIRECTION

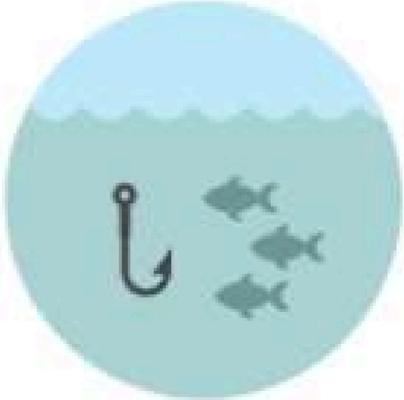
Main Causes of Loss

1

Changes in land and sea use

Humans have altered **75%** of land and **66%** of marine environments since pre-industrial times.

2



Direct exploitation of organisms

In 2015, a **third** of marine stocks were being fished at unsustainable levels.

3

Climate change

Global warming has already impacted almost **half** of threatened mammals and **one quarter** of birds.

4

Pollution

Marine plastic pollution has increased tenfold since 1980, with an average **300-400M** tons of waste dumped annually into the world's waters.

5

Invasive alien species

The numbers of invasive alien species per country have risen by about **70%** since 1970.

The more than 70 response options presented in the report, these options are designed to maximize co-benefits across sectors and are organized into 10 broad categories of action.

Ten categories of action

Sustainable production and consumption: Reducing waste, promoting resource efficiency, and shifting to consumption patterns that have a lower environmental impact.

Integrated landscape and seascape management: Coordinated management of ecosystems across different land and sea uses to balance conservation with human needs. This includes restoring carbon-rich ecosystems like forests, soils, and mangroves.

Governance, institutions, and policies: Implementing legal and policy reforms that promote inclusivity and strengthen the links between sectors.

DIRECTION

Addressing drivers of change: Tackling the underlying indirect drivers, such as overconsumption and population growth, that intensify biodiversity loss.

Economic and financial reforms: Reforming subsidies that harm nature and exploring new financing mechanisms that support biodiversity-positive activities.

Inclusive decision-making: Actively involving Indigenous Peoples, local communities, and vulnerable groups in developing and implementing solutions.

Nature-based solutions: Protecting, sustainably managing, and restoring natural or modified ecosystems to address societal challenges effectively.

Education and awareness: Promoting learning and raising awareness to shift societal values and behaviors towards sustainability.

Technology and innovation: Utilizing new technologies and traditional knowledge to create and improve sustainable practices.

Monitoring and adaptive management: Continuously monitoring the impacts of response options and adapting strategies based on new information.

The IPBES Transformative Change Assessment-2024

The IPBES Transformative Change Assessment identifies five key actions for achieving fundamental, system-wide shifts to address the drivers of biodiversity loss. These are: conserving and regenerating nature, driving systemic change in major sectors, transforming economic systems, improving governance systems, and shifting societal values.

Key actions for transformative change

- Conserve, restore, and regenerate nature: This includes protecting and restoring places that are valuable to both nature and people, using approaches based on stewardship.
- Drive systemic change in key sectors: Focus on sectors most responsible for biodiversity loss, such as agriculture, fisheries, forestry, and fossil fuels, by changing their practices and operations.
- Transform economic systems: Shift away from current economic models to ones that prioritize both nature and social equity.
- Transform governance systems: Make governance systems more inclusive, accountable, and adaptive by involving a diverse range of stakeholders in decision-making.
- Shift views and values: Move toward a societal recognition of the deep inter connected ness between humans and nature, and prioritize this relationship.

Living Planet Report 2024

Every two years WWF, in collaboration with the Zoological Society of London (ZSL), publishes an updated Living Planet Report.

The WWF's 2024 Living Planet Report found a 73% average decline in monitored wildlife populations between 1970 and 2020, with the steepest declines in Latin America and the Caribbean (95%), Africa (76%), and Asia-Pacific (60%). The report highlights habitat loss, degradation, and overexploitation as the primary threats, and warns that the planet is nearing dangerous tipping points for ecosystems like tropical forests and coral reefs

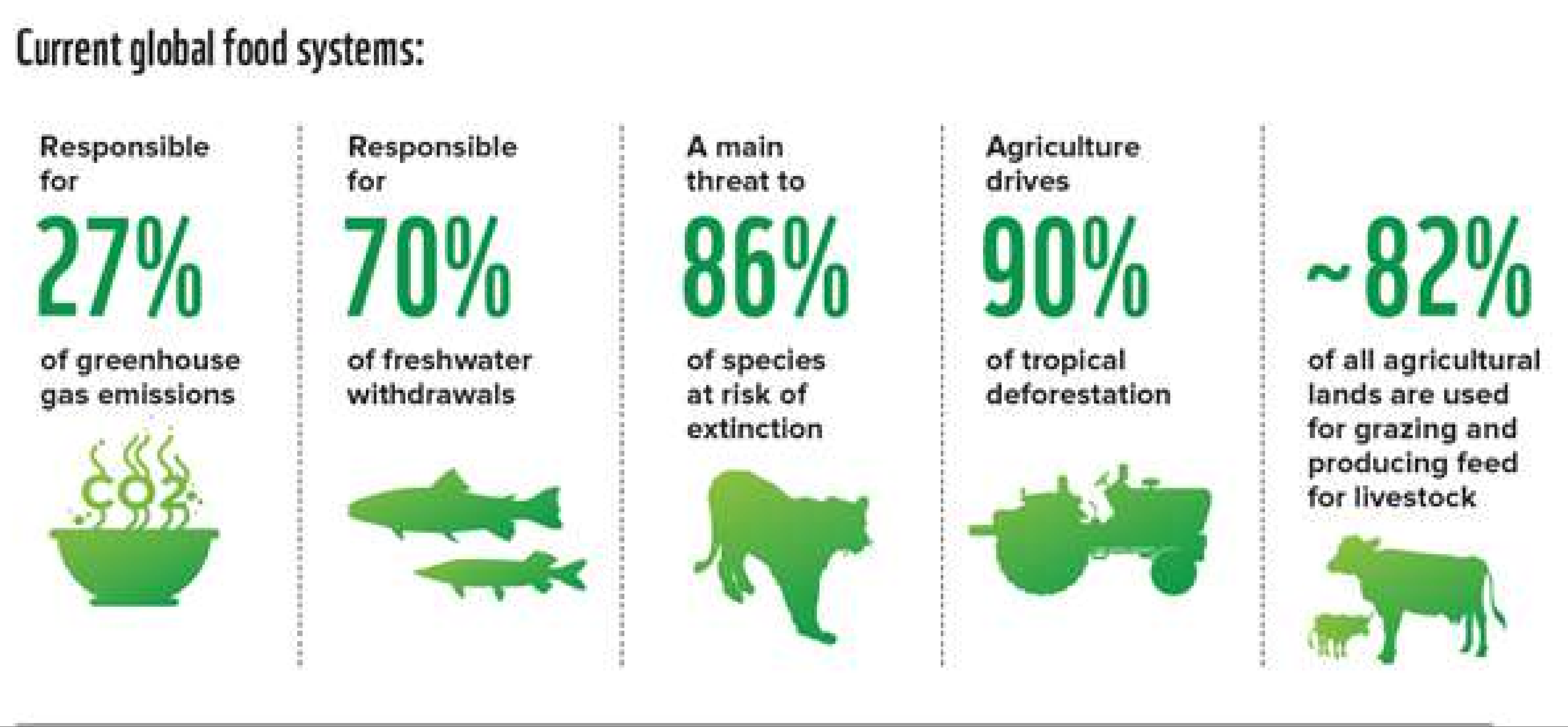
Key findings

- **Global decline:** The average size of monitored vertebrate populations has dropped by 73% since 1970.
- **Freshwater species hit hardest:** Freshwater species experienced an 85% decline, followed by terrestrial (69%) and marine populations (56%).
- **Regional disparities:** Latin America and the Caribbean saw a 95% decline, while Africa had a 76% drop and Asia-Pacific experienced a 60% decline. North America and Europe saw lower but still significant declines of 39% and 35%, respectively.
- **Primary threats:** Habitat loss and degradation, driven mainly by the food system, are the most reported threats worldwide. Other major threats include overexploitation, invasive species, disease, and climate change.
- **Tipping points:** The report warns that ecosystems like tropical forests and coral reefs are approaching critical tipping points that could have irreversible and catastrophic consequences.

UNSUSTAINABLE FOOD SYSTEMS

Experts identify food production as one of the main drivers of nature decline. It's the leading cause of habitat loss – with forests, wetlands, and other biodiversity hotspots cleared for agriculture.

Humans use over 40% of habitable land for food production. Crop production accounts for 70% of freshwater use. And the entire food sector is responsible for over a quarter of greenhouse gas emissions.



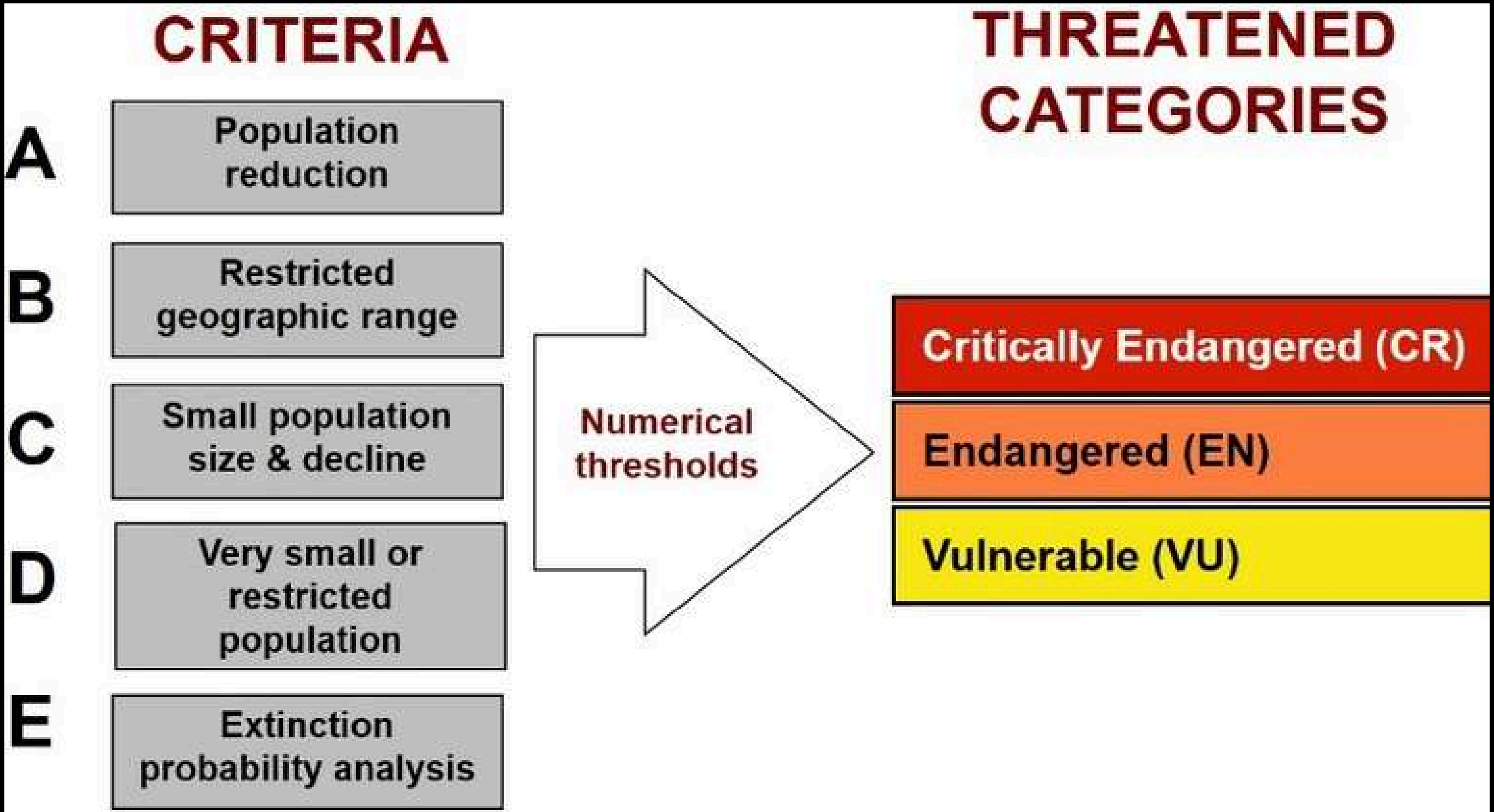
State of the World's Birds 2024

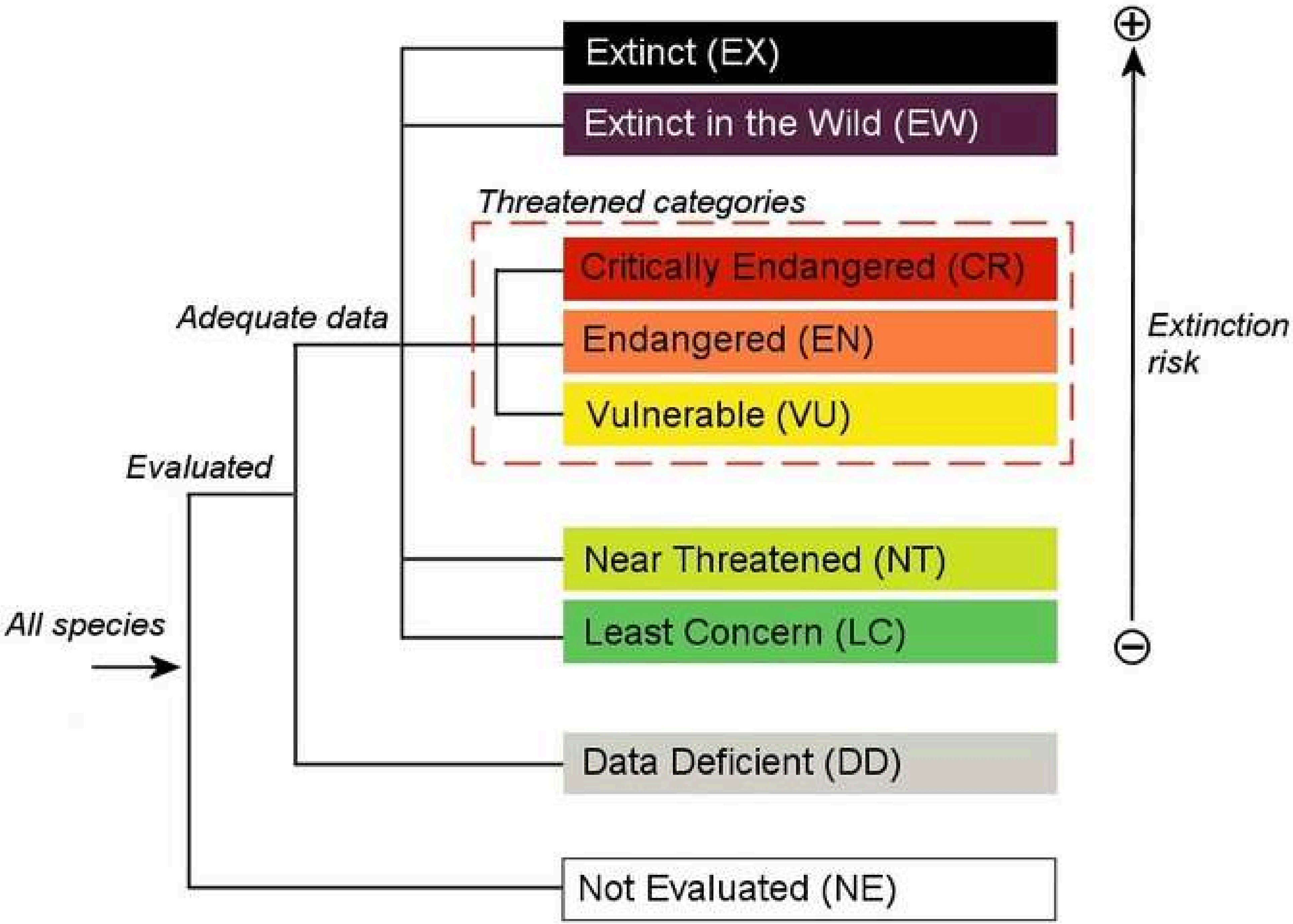
BirdLife International is the official Red List Authority for birds, responsible for assessing and documenting the global extinction risk of all 11,000+ species for the IUCN Red List.

The "State of the Birds 2024" reports highlight global threats to bird populations from climate change and habitat loss, with a significant portion of species declining.

Species threat:

- Climate change and human activities are impacting bird populations worldwide. In the 2024 Red List update, five species were reclassified as extinct, and several others moved to higher threat categories, though some species show recovery due to conservation efforts.




Extinct (EX)
Extinct in the Wild (EW)
Threatened categories
Critically Endangered (CR)
Endangered (EN)
Vulnerable (VU)
Adequate data
Evaluated
Near Threatened (NT)
Least Concern (LC)
All species
Data Deficient (DD)
Not Evaluated (NE)
Extinction risk
⊕
⊖

Among the species moved to higher threat categories were several island endemics suffering the **impacts of invasive species.**

Two of **Hawaii's honeycreepers**—Anianiau Magumma parva and Kauai Amakihi Chlorodrepanis stejnegeri—moved from Vulnerable to Endangered following estimated population declines of more than 60% during 2008–2018, largely as a result of avian malaria carried by introduced mosquitos.

DIRECTION

Elsewhere, Juan Fernandez Tit-tyrant , endemic to Robinson Crusoe Island off the coast of Chile, was uplisted from Near Threatened to Endangered after invasive plants and introduced predators drove rapid population declines.
Forest loss also continues to drive population declines worldwide. Citron-throated Toucan was moved from Least Concern to Near Threatened due to the ongoing effects of forest loss in South America, while in South-East Asia, Cinnamon-rumped Trogon Harpactes orrhophaeus was uplisted from Near Threatened to Vulnerable due to loss and fragmentation of its lowland forest habitat.

Regional findings

India:

A report noted that of 942 species studied, 142 were in decline, with the Great Indian Bustard, White-bellied Heron, and Bengal Florican among the most threatened. The report also noted that 28 species, including the Indian Peafowl and Rock Pigeon, were thriving.

North America:

Habitat loss and degradation are identified as the biggest threats to Canada's bird populations, particularly to grassland and wetland ecosystems.

Migratory birds:

A global report from BirdLife International highlights a severe decline in migratory shorebird populations and a 15% decline in the abundance of all migratory species in general

State of India's Birds 2023

The "State of India's Birds 2023" report, based on citizen science data, reveals a significant decline in many bird species, with 60% of species showing long-term declines and 39% currently declining. The report highlights that habitat specialists, particularly in grasslands, open habitats, and wetlands, are most affected, though a few common species like the Indian peafowl and Asian koel have increased in numbers.

Key findings

Widespread decline:

A significant percentage of species are declining, with 60% of species assessed for long-term trends and 39% for current trends showing a downward trend.

Habitat loss:

Birds that depend on specific habitats like grasslands, open areas, and wetlands are experiencing particularly steep declines.

High-priority species:

The report identifies 178 bird species as "High Priority" for conservation efforts, including many common and widespread species whose populations have dropped substantially.

Migratory bird declines:

Long-distance migratory birds have seen a major decline, with those wintering in India experiencing an 80% drop in numbers.

THREATS TO INDIA'S BIRDS

LOSS OF HABITAT: Forest degradation, change in geography of open habitats, loss of wetlands, riverine nesting places and coastal habitats, owing to urbanisation, infrastructural developments and change in land use patterns. Then there's the rise of monoculture plantations—such as commercial teak, oil palm, tea and coffee plantations—which support fewer bird species than natural forests

CLIMATE CHANGE: Global temperature has risen by 0.8°C in the past 150 years, causing dehydration and exhaustion in birds. Erratic climate patterns also impact avian nesting and breeding behaviour

AVIAN DISEASE: The impact of avian disease on the shrinking bird population in India has not been well researched or documented. In 2020-21, outbreaks of avian influenza across many Indian states resulted in heavy mortality among wild birds

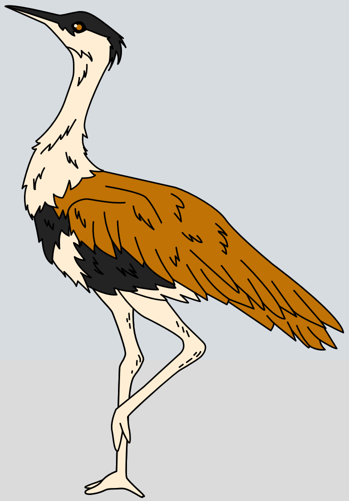
URBAN INFRA: Sound pollution and bright lights of cities may cause disorientation in birds, pushing them to alter their behaviour: urban noise may cause them to sing louder, or at different frequencies. Collisions with glass facades of buildings, wind turbines and power lines are other threats

ILLEGAL HUNTING AND TRADE: Birds continue to be removed from the wild and sold for meat or for entertainment. Thirty-seven seizures of poached birds reported in India in 2020 showed parakeets, owls and vultures to be among species at threat

LACK OF FOOD: Availability of food resources greatly affects bird populations. In India, the most visible decline in numbers has been witnessed among birds that feed on vertebrates and carrion. This implies the presence of contaminants in food

POLLUTION: Exposure to toxic chemicals—heavy metal pollutants, plastics and organophosphates in insecticides—causes hormone disruption in birds, alterations in feeding behaviour and compromised immune system

DIRECTION



Conservation Priority for 942 bird species assessed by State of Indian Birds 2023

HIGH	MOD	LOW
179	323	441

HIGH

LESSER FLORICAN

Sypheotides indicus

Habitat: Grasslands in Gujarat, Rajasthan and Maharashtra

Reason for decline: Invasive species in open habitats, collisions with power lines

DIRECTION

DIRECTION

India is home to nine vulture species:

Resident species

- Indian Vulture (or Long-billed Vulture)
- White-backed Vulture
- Slender-billed Vulture
- Red-headed Vulture
- Bearded Vulture
- Egyptian Vulture

Migratory species

- Cinereous Vulture,
- Griffon Vulture, and
- Himalayan Vulture.

In a country with over <u>307.5 million cattle</u>, obligate scavengers like vultures have a crucial role both in the ecosystem and economy.

India's first vulture conservation portal launched in Assam

DIRECTION

DIRECTION

HIGH

SLENDER-BILLED VULTURE

Gyps tenuirostris

Habitat: from the Gangetic plain north, west to Himachal, south as far as northern Odisha, and east through Assam

Reason for decline: Toxins found in carcasses they eat

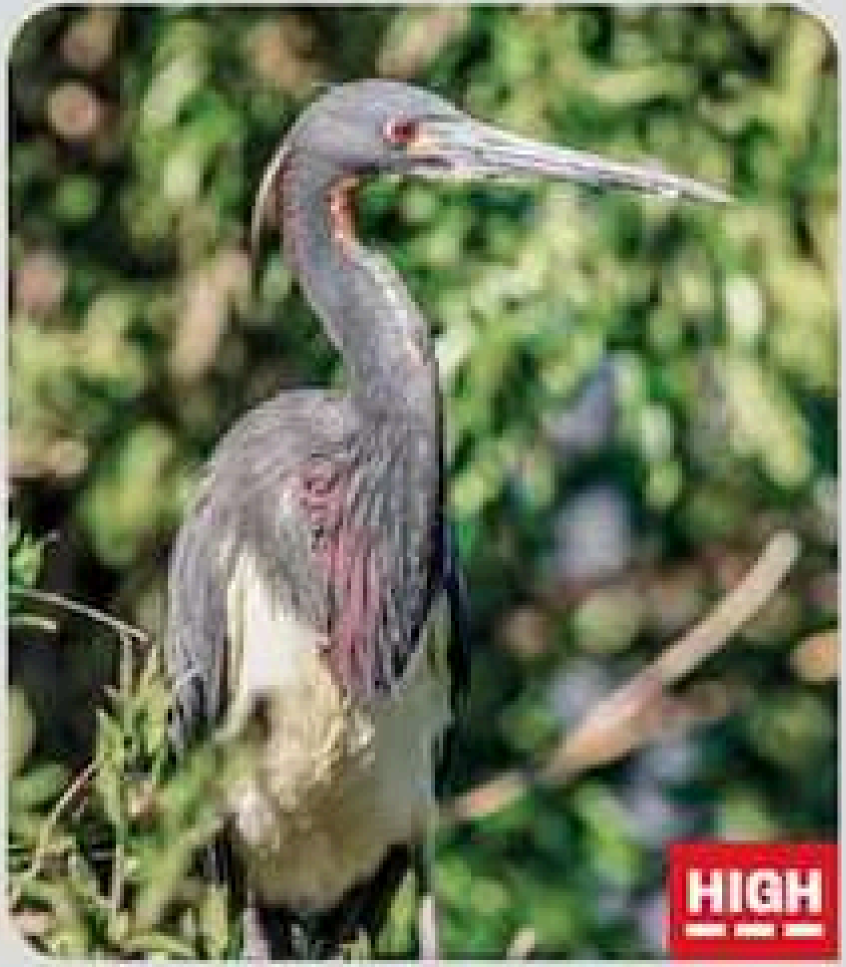
MANIPUR BUSH QUAIL

Perdicula manipurensis

Habitat: Damp grasslands of northeast India

Reason for decline: Drainage and destruction of tall grasslands; illegal trade

HIGH



WHITE-BELLIED HERON
Ardea insignis
Habitat: Wetlands of tropical/ sub-tropical forests in the foothills of the eastern Himalayas of northeast India
Reason for decline: Loss of breeding and feeding grounds

GREAT INDIAN BUSTARD
Ardeotis nigriceps
Habitat: Flat open landscapes in Rajasthan and Gujarat
Reason for decline: Loss and degradation of habitat, hunting

BUGUN LIOCICHLA
Liocichla bugunorum
Habitat: Montane forest and dense undergrowth in Arunachal Pradesh
Reason for decline: Loss of habitat

THE FOREST OWLET
Heteroglaux blewitti
Habitat: Dry deciduous teak forests in central India
Reason for decline: Deforestation, timber logging

BLACK-BELLIED TERN
Sterna acuticauda
Habitat: Wetlands of Andhra Pradesh, Delhi, MP, Odisha, Punjab, Telangana, UP
Reason for decline: Loss of breeding sites, predation by animals

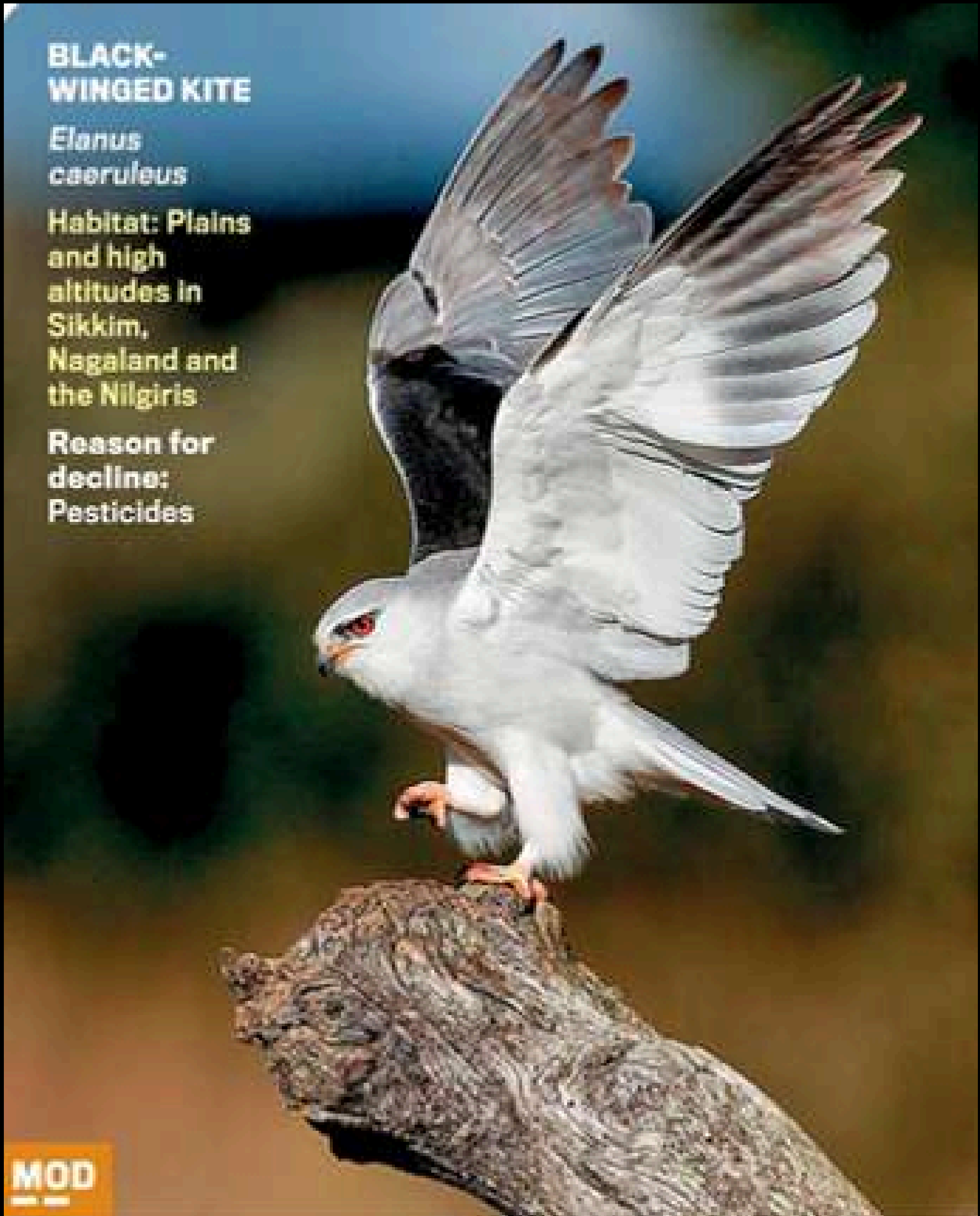
GREATER ADJUTANT
Leptoptilos dubius
Habitat: Open areas in Assam, Bihar
Reason for decline: Loss of nesting and feeding sites

DIRECTION

WHITE-WINGED WOOD DUCK
Asarcornis scutulata
Habitat: Assam and Arunachal Pradesh
Reason for decline: Habitat loss, hunting

SAKER FALCON
Falco cherrug
Habitat: Open areas in Rajasthan, Ladakh
Reason for decline: Habitat loss, scarcity of food, illegal trade

GREATER ADJUTANT
Leptoptilos dubius
Habitat: Open areas in Assam, Bihar
Reason for decline: Loss of nesting and feeding sites

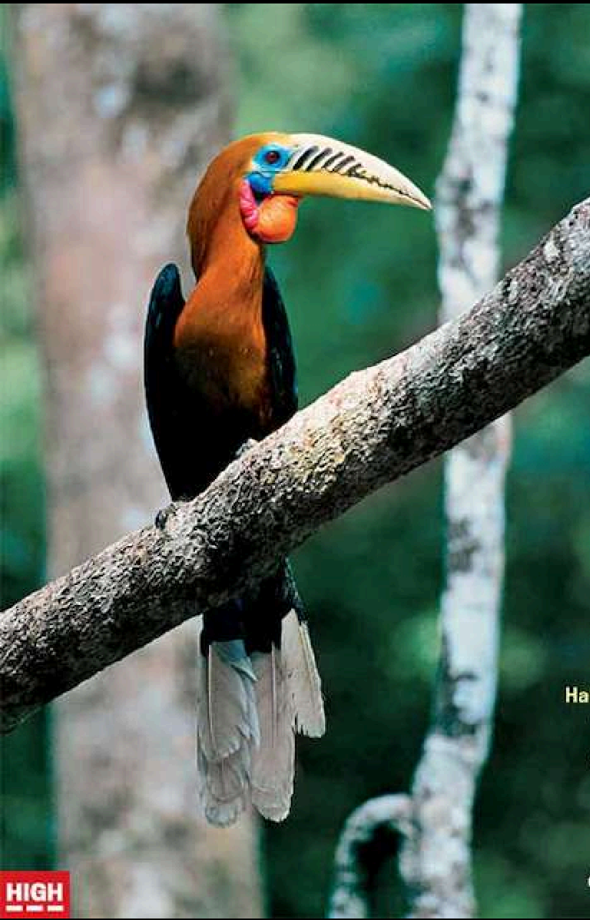


RAPTORS' FALL

TREND: Birds of prey, particularly those in open habitat or forests/ plantations, have showed an annual declining trend of around 50 per cent between 2014 and 2022. While the Pallid harrier has declined by nearly 70 per cent, the Short-toed snake eagle and Western marsh harrier also show decline between 50 and 70 per cent.

WHY: Open-habitat raptors typically feed in farming landscapes, where pesticide is used. Carrion-feeding vultures, specifically, succumbed to livestock drug diclofenac, which gave them kidney issues. Its ban may have improved things, but vultures continue to decline in the country—the Indian vulture by over 8 per cent a year, the Red-headed and White-rumped vultures by over 5 and 4 per cent, respectively. The Egyptian vulture fares only slightly better.

DIRECTION



RUFOUS-NECKED HORNBILL
Aceros nipalensis
Habitat: Forests of Arunachal Pradesh, Sikkim, West Bengal
Reason for decline: Hunting, deforestation

SILENCE OF THE HORNBILL

TREND: India is home to 9 species of hornbills. Of these, the Malabar grey hornbill, found in the Valparai plateau of the Western Ghats, declined by 56 per cent between 2004 and 2018. The Rufous-necked hornbill and Wreathed hornbill are declining.

WHY: Hornbills use the same nest year after year. Their peculiar nesting behaviour makes them particularly susceptible to disruption. Hunting poses another threat to the Great hornbill, the Rufous-necked hornbill and the Wreathed hornbill in parts of the eastern Himalaya. Forests are being lost to illegal logging, land use is changing and monoculture plantations are thriving. In northeast India, only 5 per cent landscape is suitable for these birds.

LOST IN MIGRATION

TREND: India is a key non-breeding destination for many Eurasian bird species. The decline in the number of long-distance migrants has been significant, over 50 per cent. Shorebirds that breed in the Arctic have been particularly affected, declining by close to 80 per cent as a group. By comparison, resident species as a group have remained much more stable.

WHY: Conservation of long-distance migrants requires identifying and maintaining the health of critical habitats, including intertidal mudflats, mangroves, grasslands, open wetlands, paddy fields and reedbeds. This ensures they are able to feed and build up resources for their arduous migration journeys.

DIRECTION

DECLINING DUCKS

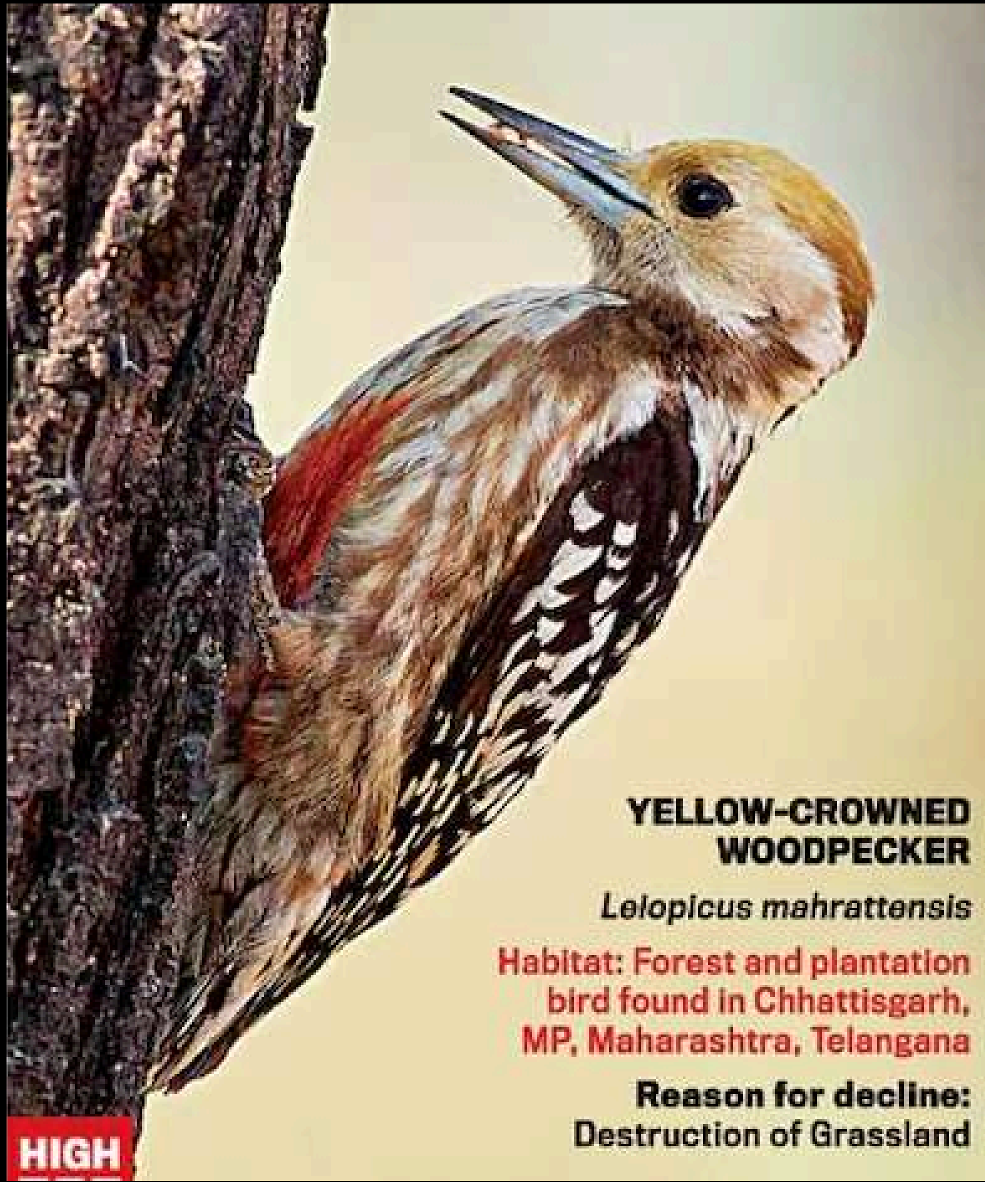
TREND: India hosts eight resident and 35 migratory species of the bird in a range of habitats, including inland lakes and tanks, submerged paddyfields, rivers, forest pools and coastal lagoons. Both kinds are experiencing long-term and continued decline. The Common pochard is declining by 2.5 per cent annually; at Chilika Lake, the counts went from 90,000 in 2001 to 2,000 by 2014. The Andaman teal has a population under 1,000; Baer's pochard has a global population of less than 1,700 and very few migrate to India now. The Tufted duck has declined by nearly 80 per cent between 2014 and 2022.

WHY: Though there are no studies to pinpoint exactly why the duck population is threatened, hunting, loss of wetlands and avian disease could be among some of the reasons.

WOODPECKER'S LAST KNOCK

TREND: Clear long-term trends are available for 11 species of woodpeckers, of which seven appear stable, two are declining, and two others are in rapid decline. The White-bellied woodpecker has dropped to less than 50 per cent of its historic baseline in the past three decades; the Yellow-crowned woodpecker has declined by more than 70 per cent in the past 30 years; and the Brown-capped pygmy woodpecker by 50 per cent in the long term.

WHY: Loss of large, old forest trees that woodpeckers prefer to make cavities in for nesting and fewer insects to feed on are the primary reasons for their decline.



DIRECTION

BUSTARDS GO BUST

TREND: Four species of bustards, a group of iconic grassland birds, are found in India. All four are specialised to open natural ecosystems (ONEs). Of these, the population of the Lesser florican, which breeds in fragments of grasslands, is less than 900 individuals. The Great Indian bustard has only 100-150 individuals, most of which survive in the Desert National Park of Rajasthan, where captive breeding has been started. The Bengal florican is restricted to the Himalayan Terai and the grasslands of northeastern India, with a South Asian population of under 400 individuals.

WHY: Bustard habitations have faced tremendous loss and change since the 1980s owing to infrastructural and developmental activities by humans.

THE HARDY BIRDS

Healthy both in abundance and in distribution, a few endemic bird species are exhibiting a rising trend in the past three decades

INDIAN PEAFOWL

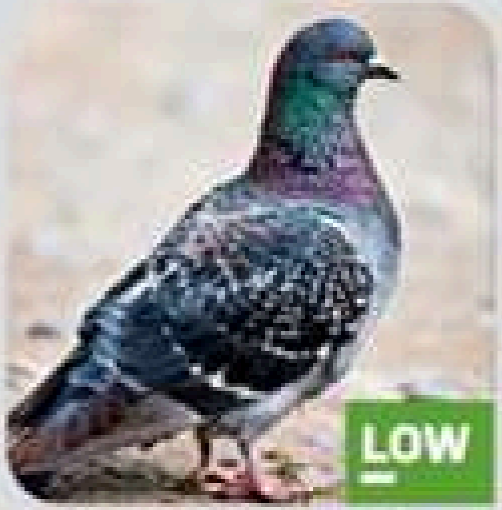
Pavo cristatus

A rapidly increasing species, it is expanding into new areas such as the rainforests in the Western Ghats and the high Himalayas. It is now found in every district of Kerala where once it was extremely rare. The exact reasons are unclear, but their proliferation owes to protection by law and through religious-cultural beliefs. However, rising uncontrolled numbers can have a negative impact on snakes and crops.

ASIAN KOEL

Eudynamys scolopaceus

It has increased by almost 75 per cent compared to its pre-2000 baseline. No one knows why, but fruit-eating birds in general are doing well



ROCK PIGEON

Columba livia

It has successfully adapted to humans and can nest and feed on whatever humans provide. Since wild populations have been interbreeding with domestic pigeons for years, a large majority of Rock Pigeons seen around us are 'feral'.

RETURN OF THE SPARROW

Once a fairly common sight, the urban house sparrow is slowly hopping back into our backyards

HOUSE SPARROW
Passer domesticus

IN the early 2000s, the sparrow population began to decline alarmingly in India, by almost 70 per cent in certain areas. Among the reasons for decline was the lack of nesting sites in concrete buildings, disappearing kitchen gardens, competition for food from pigeons, electromagnetic radiation from mobile towers and disturbances from traffic noise and pollution.

However, the State of India's Birds 2020 report noticed the sparrow population becoming stable in the past 25 years. The revival of the bird owes a lot to the several micro-conservation efforts. In Delhi, for example, the Eco Roots Foundation has put out 700,000 nests for the birds. The bird was adopted as the state bird in 2012 and March 20 is celebrated as World Sparrow Day. Many people are also returning to feeding the birds with affordable bird feeders online.

DIRECTION

TIME FOR BIRDERS TO REJOICE

Photo courtesy: Pankaj Gupta and Arvind Yadav

SONGBIRDS

Features

Arrive by late Sept

Leave by March-end

Generally small hill birds

Belong to forests

Examples: Warblers, flycatchers, larks and pipits, finches

Bar-headed goose

CRANES

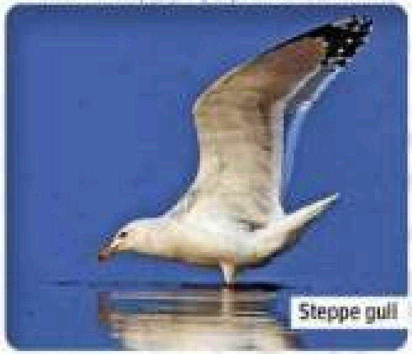
Features

Very tall birds

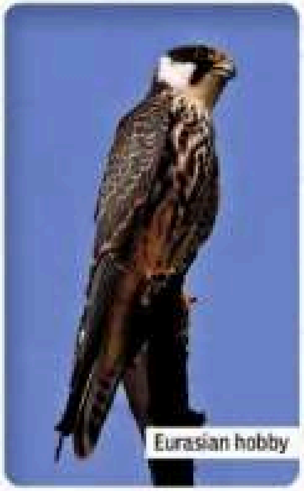
Generally passage migrants for Delhi

Come from Palearctic

Examples: Sarus crane, common crane and demoiselle cranes



Steppe gull



Eurasian hobby

WADERS

Features: Reach region by early Oct

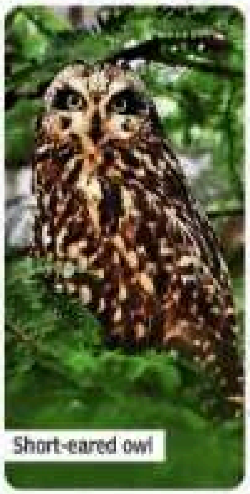
Stay in shallow water and marshes; come from Central Asia and Palearctic

Examples: Curlew, sandpipers, plovers

PELICANS

Features: Fish eating birds up to 3-4 feet tall

Examples: Rosy, great white pelican and spot-billed pelican



Short-eared owl

GEESE

Big birds, often seen around fields; Seen feeding on grasses and insects; Two major geese that come here are bar-headed goose and greylag

DUCKS

Features: Smaller than goose; Feeds on vegetation and insects or fish inside the water; Arrive by Nov from Palearctic, central Asia

Examples: Dabbling duck, diving duck

FLAMINGOS

Greater flamingos live permanently at Najafgarh and Okhla Bird sanctuaries

STORKS

Tall and large birds with long bil, neck and legs and baggy body

Examples: Painted stork, open billed stork and black necked are local

RAPTORS

Bird of prey

Come along the waterbirds to hunt

Examples: Greater spotted eagle, imperial eagle, hobby, peregrine falcons

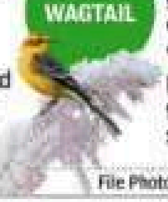
SUGGESTIONS FOR BIRDING

1. Wetlands are best places to watch migratory waterbirds. Sultanpur, Najafgarh, Okhla and Surajpur are good places
2. A good binocular or spotting scope is must
3. Bird activity is at its peak in morning & evening
4. A bird guidebook or online guide will help
5. Photography helps in identifying later
6. Wear drab colour clothes
7. Do not go too close to birds
8. A notebook to make a sketch or scribble other details will be a good idea
9. A local birder or guide can be of immense help
10. Try to be at a vantage point with sun behind and birds in front
11. Watching and clicking from inside the vehicle is always advantageous
12. Read about what all kinds of birds you are likely to encounter

PREVIOUS SEASON

Last year Dec, 257 species of migratory, passage migratory and resident birds were recorded. Two of them spotted for the first time in the region

CITRINE WAGTAIL

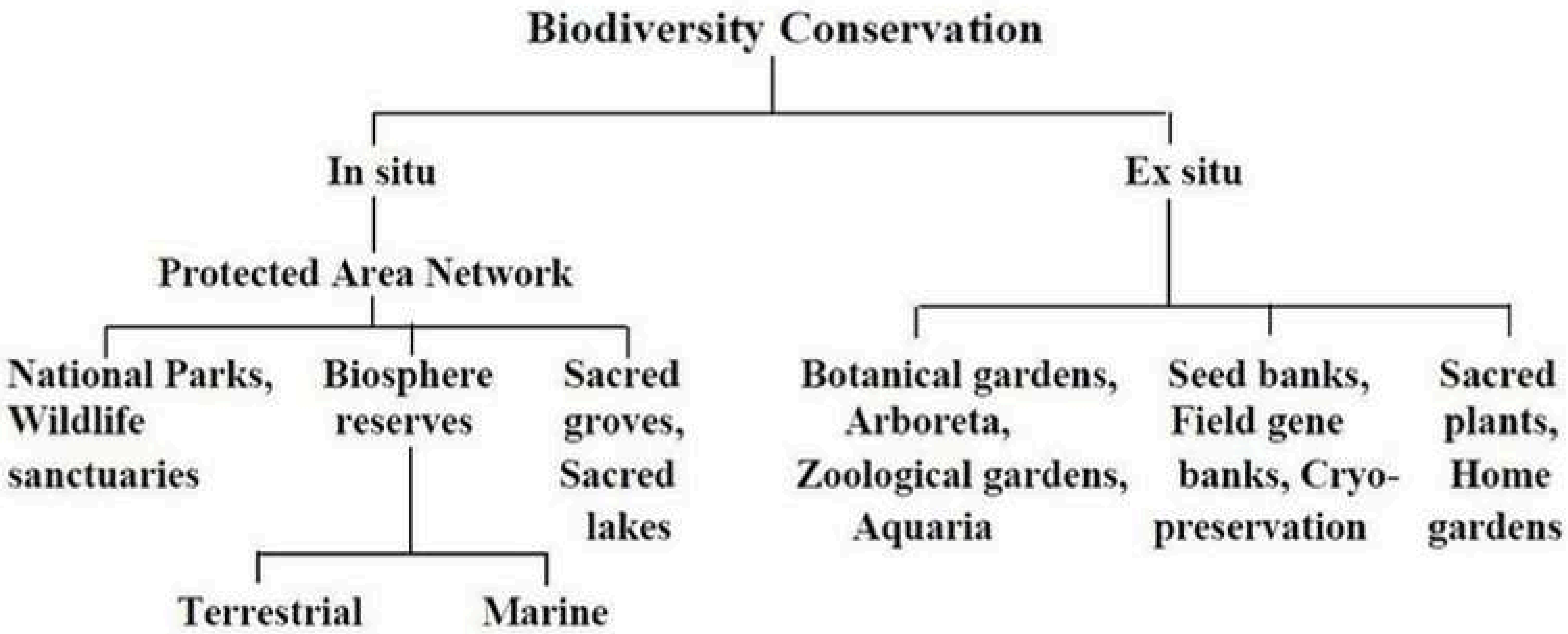


File Photo

The species spotted are spread over 70 groups of birds like duck, geese and waterfowls; hawk eagles and kites; sandpipers; old world flycatchers; wagtails and pipits; herons, egrets and bitterns; gulls, terns and skimmers; larks; starlings; osprey; rollers

DIRECTION

India is a major destination for migratory birds, with numerous species arriving from regions like Europe, Siberia, and the Arctic to escape harsh winters and find food. Some of the most notable migratory birds include the Siberian Crane, Bar-headed Goose, Greater Flamingo, Bluethroat, and Amur Falcon


Biodiversity Conservation
In situ
Ex situ
Protected Area Network
National Parks, Wildlife sanctuaries
Biosphere reserves
Sacred groves, Sacred lakes
Terrestrial
Marine
Botanical gardens, Arboreta, Zoological gardens, Aquaria
Seed banks, Field gene banks, Cryo-preservation
Sacred plants, Home gardens

Protected forests and reserved forests are classifications under the Indian Forest Act, 1927, designed to ensure the conservation of forest resources in India. While both aim to safeguard forests, they differ in the level of protection, permissible activities, and rights granted to local communities.

Reserved Forest: An area notified under the provisions of India Forest Act or the State Forest Acts having full degree of protection. In Reserved Forests all activities are prohibited unless permitted. **Governing Laws**

- Indian Forest Act, 1927: This Act empowers the government to declare any forest area as “Reserved” to ensure its complete protection. Reserved Forests are maintained by state governments and primarily focus on conservation.
- Forest Conservation Act, 1980: Requires government approval for converting Reserved Forests for non-forestry purposes, thereby reducing deforestation.

Protected Forest: An area notified under the provisions of India Forest Act or the State Forest Acts having limited degree of protection. In Protected Forests all activities are permitted unless prohibited. **Governing Laws**

- Indian Forest Act, 1927: Grants state governments the authority to declare areas as Protected Forests. Activities here are partially regulated to ensure sustainable usage while maintaining ecological balance.
- Forest Rights Act, 2006: Recognises the rights of traditional forest-dwelling communities and allows them to continue using forest resources responsibly.

Unclassed Forest: An area recorded as forest but not included in reserved or protected forest category. Ownership status of such forests varies from state to state.

DIRECTION

Forest Landscape Restoration (FLR)- IUCN & WWF

Forest Landscape Restoration (FLR) is a long-term process aimed at regaining ecological integrity and enhancing human well-being in deforested or degraded landscapes. It goes beyond simply planting trees—it focuses on restoring the entire ecosystem while supporting local livelihoods and sustainable land use.

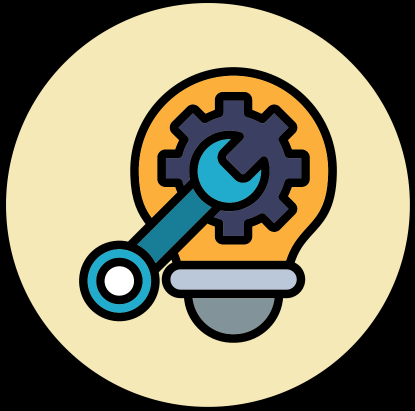
Key Objectives:

- Restore ecological balance by improving soil, water, and biodiversity health.
- Enhance ecosystem services such as carbon sequestration, water regulation, and soil fertility.
- Support local communities through sustainable livelihoods and resource management.
- Increase climate resilience by reducing the impacts of land degradation and extreme weather events.

Principles of FLR:

- Focuses on landscapes, not just individual sites.
- Aims for multiple benefits—ecological, social, and economic.
- Encourages participation of local communities and stakeholders.
- Promotes adaptive management based on continuous learning and monitoring.

Approaches and Techniques:



- Natural regeneration of forests.
- Agroforestry and sustainable agriculture.
- Assisted natural regeneration and enrichment planting.
- Watershed management and soil conservation.
- Invasive species control and habitat restoration.

India’s Efforts in FLR:

India is committed to restoring 26 million hectares of degraded land by 2030 under the Bonn Challenge.

Initiatives like

- the National Afforestation Programme,
- Green India Mission, and
- Compensatory Afforestation Fund Management and Planning Authority (CAMPA) support FLR goals.

The UN Strategic Plan for Forests (2017-2030)

The UN Strategic Plan for Forests (2017-2030) is a global framework with six Global Forest Goals and 26 associated targets to promote the sustainable management of forests worldwide. Its vision is for forests to provide economic, social, and environmental benefits for current and future generations, aiming to reverse forest cover loss, improve livelihoods, increase protected areas, and enhance cooperation and finance for sustainable management.

A key target is to increase the global forest area by 3% by 2030.

The Wildlife (Protection) Act, 1972

The Wildlife (Protection) Act, 1972 is a key piece of legislation in India aimed at protecting wild animals, birds, and plants to ensure the ecological and environmental security of the country.

Objectives:

- To protect wildlife and their habitats.
- To control poaching, smuggling, and illegal trade in wildlife and its derivatives.
- To ensure ecological balance and biodiversity conservation.

Authorities Established:

- Wildlife Advisory Board in each state.
- Chief Wildlife Warden and other officers for enforcement.
- Wildlife Crime Control Bureau (WCCB) for combating organized wildlife crime.

Protected Areas:

The Act provides for the creation of:

- National Parks
- Wildlife Sanctuaries
- Conservation Reserves
- Community Reserves

Schedules under the Wildlife (Protection) Act, 1972

The Act classifies species into six schedules, each offering different levels of protection and regulation. These schedules determine the degree of protection, penalties, and permissible human activities related to the listed species.

The Wildlife (Protection) Amendment Act, 2022, rationalized the original six schedules down to four.

- **The original Schedule I and Schedule II were merged into the new Schedule I** for animals with the highest level of protection. Royal Bengal Tiger, Indian Rhinoceros, Black Buck, Snow Leopard, Himalayan Brown Bear, Lion-tailed Macaque, Great Indian Bustard, Asiatic Lion, Elephant
- **The original Schedule III and Schedule IV animals were moved to the new Schedule II**, which offers a lesser level of protection.Assamese Macaque, Himalayan Black Bear, Indian Cobra, King Cobra, Flying Squirrel, Indian Fox, Large Indian Civet, Indian Leopard, Jackal
- **A new Schedule III was created for protected plant species.** Beddomes' cycad (Native to India), Blue Vanda (Blue Orchid), Red Vanda (Red Orchid), Kuth (Saussurea lappa), Slipper orchids (Paphiopedilum spp.), Pitcher plant (Nepenthes khasiana), Neelakurinji
- **A new Schedule IV was added** for species listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Protected Areas under the Wildlife (Protection) Act, 1972

The Act provides for the establishment of different categories of Protected Areas to ensure the conservation of wildlife and their habitats. These areas are managed and regulated according to their level of protection and permissible human activities.

1. National Parks

Areas set aside for the protection of wildlife and natural environment.

Human activities like grazing, hunting, or private ownership are strictly prohibited.

Managed by the State Government.

Example: Jim Corbett National Park (Uttarakhand).

2. Wildlife Sanctuaries

Areas where certain human activities may be permitted, but hunting and exploitation of wildlife are banned.

Local communities may have limited rights for resource use.

Example: Ranthambore Wildlife Sanctuary (Rajasthan).

3. Conservation Reserves

Areas adjacent to National Parks or Sanctuaries, or those linking one protected area with another.

Created to protect landscapes, seascapes, and corridors.

Managed jointly by the government and local communities.

Example: Mehao Conservation Reserve (Arunachal Pradesh).

4. Community Reserves

Areas owned and managed by local communities or private individuals.

Established to promote community participation in wildlife conservation.

Example: Kadalundi-Vallikkunnu Community Reserve (Kerala).

Biosphere Reserves are also called “living laboratories” as they provide great scope for scientific research and a valuable source of education. Each reserve covers large areas and sometimes include one or more national parks and wildlife sanctuaries.

A biosphere reserve is generally divide into three zones, these zones are also commonly known as area. They are

Core Area / Zone

This is the main zone of the reserve, it is thoroughly protected and no human disturbance is allowed. Least or no activity is allowed in this region. This is the part of the park which is most important for protection.

Buffer Area / Zone

This is the area of the reserve that surrounds or adjoins the core zone. Some activity is allowed in this region. Scientific research, monitoring, education purposes, etc are allowed as long as they are compatible with the ecosystem.

Transition Area / Zone

The most activity is allowed in this region of the park. Scientific research, human entertainment, education tours, etc can be held here. There are no restrictions as far as no harm comes to the ecosystem.

The World Network of Biosphere Reserves (WNBR) consists of a dynamic and interactive network of sites of excellence.

- **Objective: It promotes North-South, South-South and South-North-South collaboration and represents a unique tool for international cooperation through the exchange of experiences and know-how, capacity-building and the promotion of best practices among Biosphere Reserves.**
- **UNESCO Affiliation: The WNBR operates under the United Nations Educational, Scientific and Cultural Organization's (UNESCO) Man and the Biosphere Programme.**
- **Global Coverage: The WNBR now includes 785 sites in 142 countries, with an additional one million sq km of natural areas brought under protection since 2018 — equivalent to the size of Bolivia.**

DIRECTION

DIRECTION

UNESCO Recognition: 13 of these are part of the UNESCO Man and the Biosphere (MAB) Programme.

UNESCO declares India’s Cold Desert Biosphere Reserve as part of its World Network of Biosphere Reserves.

The Cold Desert Biosphere Reserve in Himachal Pradesh, located in the Lahaul-Spiti district, is a high-altitude trans-Himalayan region known for its rugged terrain and rare wildlife like the snow leopard.

Established in 2009, it officially became India's 13th site in the UNESCO World Network of Biosphere Reserves in September 2025.

The reserve covers an area of about 7,770 square kilometers and includes protected areas such as Pin Valley National Park and Kibber Wildlife Sanctuary.

Home to:

- Imedicinal herbs, rare stands of Persian juniper, Himalayan birch, and willow-leaved sea buckthorn, as well as hardy alpine grasses, nearly 732 plant species | 30 endemic
- Snow Leopard
- Himalayan Ibex
- Blue Sheep
- Golden Eagle
- 12,000 residents preserving traditions, pastoralism & Tibetan medicine

India now proudly holds 13 UNESCO Biosphere Reserves—joining a global family of 785 sites.

DIRECTION

The **snow leopard** is one of the most elusive and majestic big cats in the world, perfectly adapted to the harsh, cold environments of Central and South Asia's high mountains. Known as the "ghost of the mountains," it's admired for its beauty, strength, and mysterious nature.

Key facts about the Snow Leopard:

DIRECTION

- **Scientific name:** Panthera uncia
- **Habitat:** Mountain ranges of Central and South Asia, including the Himalayas, Pamirs, and Altai, typically between 3,000–5,500 meters
- **Appearance:** Thick, smoky-gray fur with black rosettes and spots; long tail for balance and warmth
- **Diet:** Carnivorous — preys on Blue Sheep (Bharal), Himalayan Ibex, marmots, and other mountain animals
- Behavior: Solitary and territorial; mostly active at dawn and dusk
- **Adaptations:** Wide, fur-covered paws act like natural snowshoes; powerful hind legs allow it to leap up to 15 meters; dense fur and nasal adaptations help it survive freezing temperatures
- The snow leopard is a **keystone species** in its ecosystem, maintaining the balance of prey populations.

IUCN Status: Vulnerable due to habitat loss, poaching, and declining prey, making conservation efforts vital for its survival.

The Himalayan ibex is a wild mountain goat found in the rugged terrains of the Himalayas, particularly in northern India, Pakistan, and parts of China. It's known for its impressive curved horns, which can grow over a meter long in males, and its thick, woolly coat that helps it survive in freezing alpine conditions.

Key facts about the Himalayan Ibex:

- **Scientific name:** Capra sibirica hemalayanus
- **Habitat:** High-altitude regions (3,000–5,000 meters) with rocky cliffs and sparse vegetation
- **Diet:** Herbivorous — mainly grasses, herbs, and shrubs
- **Behavior:** Lives in herds; males and females often form separate groups except during mating season
- **Adaptations:** Strong hooves for climbing steep slopes, dense fur for insulation, and excellent balance
- IUCN Status: Least Concerned

IUCN Status: Least Concerned

DIRECTION

The Blue Sheep, also known as the Bharal, is a remarkable mountain ungulate native to the high Himalayas. Despite its name, it's not truly blue or a sheep—it's more closely related to goats. Its bluish-grey coat gives it a unique appearance that blends perfectly with the rocky slopes it inhabits.

Key facts about the Blue Sheep (Bharal):

- **Scientific name:** Pseudois nayaur
- **Habitat:** High-altitude regions (3,000–5,500 meters) across the Himalayas, including India, Nepal, Bhutan, and Tibet
- **Diet:** Primarily grasses, herbs, and lichens
- **Behavior:** Lives in herds; males and females often separate except during the rutting season
- **Adaptations:** Excellent climbers with strong hooves for navigating steep, rocky terrain; their coloration provides effective camouflage against predators like the snow leopard
- IUCN Status: Least Concerned

IUCN Status: Least Concerned

DIRECTION

The golden eagle is one of the largest and most powerful birds of prey in the world, revered for its strength, speed, and keen eyesight. It's a symbol of freedom and majesty across many cultures and thrives in open, mountainous regions.

Key facts about the Golden Eagle:

- **Scientific name:** Aquila chrysaetos
- **Habitat:** Found across the Northern Hemisphere — in North America, Europe, and Asia, including the Himalayas and Central Asian mountains
- **Appearance:** Dark brown plumage with golden feathers on the back of the head and neck; wingspan can reach up to 2.3 meters
- **Diet:** Carnivorous — hunts mammals like hares, marmots, and young ungulates; also preys on birds and occasionally scavenges
- **Behavior:** Solitary or found in pairs; known for powerful flight and spectacular hunting dives reaching speeds over 240 km/h
- **Adaptations:** Exceptional vision for spotting prey from great distances; strong talons and beak for capturing and tearing flesh
- The golden eagle plays a crucial role as a **top predator** in mountain ecosystems, helping control populations of smaller animals and maintaining ecological balance.

IUCN Status: Least Concerned

DIRECTION

National Wildlife Database Cell

The National Wildlife Database Centre of Wildlife Institute of India (WII) has been developing a National Wildlife Information System (NWIS) on the Protected Areas of the country.

As of 27th November, 2023 India has a network of 1014 Protected Areas including 106 National Parks, 573 Wildlife Sanctuaries, 115 Conservation Reserves and 220 Community Reserves covering a total of 1,75,169.42 km2 of geographical area of the country which is approximately 5.32%.

The National Wildlife Database Centre (NWDC) is providing information on the conservation status of animal species, biogeographic regions, administrative units, habitat types and the network of protected areas in India, in a variety of formats and also providing an extensive bibliographic support for wildlife research.

DIRECTION

Legislative and Policy Framework

National Wildlife Action Plan (2017-2031):
This strategic plan emphasizes landscape-level conservation, community involvement, and the integration of climate change considerations into wildlife management.[10]

National Human-Wildlife Conflict Mitigation Strategy and Action Plan:
The National Human-Wildlife Conflict Mitigation Strategy and Action Plan (2021-26) (HWC-NAP) aims to systematically reduce human-wildlife conflict (HWC) while ensuring wildlife conservation, ecosystem protection, and sustainable development.
Developed through a four-year consultative process under the Indo-German Project on HWC Mitigation, it integrates scientific, policy, and community-driven approaches to balance human well-being with wildlife protection.

INTERNATIONAL CONSERVATION EFFORTS

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

CMS

Convention on Wetlands

Ramsar
Convention
on Wetlands

The Convention on Biological Diversity

Convention on
Biological Diversity

DIRECTION

DIRECTION

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

- CITES is a multilateral treaty regulating trade in endangered species of wild fauna and flora.
- It was proposed in 1963 at an IUCN conference and formally signed in 1973 in Washington, D.C.
- CITES has 185 Parties (nearly all UN member states and the European Union). India ratified in 1976.
- The treaty is legally binding on Parties but does not override their national legislation.
- Member countries are required to enact domestic laws to implement their obligations under CITES

Objectives and Scope

- The purpose of CITES is to make sure that international trade does not endanger wild species.
- CITES currently protects over 40,900 listed species of animals and plants.
    - It covers both live specimens and derivatives like skins, tusks, roots, and timber.
    - It covers terrestrial and aquatic species traded globally for commercial or scientific use.
    - Institutional Framework
    - The CITES Secretariat operates under UNEP and is headquartered in Geneva, Switzerland.
    - It enables sustainable and traceable wildlife trade through a science-based permit system.
    - Parties appoint a Management Authority for permits and a Scientific Authority for expert advice.
    - The global CITES Trade Database is managed by UNEP–WCMC for transparency and recordkeeping.
- CITES decisions are reviewed at regular Conferences of the Parties (CoPs) held every 2–3 years.

CITES Appendix

The term CITES Appendix refers to the three appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). These appendices categorize species based on their level of protection and the degree of control required over their international trade.

Appendix I: Lists the most endangered species. Commercial international trade in these species is generally prohibited, except under exceptional circumstances such as scientific research.

- Snow Leopard (Panthera uncia)
- Tiger (Panthera tigris)
- Asian Elephant (Elephas maximus)
- Hawksbill Turtle (Eretmochelys imbricata)

Appendix II: Includes species that are not necessarily threatened with extinction but may become so if trade is not regulated. Trade is allowed but controlled through permits to ensure sustainability.

- Himalayan Ibex (Capra sibirica)
- Blue Sheep (Bharal) (Pseudois nayaur)
- African Lion (Panthera leo)
- Green Iguana (Iguana iguana)

Appendix III: Contains species that are protected in at least one country, which has requested assistance from other CITES member countries to help regulate trade.

- Walrus (Odobenus rosmarus) – listed by Canada
- Two-toed Sloth (Choloepus hoffmanni) – listed by Costa Rica
- Indian Pangolin (Manis crassicaudata) – listed by India

Report on the conservation and trade of CITES-listed rosewood tree species-2024

'Rosewood' also called as "palisander" encompasses a wide range of tropical hardwoods in the Fabaceae (Leguminosae) family.

Rosewood in Appendix II of CITES include:

- Dalbergia latifolia (Malabar rosewood) and Dalbergia Sissoo (Shisham) are found in India and are listed as Vulnerable and Least Concern on IUCN red list.

Only 17.2% of India's suitable habitat for Dalbergia latifolia — Indian rosewood — lies within protected areas, according to recent habitat modelling by the Institute of Wood Science and Technology (IWST), Bengaluru.

- African rosewood, native to West African countries, is listed as endangered on IUCN red list.

Utility: Crafting furniture and musical instruments.

Role in Ecosystem:

Soil Improvement: Dalbergia species can improve degraded soil through fast decomposing leaf litter, rich in nitrogen, phosphorus, and carbon.

Nitrogen Fixation: Some species form symbiotic associations with soil bacteria to fix atmospheric nitrogen.

DIRECTION

Programmes and Initiatives

- MIKE: Monitors the Illegal Killing of Elephants through field-level data collection across Asia and Africa.
- ICCWC: Coordinates global enforcement by linking CITES with INTERPOL, UNODC, WCO, etc.
- Tree Species Programme: Regulates the trade of listed timber species like rosewood, mahogany, etc.
- Site-Based Monitoring: Connects local ecological surveillance systems with CITES trade permit system.
- Strategic Vision 2021–2030: Provides long-term guidance for aligning CITES actions with the Kunming–Montreal Global Biodiversity Framework.

India and CITES

- India became a Party to CITES in 1976 by formally ratifying the Convention.
- ADG (Wildlife), MoEFCC, is the Management Authority responsible for CITES implementation in India.
- Wildlife Crime Control Bureau (WCCB) also acts as a Management Authority and issues permits.
- Kunming–Montreal Framework: It is an agreement that sets 2030 targets for halting biodiversity loss and ensuring fair benefit-sharing from natural resources.

Convention on the Conservation of Migratory Species of Wild Animals (CMS)

The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention, is an international treaty aimed at conserving migratory species that cross national boundaries. It was signed in Bonn, Germany, in 1979 and came into force in 1983.

Key Objectives:

- To conserve migratory species and their habitats across their entire range.
- To promote international cooperation among countries that share migratory routes.
- To ensure sustainable management of migratory species populations.

Structure:

- Appendix I: Lists migratory species that are endangered. Parties are required to strictly protect these species, conserve their habitats, and remove obstacles to migration.
- Appendix II: Lists migratory species that would benefit from international agreements for their conservation and management.

DIRECTION

Examples of Species Listed in CMS Appendices

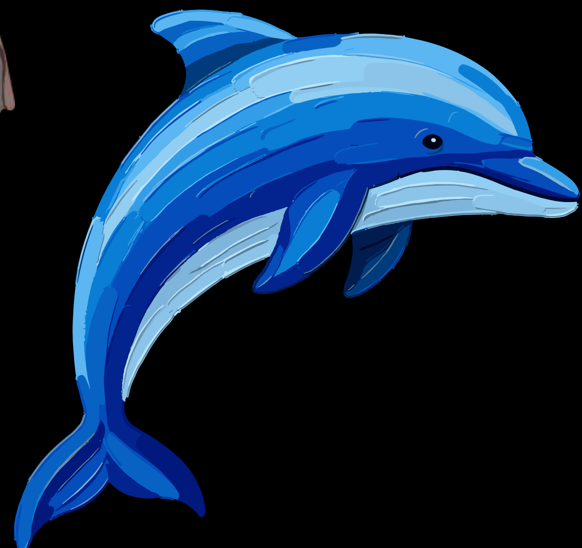
Appendix I (Endangered Migratory Species – Strict Protection Required):

Snow Leopard
Siberian Crane
Hawksbill Turtle
Blue Whale
Saiga Antelope

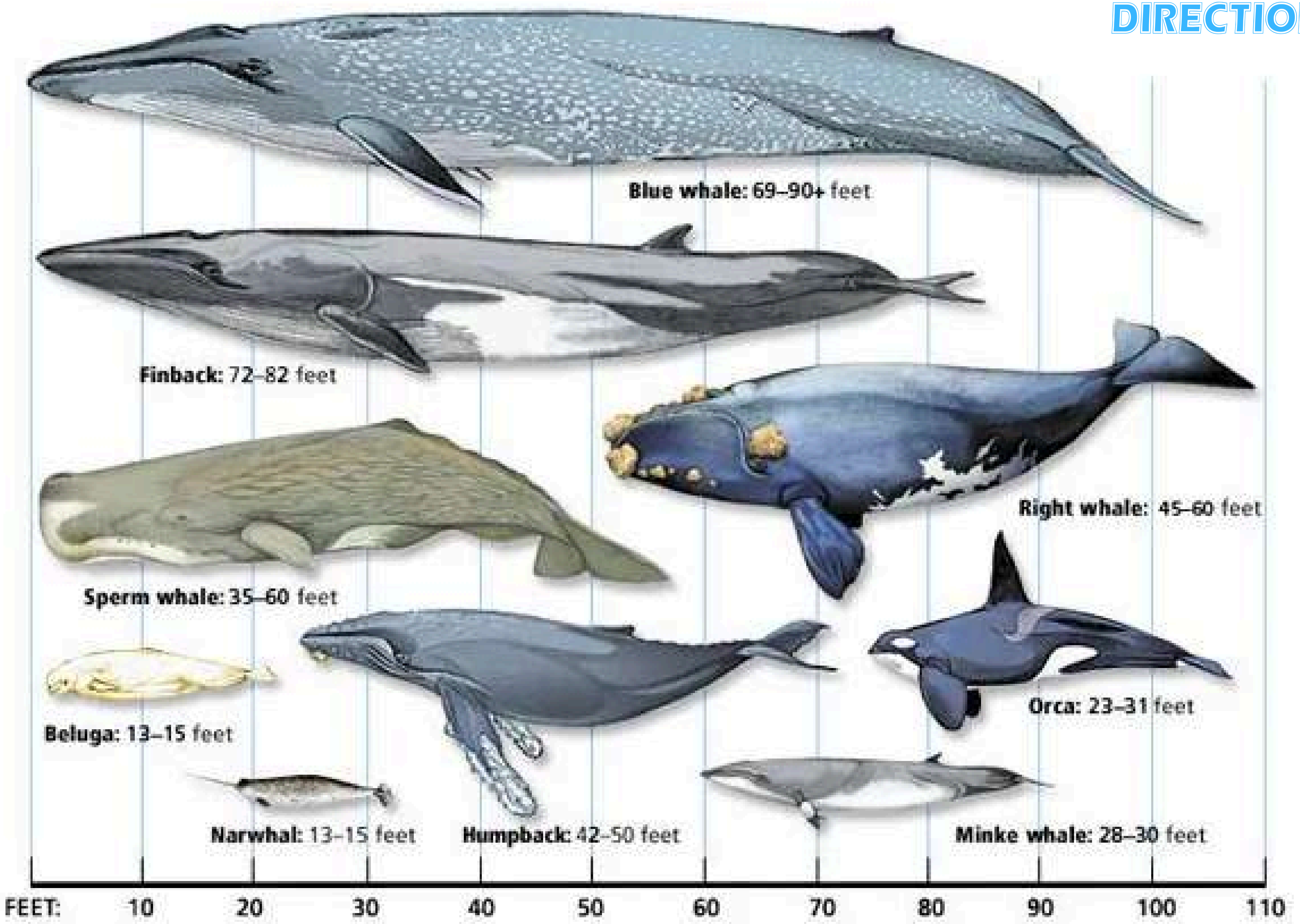


Appendix II (Species Benefiting from International Cooperation):

African Elephant
Whale Shark
Great White Shark
Common Dolphin
Saker Falcon

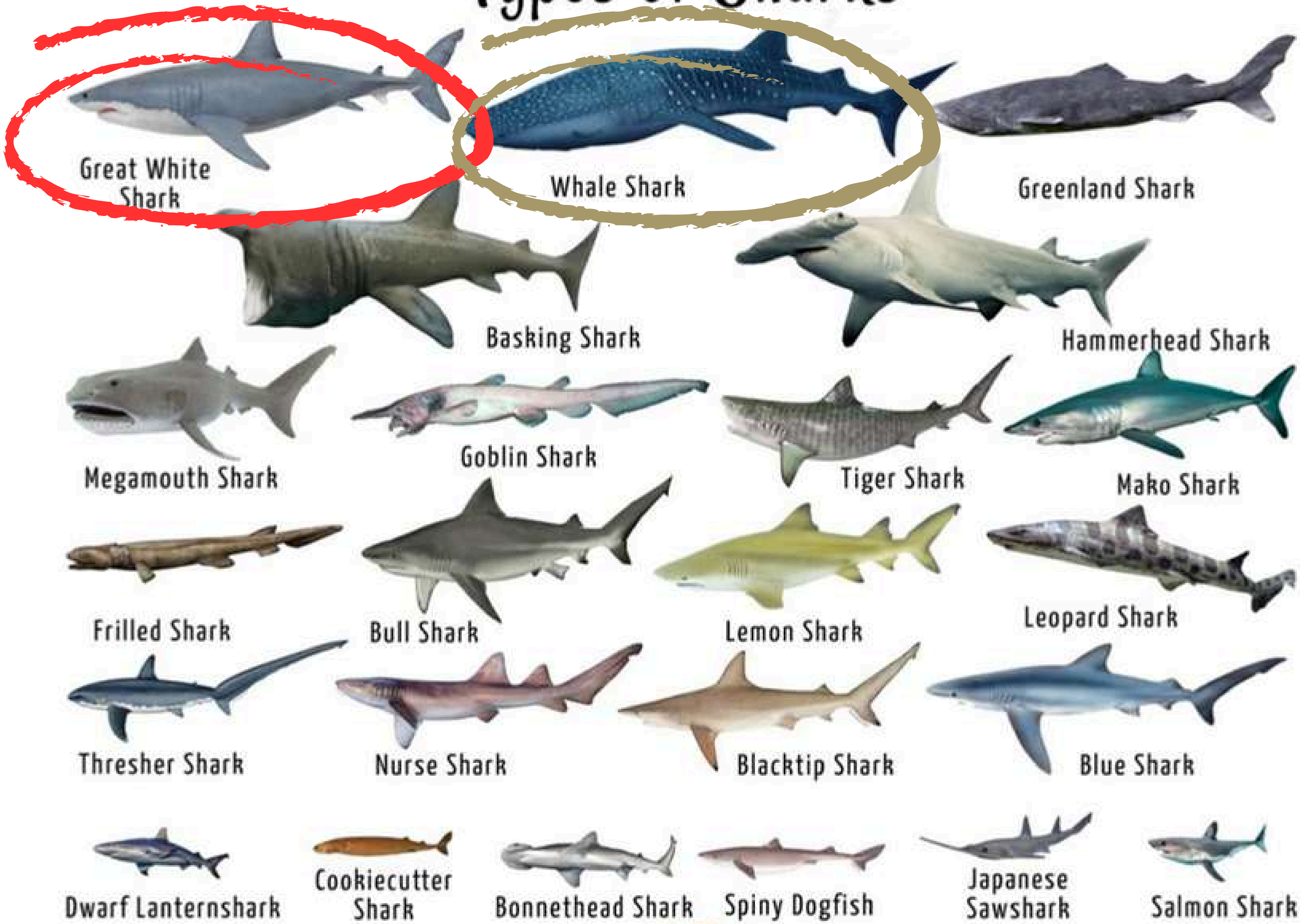




DIRECTION



Blue whale: 69–90+ feet
Finback: 72–82 feet
Right whale: 45–60 feet
Sperm whale: 35–60 feet
Orca: 23–31 feet
Beluga: 13–15 feet
Narwhal: 13–15 feet
Humpback: 42–50 feet
Minke whale: 28–30 feet
FEET: 10 20 30 40 50 60 70 80 90 100 110

Types of Sharks



Examples of action under the CMS

Central Asian Flyway (CAF): India, a party to the CMS, plays a crucial role in the CAF, which is a network of routes used by migratory birds. India has launched a national action plan under the CAF framework to protect the migratory birds and their habitats that fall within its jurisdiction.

Global Partnership on Ecological Connectivity (GPEC): This initiative aims to maintain and restore ecological connectivity in critical areas for migratory species.

Global Swimways Network: This project specifically focuses on identifying and protecting the migration routes of freshwater fish.

Central Asian Mammals Initiative: This initiative works to improve the conservation of large migratory mammals in the Central Asian region through cross-border cooperation and strengthened coordination.

The **Central Asian region harbours** the largest intact and still interconnected grasslands worldwide. As such, it is of global importance for many migratory and nomadic mammals which rely on the vast steppe, desert and mountain ecosystems that enable the essential long-distance movements which ensure their survival.

Mass migrants in this region include CMS-listed species such as

- the Saiga antelope, Bukhara deer Przewalski's horse Argali sheep
- Mongolian gazelle and Khulan.
- Other examples: Other species included are the Asiatic cheetah, Asiatic wild ass (kiang), goitered gazelle, Mongolian gazelle, Pallas's cat, Persian leopard, urial, and wild yak.

Saiga antelope,

Bukhara deer

Przewalski's horse

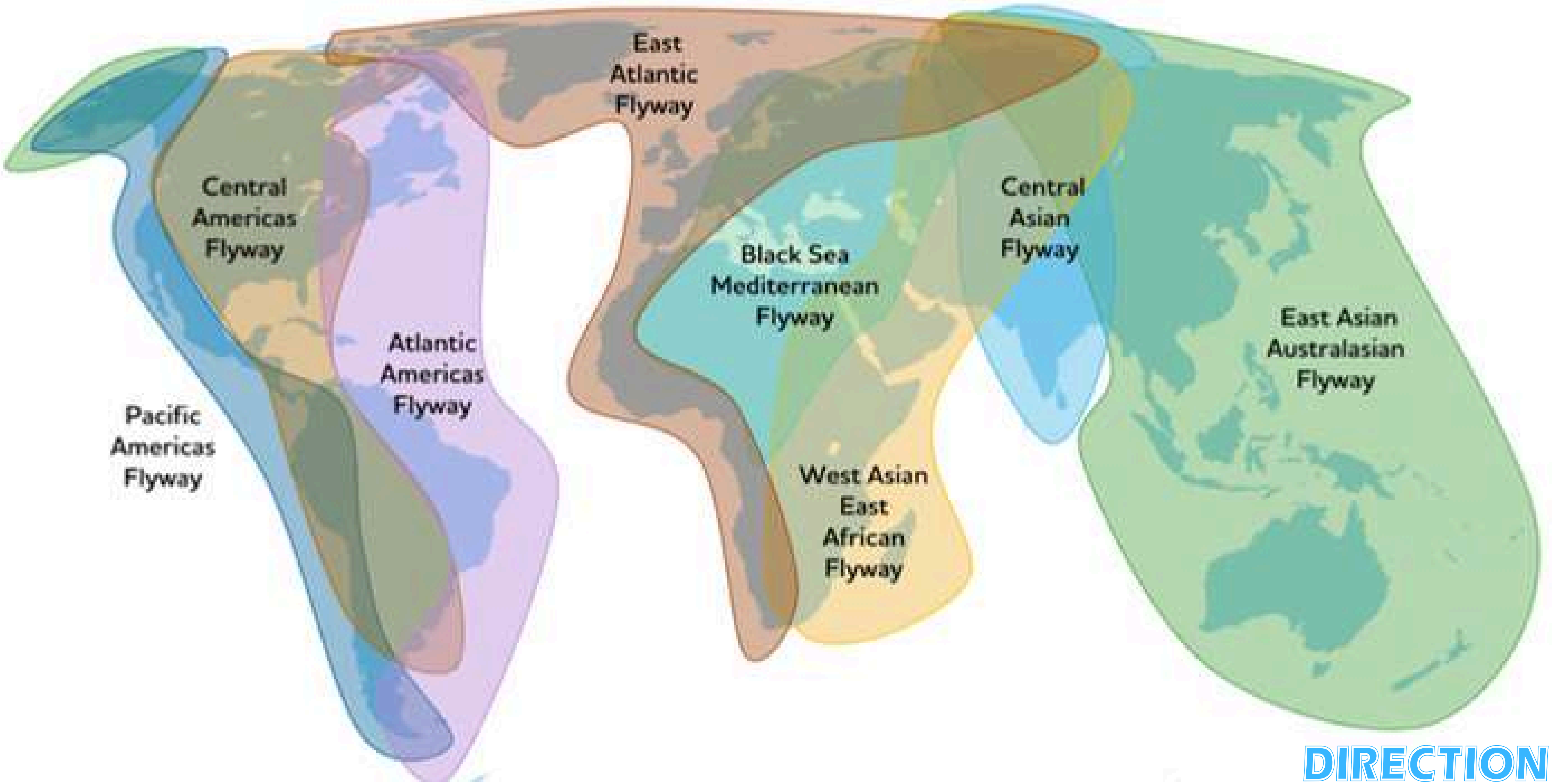
Argali sheep

Pallas's cat

Khulan.

DIRECTION

A "flyway" is the migratory route used by birds between their breeding and non-breeding grounds



DIRECTION

Types of Wildlife Crossings

Wildlife crossings are structures that allow animals to safely cross human-made barriers like roads, railways, and canals, reducing collisions and maintaining ecological connectivity. They are designed based on the behavior and habitat needs of different species.

1. Overpasses (Green Bridges or Eco-ducts):

Vegetated bridges built over highways or railways.
Used by large mammals such as deer, bears, and big cats.
Help reconnect fragmented habitats.

2. Underpasses (Tunnels or Culverts):

Passages built beneath roads or railways.
Suitable for medium and small animals like foxes, porcupines, amphibians, and reptiles.

3. Rope Bridges (Canopy Crossings):

Suspended bridges made of ropes or nets.
Designed for arboreal species such as monkeys, squirrels, and sloths.

DIRECTION

4. Amphibian and Reptile Tunnels:

Small tunnels or pipes with guiding fences.

Allow frogs, toads, turtles, and snakes to cross roads safely.

5. Fish Passages (Fish Ladders or Fishways):

Structures that help fish migrate upstream or downstream around dams and barriers.

Commonly used by salmon, trout, and other migratory fish.

6. Aerial Crossings:

Poles or wires installed above roads.

Used by flying species like bats and gliding mammals.

These crossings play a vital role in reducing wildlife-vehicle collisions and preserving biodiversity by maintaining natural movement patterns

DIRECTION

India, a member of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) since 1983, has been actively involved in conservation efforts both domestically and internationally.

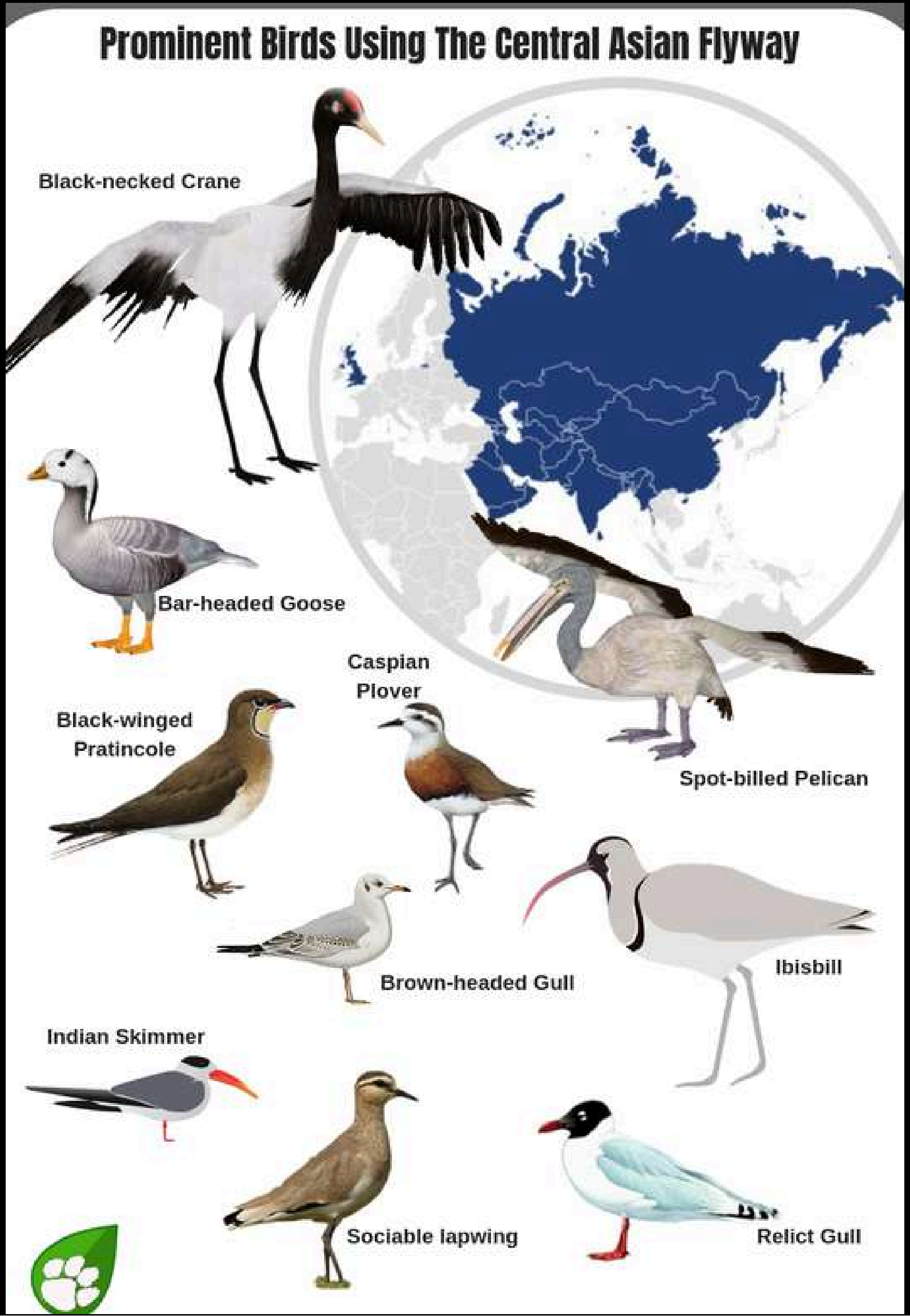
The country is home to numerous migratory species and is a critical part of the Central Asian Flyway for birds.

Conservation projects: The Indian government has launched various conservation projects that benefit CMS-listed species, including:

- Project Dolphin: A national program launched in 2020 to focus on both riverine (Ganges River) and marine dolphins.
- Project Lion, Tiger, and Elephant: Flagship projects that protect the habitats of these species, aiding migratory populations where applicable.
- Project Great Indian Bustard: A project focused on the conservation of this critically endangered species, which was also added to CMS Appendix I in 2020.
- National Action Plans: India has developed a National Action Plan for the conservation of migratory species along the Central Asian Flyway (2018-2023). It has also launched a National Marine Turtle Action Plan (2021-2026).

National Action Plan for the conservation of migratory species along the Central Asian Flyway (2018-2023)

At least 370 species of migratory birds from three flyways are reported to visit the Indian subcontinent, of which 310 predominantly use wetlands as habitats, the rest being landbirds, inhabiting dispersed terrestrial areas Of the wetlands of ornithological importance identified based on existing monitoring information, 29 sites including 20 major wetlands and nine wetland clusters have been identified as significant bottleneck sites for migratory waterbirds



DIRECTION

National Marine Turtle Action Plan (2021-2026)

The Indian coastal waters supports **five species of sea turtles** found worldwide. These are the **Olive ridley , Green , Hawksbill , Leatherback and Loggerhead**

These five species of sea turtles that occur in Indian coastal waters are protected under Schedule I of the Wildlife (Protection) Act, 1972.

Bilateral and multilateral agreements

India has signed several non-legally binding Memorandums of Understanding (MoUs) under the CMS framework for the conservation of specific species, including:

- Siberian Cranes: Signed in 1998.
- Marine Turtles: Signed in 2007.
- Dugongs: Signed in 2008.
- Raptors: Signed in 2016.

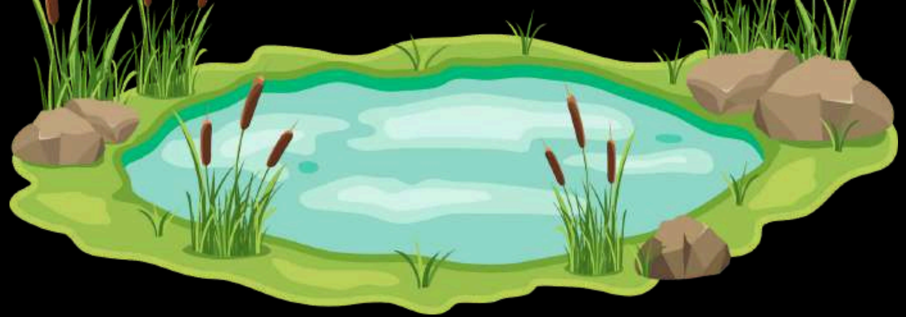
Transboundary Elephant Conservation: India signed a protocol with Bangladesh in 2020 to ensure the safe migration of elephants and mitigate human-elephant conflict.

International recognition and recent progress

At the most recent COP14 in Uzbekistan (February 2024), **India was awarded the Migratory Species Champion Programme** for its contributions to conserving migratory birds in the Central Asian Flyway. India was also elected as a member of both the Standing Committee and the Scientific Council of the CMS, enabling it to continue its influential role.

DIRECTION

The Ramsar Convention



The Ramsar Convention takes a broad approach in determining the wetlands which come under its aegis.

Under the text of the Convention (Article 1.1), wetlands are defined as: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres".

In addition, for the purpose of protecting coherent sites, the Article 2.1 provides that wetlands to be included in the Ramsar List of internationally important wetlands: "may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands".

Five major wetland types are generally recognized:

- marine (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
- estuarine (including deltas, tidal marshes, and mangrove swamps);
- lacustrine (wetlands associated with lakes);
- riverine (wetlands along rivers and streams); and
- palustrine (meaning "marshy" - marshes, swamps and bogs).

DIRECTION

A wetland needs to meet only one of these nine criteria to be designated a site of international importance.

The nine Ramsar criteria are divided into three groups:

1. Unique wetland types

Criterion 1: The wetland contains a rare, unique, or representative example of a natural or near-natural wetland type found within its specific biogeographic region.

2. General biological diversity

- Criterion 2: The wetland supports threatened species or communities.
- Criterion 3: The wetland is important for maintaining regional biodiversity.
- Criterion 4: The wetland is crucial for plant or animal species during critical life stages or provides refuge.

3. Species-specific criteria

Wetlands can also be designated based on the populations of waterbirds, fish, and other wetland-dependent non-avian animal species they support.

- These include criteria related to supporting large numbers of waterbirds (Criterion 5),
- a significant percentage of a specific waterbird species or subspecies population (Criterion 6),
- a significant number of indigenous fish (Criterion 7), or
- being important for fish as a food source, spawning ground, nursery, or migration route (Criterion 8).
- Additionally, Criterion 9 focuses on supporting a notable percentage of a population of other wetland-dependent, non-avian animal species.

As of September 2025, **there are over 2,544 Ramsar sites globally, with 93 in India.**

Global status (as of August 2025)

- Total sites: 2,544
- Participating countries: 172
- Total area: 257,994,488 hectares
- Countries with most sites: United Kingdom (175), Mexico (142)
- Country with largest wetland area: Bolivia (~148,000 sq km)

India's status (as of September 2025)

Total sites: 93

State with most sites: Tamil Nadu (20 sites)

New sites in 2025:

February: Udhwa Lake Bird Sanctuary, Khecheopalri Wetland, Sakkarakottai Bird Sanctuary, and Therthangal Bird Sanctuary

June: Khichan Wetland and Menar Wetland Complex

September: Gokul Jalashay (Buxar, Bihar) and Udaipur Jheel (West Champaran, Bihar)

India names its 92nd and 93rd Wetlands of International Importance

India has designated Gokul Jalashay and Udaipur Jheel as Wetlands of International Importance (“Ramsar Sites”).

Gokul Jalashay is an oxbow lake located on the southern edge of the Ganga (Ganges) River.In total, over 50 bird species are found in the Site and its surroundings; in the pre-monsoon season, exposed marshland and shrubs provide food and breeding habitats.

Udaipur Jheel which is also an oxbow lake, is bordered to the north and west by the dense forest of Udaipur Wildlife Sanctuary. The lake surrounds a village. Over 280 plant species are found in the wetland, including Alysicarpus roxburghianus, a perennial herb endemic to India.The wetland is an important wintering ground for around 35 migratory bird species, including the vulnerable common pochard (Aythya ferina)

DIRECTION

The Convention on Biological Diversity

The Convention on Biological Diversity (CBD) is an international treaty adopted at the Earth Summit in Rio de Janeiro in 1992. It is dedicated to the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources.

Key Objectives:

- Conservation of biodiversity – protecting ecosystems, species, and genetic diversity.
- Sustainable use of biodiversity – ensuring that natural resources are used responsibly to meet present and future needs.
- Equitable sharing of benefits – promoting fairness in the use of genetic resources, especially for countries rich in biodiversity.

India and the CBD:

- India became a party to the CBD in 1994.
- The country enacted the Biological Diversity Act, 2002, to implement the provisions of the Convention.
- India has also developed a National Biodiversity Action Plan (NBAP) to guide conservation and sustainable development efforts.

DIRECTION

Biological Diversity Act, 2002

Key Provisions:

- Establishes a three-tier institutional structure:

1. **National Biodiversity Authority (NBA)**: Regulates access to biological resources by foreign individuals, companies, and organizations.
2. **State Biodiversity Boards (SBBs):** Manage and advise on the use of biological resources within states.
3. **Biodiversity Management Committees (BMCs)**: Formed at local levels to document and manage biodiversity through People's Biodiversity Registers (PBRs).

- Requires prior approval from the NBA for foreign entities seeking access to biological resources or associated knowledge.
- Promotes benefit-sharing mechanisms to ensure that local communities receive compensation for their traditional knowledge and resource use.
- Provides for the protection of traditional knowledge and prevention of biopiracy.

Significance:

The Act strengthens India's commitment to biodiversity conservation and ensures that the use of biological resources contributes to sustainable development while protecting the rights of local and indigenous communities.

National Biodiversity Action Plan (NBAP)

The National Biodiversity Action Plan (NBAP) is India's strategic framework for implementing the objectives of the Convention on Biological Diversity (CBD) and the Biological Diversity Act, 2002. It provides a roadmap for conserving biodiversity, ensuring its sustainable use, and promoting equitable benefit-sharing.

The first NBAP was formulated in 2008 by the Ministry of Environment, Forest and Climate Change (MoEFCC).

It was revised in 2014 to align with the Aichi Biodiversity Targets (2011–2020) adopted under the CBD.

Objectives:

- Conservation of biological diversity across ecosystems and species.
- Sustainable use of biological resources to support livelihoods and economic development.
- Fair and equitable sharing of benefits arising from the use of genetic resources and traditional knowledge.
- Integration of biodiversity concerns into national and sectoral planning.
- Strengthening institutional and legal frameworks for biodiversity management.

Key Features:

- Focuses on ecosystem restoration, climate change adaptation, and mainstreaming biodiversity into agriculture, forestry, fisheries, and tourism.
- Encourages community participation through Biodiversity Management Committees (BMCs).
- Promotes research, education, and awareness on biodiversity conservation.
- Supports the creation and maintenance of People's Biodiversity Registers (PBRs) to document local biodiversity and traditional knowledge.

The Nagoya Protocol on Access and Benefit-Sharing

The Nagoya Protocol is a supplementary agreement to the Convention on Biological Diversity (CBD), adopted in Nagoya, Japan, in 2010 and entered into force in 2014.

It provides a legal framework for the fair and equitable sharing of benefits arising from the use of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity.

Key Objectives:

- To ensure that countries providing genetic resources receive fair compensation and benefits when those resources are used for research, innovation, or commercial purposes.
- To promote transparency and legal certainty in the use of genetic materials and associated traditional knowledge.
- To strengthen the rights of indigenous and local communities over their traditional knowledge and biological resources.

Main Provisions:

- Establishes clear rules for access to genetic resources based on prior informed consent (PIC) and mutually agreed terms (MAT).
- Encourages benefit-sharing in the form of monetary payments, technology transfer, research collaboration, or capacity building.
- Supports compliance measures to ensure users respect the laws and regulations of provider countries.

India and the Nagoya Protocol:

India ratified the Nagoya Protocol in 2012.

The National Biodiversity Authority (NBA) oversees its implementation under the Biological Diversity Act, 2002.

DIRECTION

Cartagena Protocol on Biosafety

The Cartagena Protocol on Biosafety is a supplementary agreement to the Convention on Biological Diversity (CBD). It was adopted in 2000 in Cartagena, Colombia, and came into force in 2003.

The Protocol aims to ensure the safe handling, transport, and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biodiversity and human health.

Key Objectives:

- To protect biological diversity from potential risks posed by LMOs.
- To ensure safe transfer, handling, and use of LMOs across borders.
- To promote informed decision-making by countries regarding the import of LMOs.

Main Provisions:

- Establishes the Advance Informed Agreement (AIA) procedure, requiring exporters to notify and obtain consent from importing countries before the first intentional transboundary movement of LMOs.
- Creates the Biosafety Clearing-House (BCH) to facilitate information exchange on LMOs and national biosafety regulations.
- Encourages capacity building, public awareness, and participation in biosafety decision-making.

India and the Cartagena Protocol:

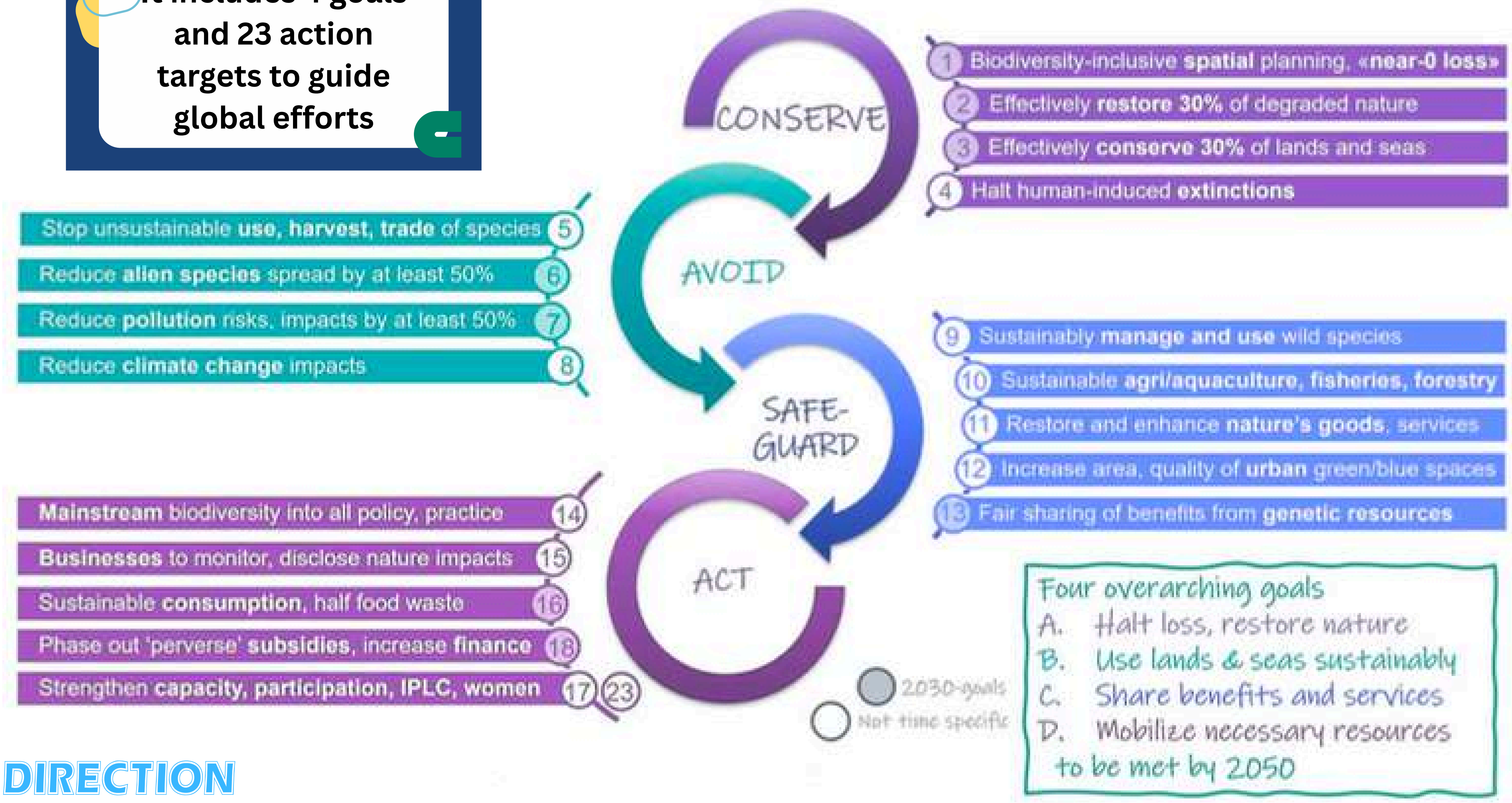
India ratified the Protocol in 2003.

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the national authority responsible for its implementation.

The Genetic Engineering Appraisal Committee (GEAC) regulates the use, release, and import of genetically modified organisms in India.

The Kunming-Montreal Global Biodiversity Framework is a landmark international agreement adopted in December 2022 to halt and reverse biodiversity loss by 2030

It includes 4 goals and 23 action targets to guide global efforts



DIRECTION

50 Years of Project Tiger

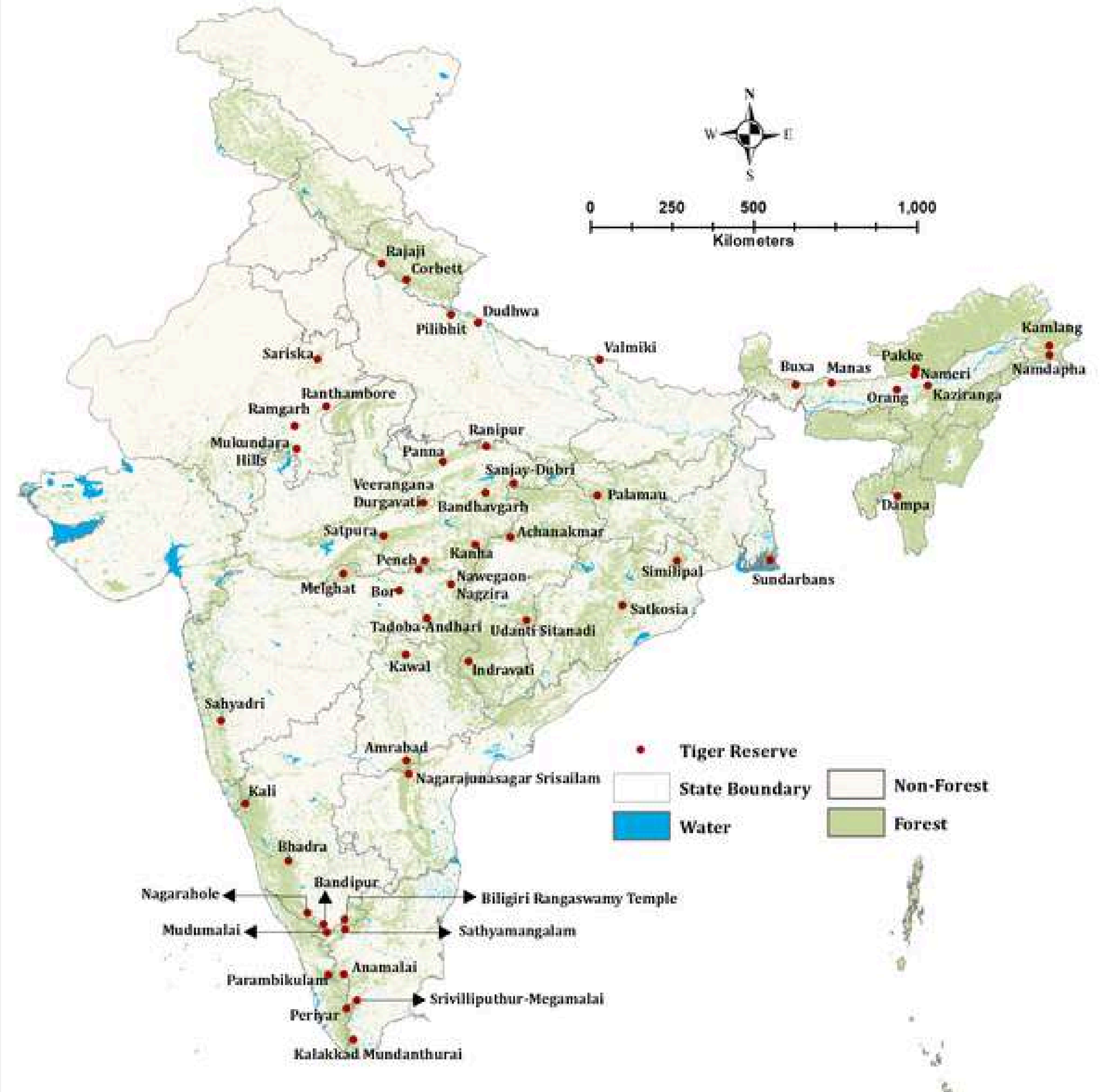
DIRECTION

50 YEARS

Project Tiger, initiated in 1973, has been India's flagship conservation initiative, successfully completing 50 years in 2023. Focused on tiger conservation through dedicated reserves and strict protection measures, it has played a crucial role in reviving tiger populations. As per the 5th cycle of All India Tiger Estimation 2022, India now hosts over 70% of the world's wild tiger population, reaffirming its leadership in global tiger conservation.

Landscape	Camera Trapped Tigers 2022
Shivalik Hills & Gangetic Plains Landscape	804
Central Indian Highlands & Eastern Ghats Landscape	1,161
Western Ghats Landscape	824
North Eastern Hills & Brahmaputra Plains Landscape	194
Sunderbans Landscape	100
India	**3,080***

**Ranipur (Uttar Pradesh) is added in Shivalik landscape for convenience. Three tigers were common between Ranipur & Madhya Pradesh (Central Indian landscape), hence 3 tigers were subtracted from the Total addition of all landscapes.*



55 Dholpur – Karauli Tiger Reserve – Rajasthan 2023

56 Guru Ghasidas – Tamor Pingla Tiger Resereve – Chhattisgarh 2024

57 Ratapani Tiger Resereve – Madhya Pradesh 2024

58 Madhav – Madhya Pradesh 2025

DIRECTION

MSTrIPES (Monitoring System for Tigers: Intensive Protection and Ecological Status)

Developed by the National Tiger Conservation Authority (NTCA) and the Wildlife Institute of India (WII). It is a platform where modern technology is used to assist effective patrolling, assess ecological status and mitigate human-wildlife conflict in and around tiger reserves.

The MSTrIPES program uses Global Positioning System (GPS), General Packet Radio Services (GPRS), and remote sensing, to collect information from the field, create a database using modern Information Technology (IT) based tools, analyses the information using GIS and statistical tools to provide inferences that allow tiger reserve managers to better manage their wildlife resources.

Patrol module

The patrol module maintains a spatial database of patrol track logs, crime scenes with geotagged photographs and important observations made by field staff while on different types of patrol duties.

Ecological Module

The tiger reserves of India use a set of standardized protocols for ecological monitoring by field staff which include the following components:

- Occupancy of carnivores and large ungulates,
- Abundance estimation of ungulates,
- Assessment of anthropogenic impacts and
- Habitat assessment.

Conflict Module

The conflict module of MSTrIPES addresses data recording, achieving, geotagging, and spatial analysis of human-wildlife conflict details. The app has provision for recording the details of attacks on humans, attacks on livestock, crop damage and property damage.

International Big Cat Alliance (IBCA) Becomes a Treaty-Based Organization

The International Big Cat Alliance (IBCA) officially became a treaty-based intergovernmental organization on January 23, 2025, with Nicaragua, Eswatini, India, Somalia, and Liberia ratifying the agreement. With 27 countries onboard, IBCA aims to drive global big cat conservation through cross-border collaboration.

Launched by PM Narendra Modi on April 9, 2023, during the 50 Years of Project Tiger event.

Union Cabinet approved its establishment in February 2024, with headquarters in India.

Founded by the National Tiger Conservation Authority (NTCA) under MoEFCC on March 12, 2024.

Focuses on the conservation of seven big cat species: Tiger, Lion, Leopard, Snow Leopard, Cheetah, Jaguar, and Puma.

Key Objectives & Impact

- Enhances global collaboration among governments, conservationists, and NGOs.
- Establishes a central fund and technical hub for research and conservation efforts.
- Strengthens habitat protection, anti-poaching strategies, and wildlife law enforcement.
- Combats illegal wildlife trade and promotes sustainable conservation practices.
- Integrates climate change mitigation into conservation strategies.

With IBCA's legal status now formalized, it marks a historic milestone in global big cat conservation, fostering stronger international cooperation to protect these apex predators and their ecosystems.

In collaboration with Kaziranga National Park and Tiger Reserve, the IBCA organized an executive course on capacity building for wildlife and conservation practitioners, bringing together officials from 27 countries, underscoring the shared global commitment to wildlife conservation and sustainable development

DIRECTION

Tigers

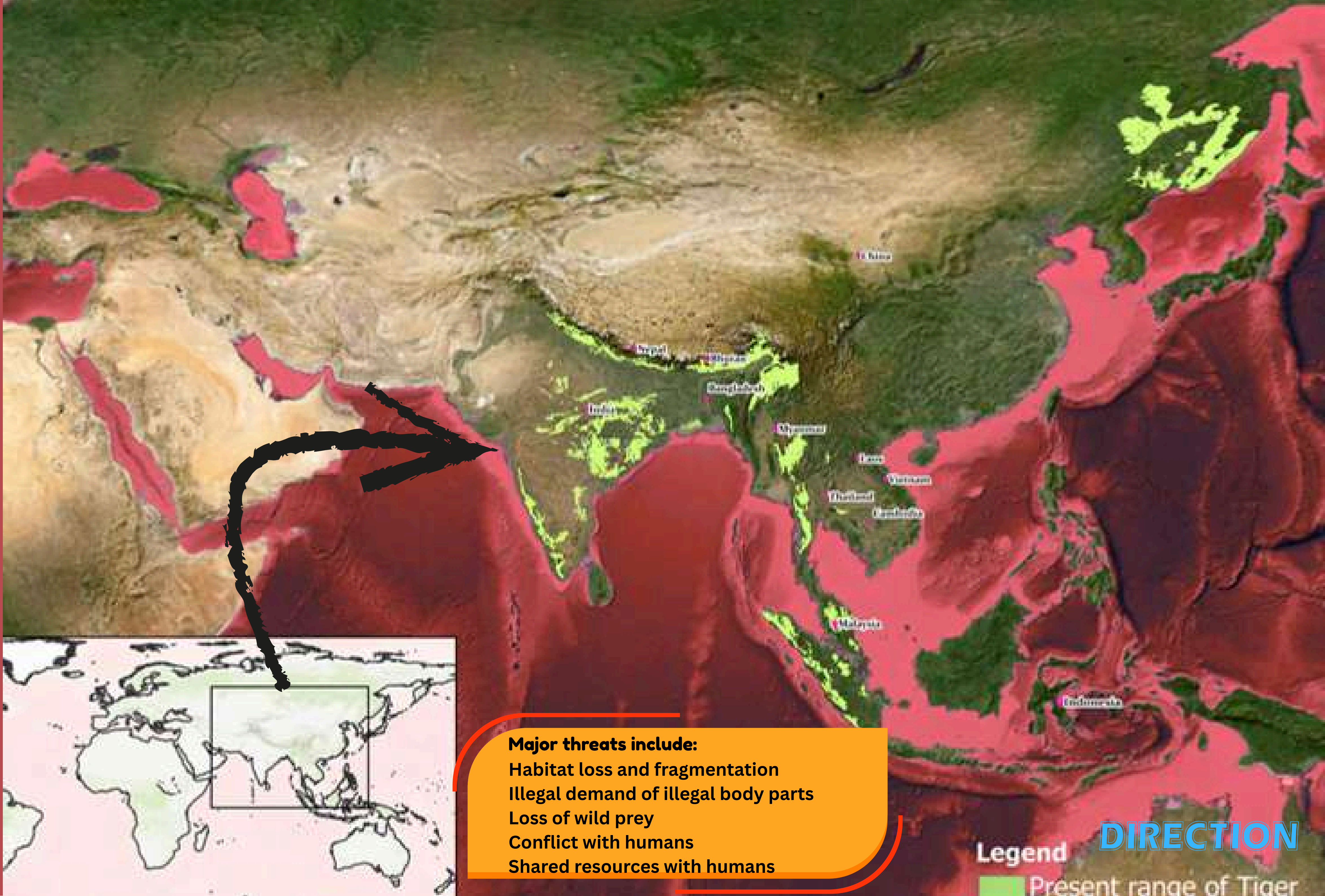
Tigers, known scientifically as Panthera tigris, stand as the largest among the living cat species. Recognizable by their distinctive dark vertical stripes on orange fur with a white underside, they serve as apex predators.

two subspecies:

- Panthera tigris tigris: This subspecies includes the Bengal, Malayan, Indochinese, South Chinese, and Siberian tiger populations in mainland Asia.
- Panthera tigris sondaica: This subspecies includes the Javan

Endangered

Globally, the tiger population stands at 5,574 in 2023, experiencing a notable increase. India and Nepal played a significant role in this growth, with both countries effectively doubling their tiger numbers during a period to 2016 to 2023. India is home for more than 70% of world's wild tiger population.



Major threats include:

Habitat loss and fragmentation

Illegal demand of illegal body parts

Loss of wild prey

Conflict with humans

Shared resources with humans

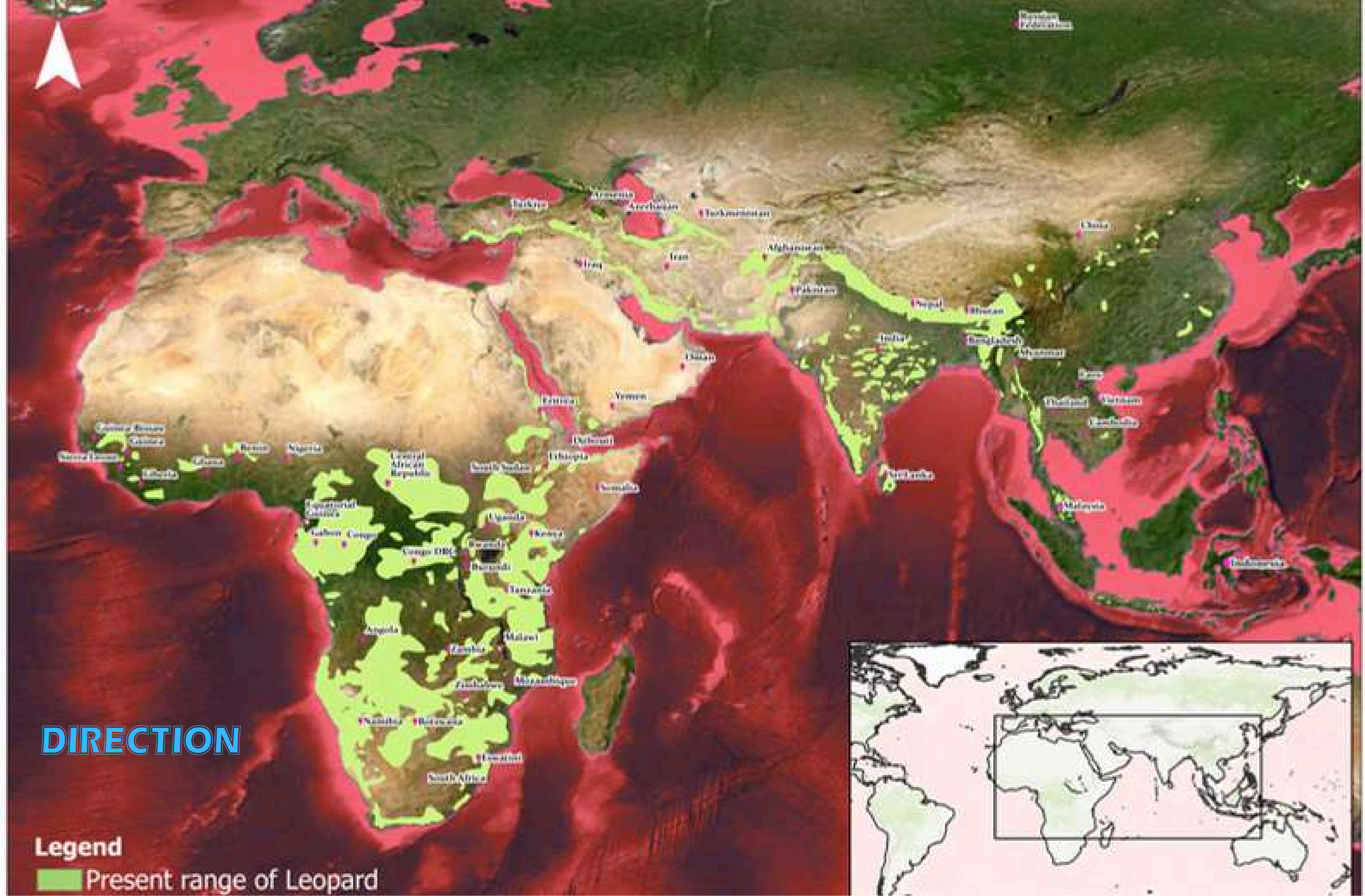
Leopards

Leopards, known scientifically as Panthera pardus, are one of the five extant species in the Panthera genus, which also includes lions, tigers, and jaguars. The term "leopard" finds its origins in the Greek language, specifically from the combination of "leon" (meaning lion) and "pardus" (referring to a panther), reflecting the unique characteristics and features of these large feline predators. Their stealth, agility, and ability to adapt to various environments make them formidable predators.

8 sub-species of leopards have been identified:

- Panthera pardus pardus – Africa
- Panthera pardus tulliana – South West Asia (Turkey, Caucasus, Turkmenistan, Uzbekistan, Iran, Iraq, Afghanistan and Pakistan)
- Panthera pardus fusca – Indian subcontinent, Myanmar and China
- Panthera pardus kotiya-Sri Lanka
- Panthera pardus delacouri – SE Asia and probably south China
- Panthera pardus orientalis – Eastern Asia from Russian Far East to China
- Panthera pardus melas –Java
- Panthera pardus nimr –Arabian peninsula

DIRECTION


DIRECTION
Legend
Present range of Leopard
Russian Federation
Turkiye
Armenia
Azerbaijan
Turkmenistan
China
Iraq
Iran
Afghanistan
Pakistan
Nepal
Bhutan
India
Bangladesh
Myanmar
Laos
Thailand
Vietnam
Cambodia
Sri Lanka
Malaysia
Indonesia
Oman
Yemen
Eritrea
Djibouti
Ethiopia
Somalia
South Sudan
Central African Republic
Guinea Bissau
Guinea
Sierra Leone
Liberia
Ghana
Benin
Nigeria
Equatorial Guinea
Gabon
Congo
Congo DRC
Uganda
Kenya
Rwanda
Burundi
Tanzania
Angola
Zambia
Malawi
Zimbabwe
Mozambique
Namibia
Botswana
Eswatini
South Africa

Jaguars

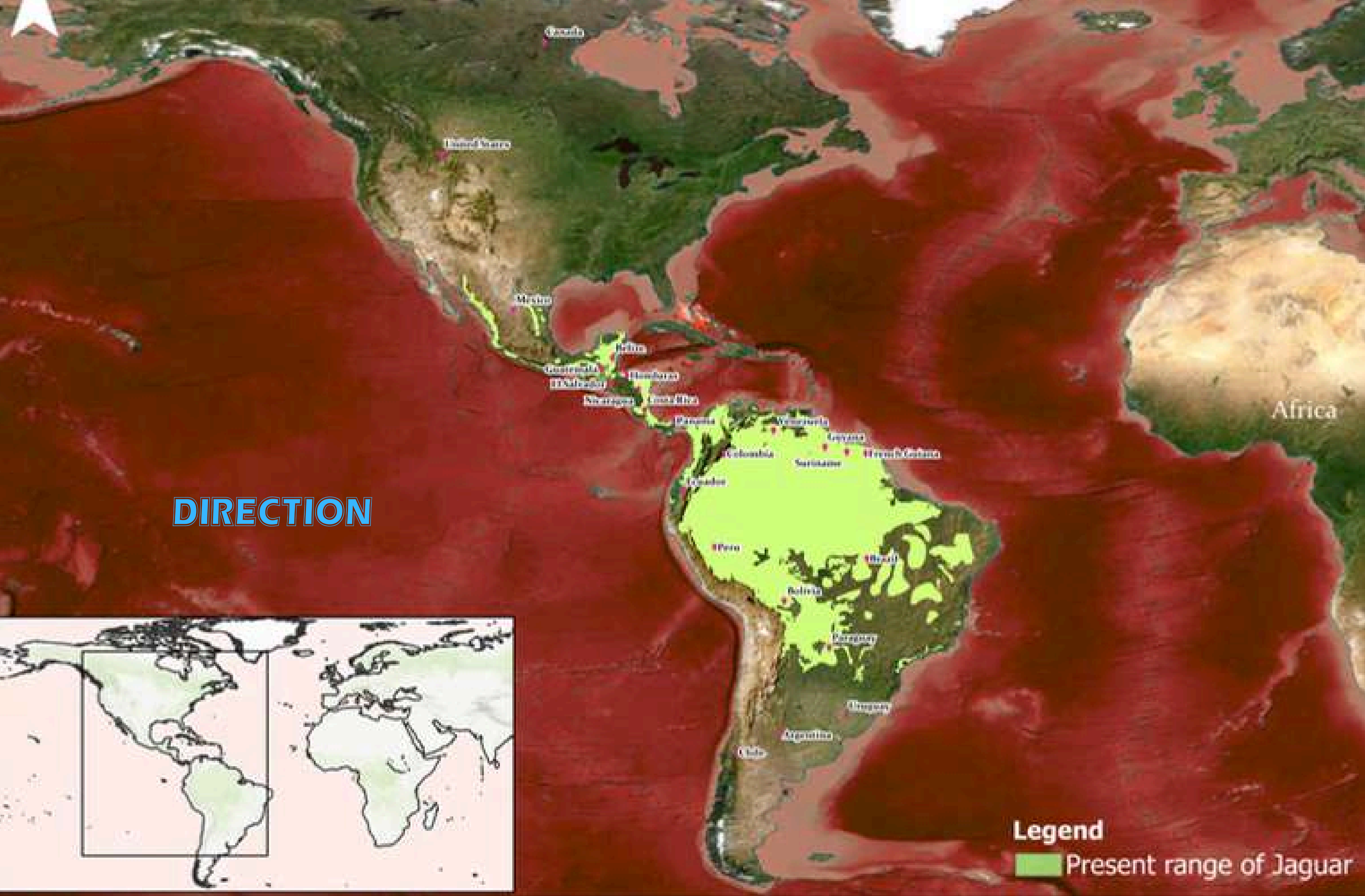
Jaguars are the largest big cats native to the Americas and recognized for their strong build and distinctive coat pattern. The word 'jaguar' probably originates from yaguara, a Tupí-Guaraní word of South America meaning "true, fierce beast who kills with one leap." They are the largest cats in the Americas and the third-largest globally, following tigers and lions.

The latest Felidae taxonomy revision in 2017 proposed that the jaguar is a monotypic species (with no sub-species).

Near Threatened

Jaguars have a wide range in the Western Hemisphere, extending from the southwestern United States across Mexico and much of Central America to South America, as far south as Paraguay and northern Argentina. Brazil holds around half of the wild jaguars in the world with approximately 89% of the global population living in the Amazon River basin.

DIRECTION



Mexico
Colombia
Peru
Brazil
Bolivia
Paraguay
Uruguay
Argentina
Chile
Africa
DIRECTION
Legend
Present range of Jaguar

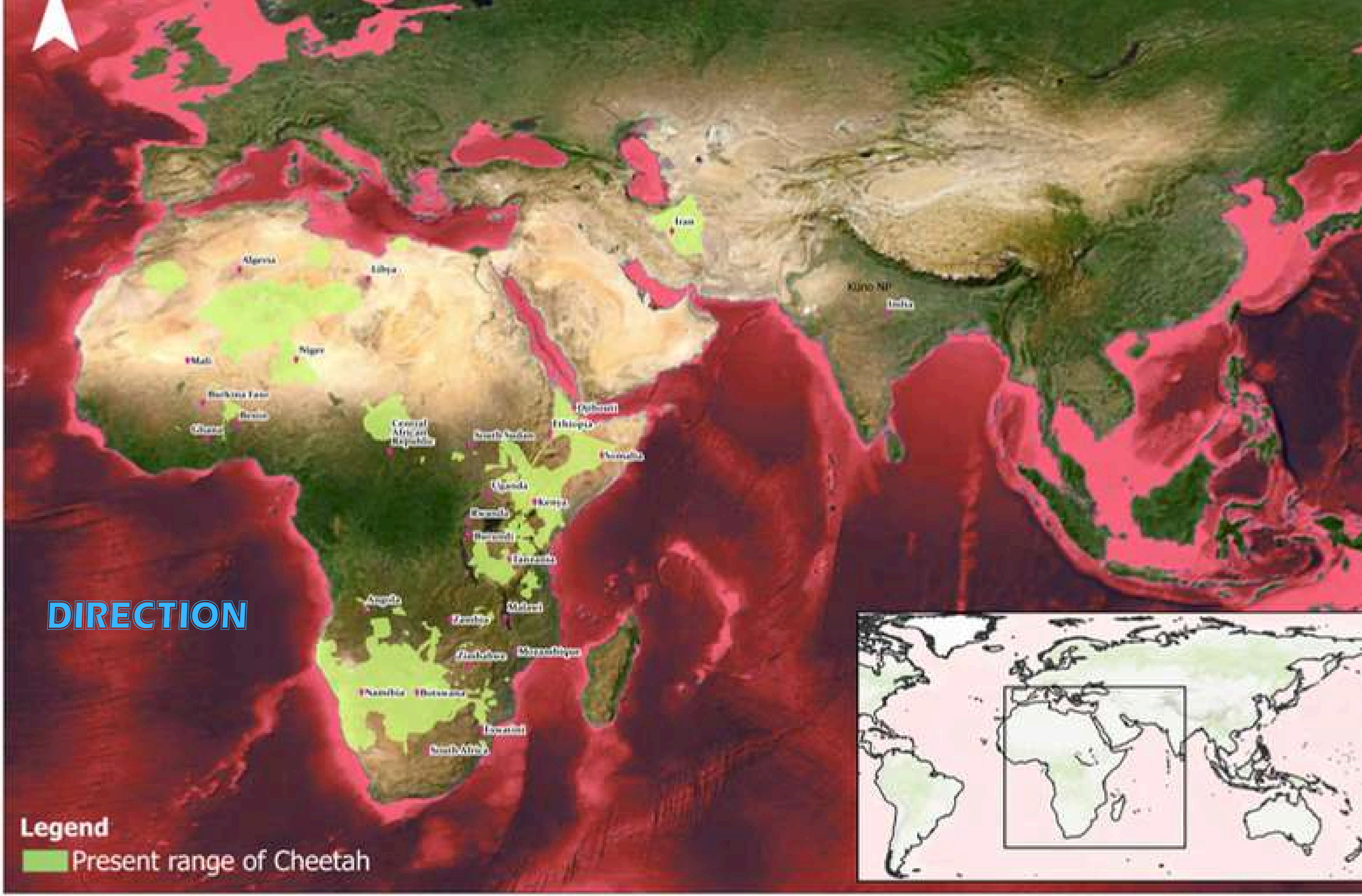
Cheetah

The cheetah is a large feline recognized for its speed and distinctive physical characteristics. The name "Cheetah" is derived from a Sanskrit word "Chitra" means spots. The cheetah and humans have coexisted since at least 3000 BCE, when an official seal from the Sumerians included a hooded, leashed cheetah on its head

Originally, five subspecies of cheetahs were recognized, but recent genetic studies suggest that only four subspecies can be acknowledged:

- Southeast African cheetah : This is the nominate subspecies, with the largest population found in Angola, Botswana, Mozambique, Namibia, South Africa, and Zambia.
- Asiatic cheetah :Confined to central Iran, this subspecies represents the only surviving cheetah population in Asia.
- Northeast African cheetah : Found in the northern Central African Republic, Chad, Ethiopia, and South Sudan.
- Northwest African cheetah : Occurs in Algeria, Benin, Burkina Faso, Mali, and Niger, and is listed as Critically Endangered on the IUCN Red List.

DIRECTION



Iran
Kuno NP
India
Libya
Niger
Mali
Djibouti
Ethiopia
South Sudan
Uganda
Kenya
Rwanda
Burundi
Tanzania
Angola
Malawi
Zambia
Mozambique
Namibia
Botswana
Eswatini
South Africa
DIRECTION
Legend
Present range of Cheetah

Project Cheetah

Project Cheetah is a landmark wildlife conservation initiative launched on September 17, 2022 aimed at reintroducing cheetahs to India after their extinction in the late 1940s and early 1950s. It operates under the umbrella of Project Tiger and aligns with the Cheetah Action Plan to restore and conserve the species. Efforts are underway to expand suitable habitats, ensuring long-term survival and ecological balance in India's grassland ecosystems.

Key Achievements:

- **Transcontinental Relocation:** In September 2022, eight cheetahs from Namibia were translocated to Kuno National Park, followed by twelve cheetahs from South Africa in February 2023.
- **Successful Adaptation:** The majority of these cheetahs have adapted well to their new environment, exhibiting natural behaviours such as hunting, territory establishment, and mating. Notably, a female cheetah gave birth to cubs on Indian soil after 75 years-three cubs were born to Namibian Cheetah Aasha at the Kuno National Park.
- **Community Engagement:** The project has actively involved local communities, providing direct and indirect employment opportunities. Over 350 'Cheetah Mitras' (Cheetah Friends) from surrounding villages have been engaged to educate the public on cheetah behaviour and human-wildlife conflict mitigation, fostering peaceful coexistence.

Puma

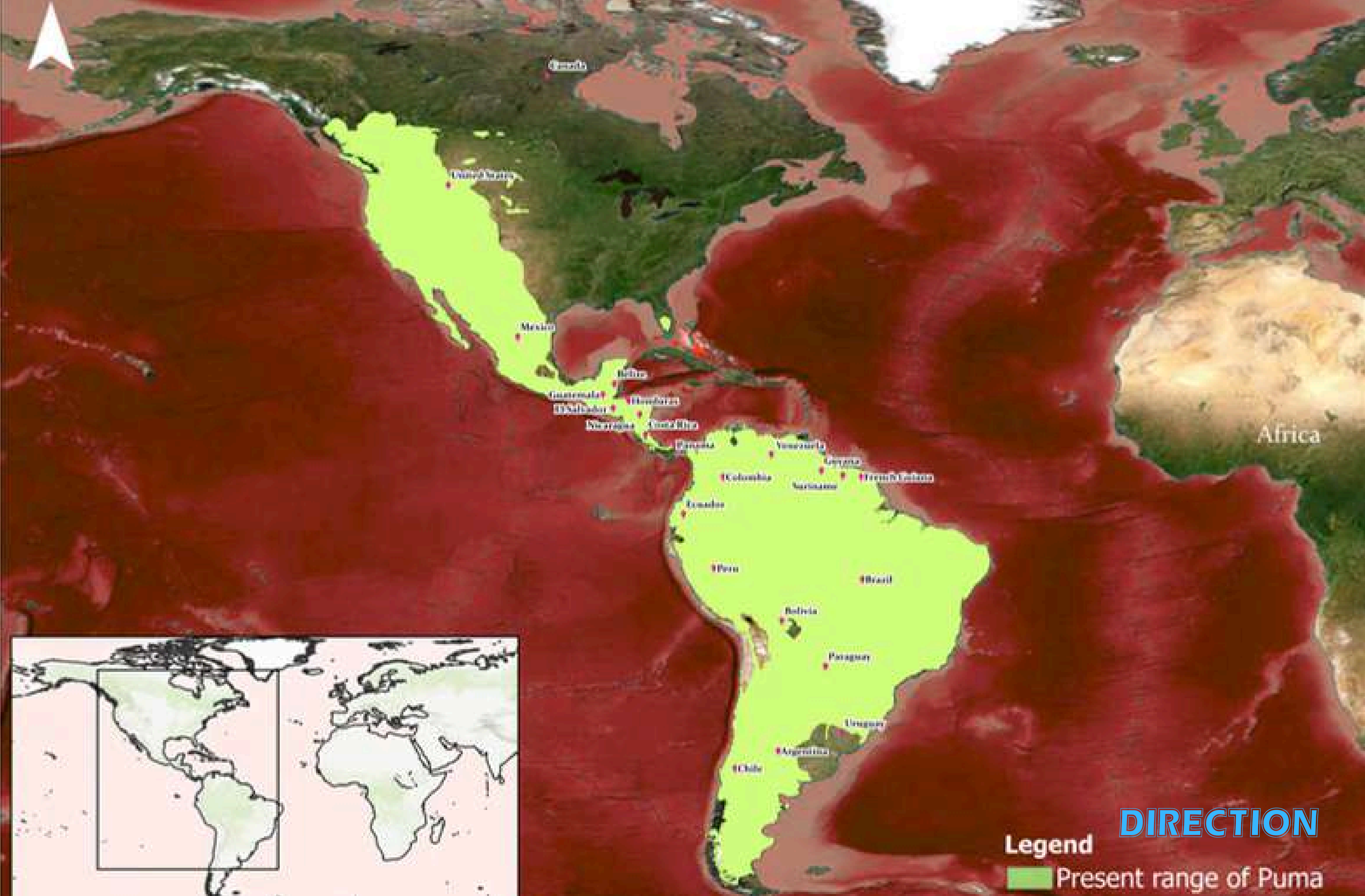
The puma, also known as the cougar or mountain lion, is a large cat species with the widest distribution of any New World mammal, spanning from southeastern Alaska to the southern tip of Chile. This remarkable range makes it one of the most widespread terrestrial mammals in the Western Hemisphere.

six subspecies were suggested

- Puma concolor cougar in North America
- Puma concolor costaricensis in Central America
- Puma concolor capricornensis in eastern South America
- Puma concolor concolor in northern South America
- Puma concolor cabrerae in central South America
- Puma concolor in southern South America

Least Concern

DIRECTION



Canada
Mexico
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Costa Rica
Panama
Venezuela
Guyana
French Guiana
Colombia
Suriname
Ecuador
Peru
Brazil
Bolivia
Paraguay
Uruguay
Argentina
Chile
Africa
DIRECTION
Legend
Present range of Puma

DIRECTION

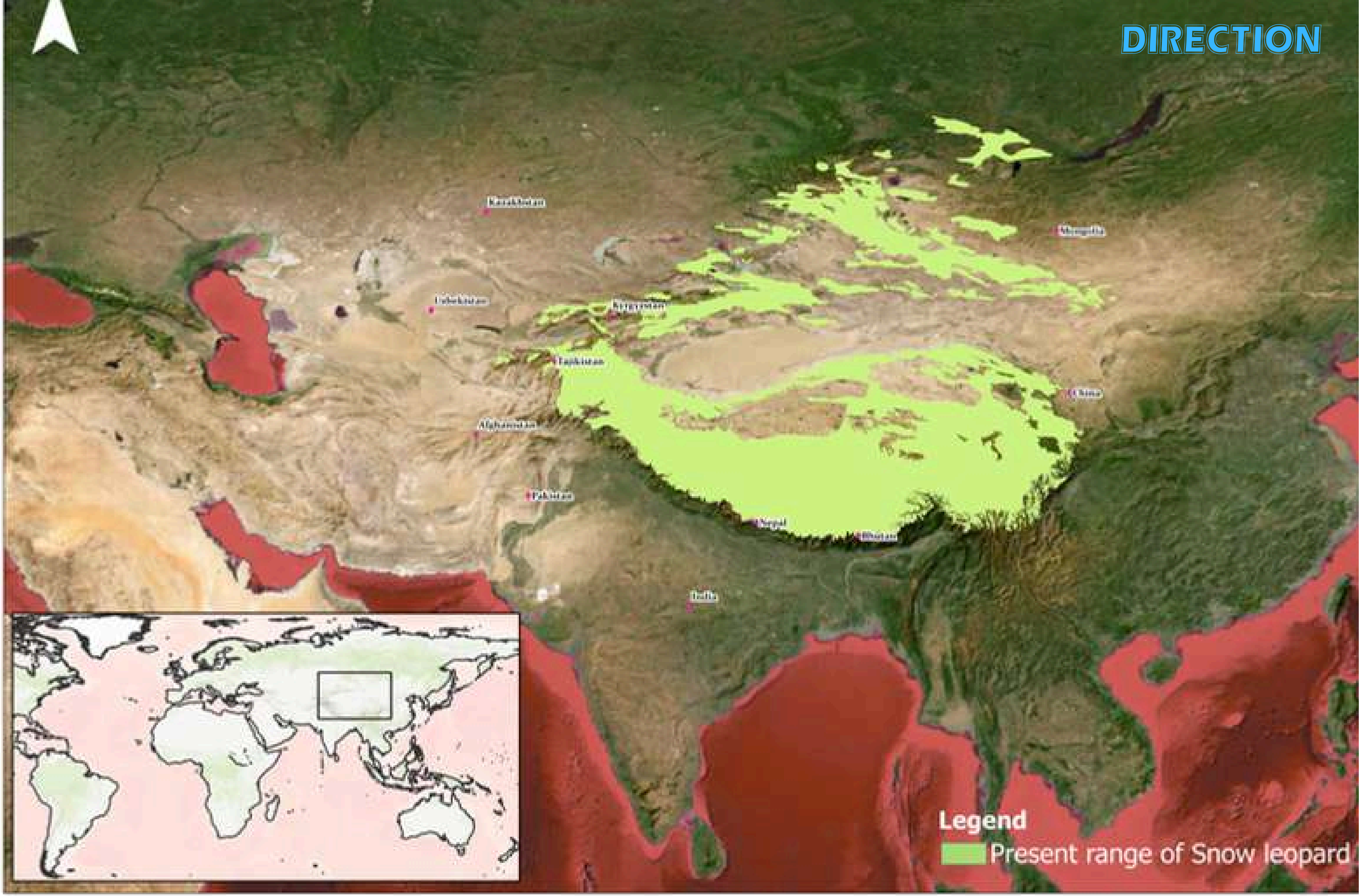
Snow leopard

The snow leopard, also known as the ounce, is a large cat species native to the mountain ranges of Central and South Asia. Also known as the "Ghost of the Mountains," snow leopard is an elusive big cat that serves as ambassadors for the planet's highest places and are revered by the local communities.
The presence of this big cat, as an apex predator, indicates a healthy ecosystem.

three subspecies:

- Western group (Tian Shan, Pamir, trans-Himalaya region)
- Northern group found in Altai region of Mongolia
- Central group inhabiting the Himalayas and Qinghai (Tibetan Plateau)

Vulnerable


DIRECTION
Legend
Present range of Snow leopard

Lions

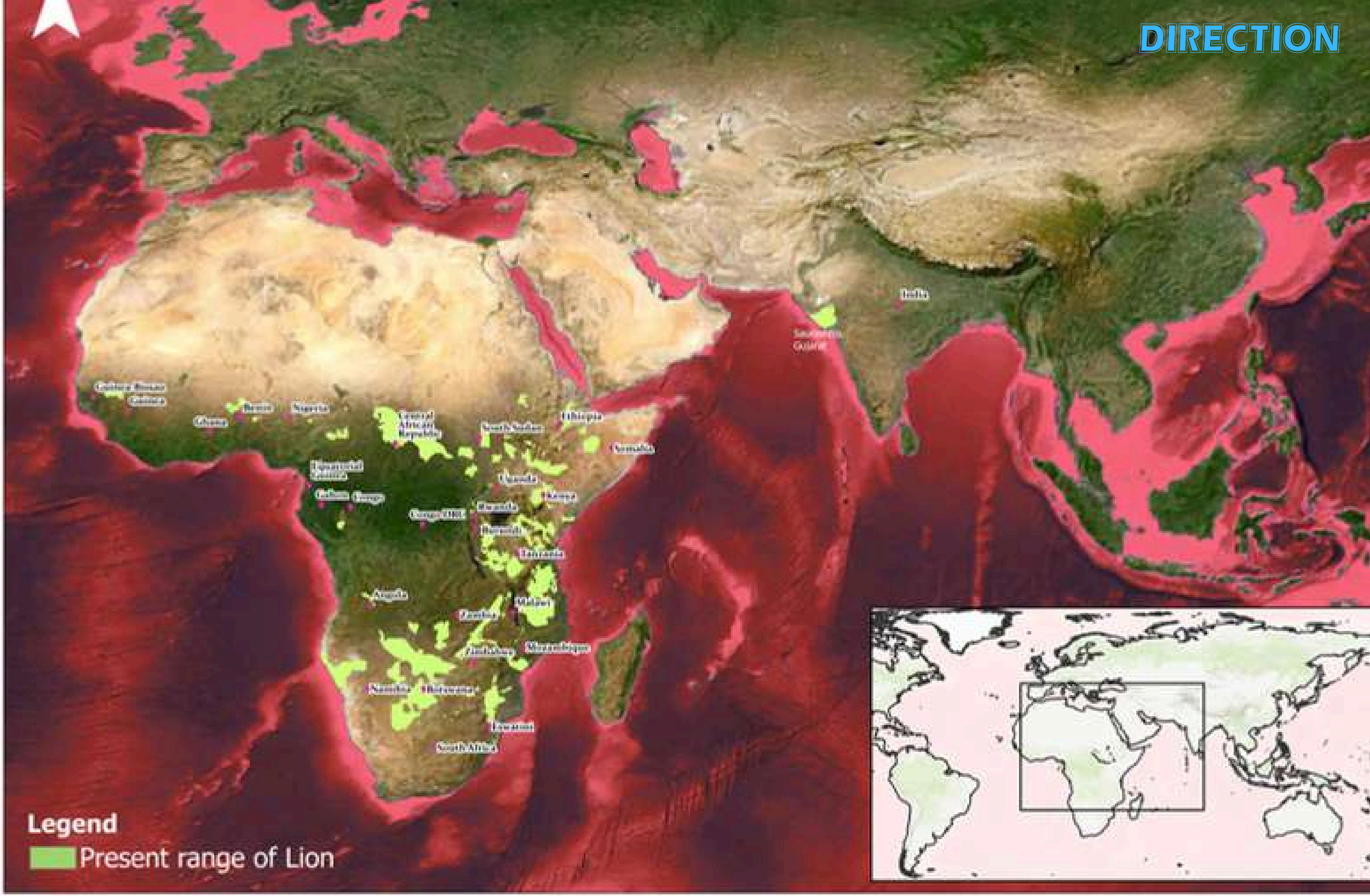
Often depicted as the "King of the beasts", lions are among the one of the most iconic big cats in the world. It is an apex predator and is second only to in size among felids.

two main subspecies:

- Northern lion : Populations of this subspecies are found in North, Central, and West Africa. This subspecies also includes the Asiatic lion and regionally extinct Barbary lion.
- Southern lion : Covers the East and South African lion populations.

Vulnerable

DIRECTION


DIRECTION
India
Legend
Present range of Lion

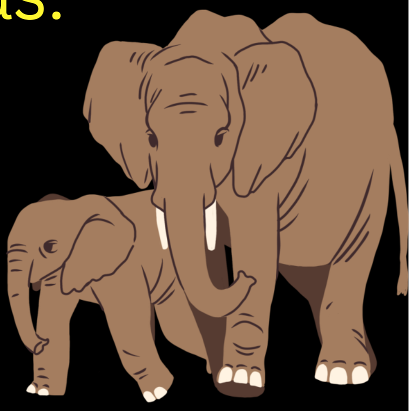
Project Elephant

India, home to over 60% of the global Asian elephant population, has undertaken significant measures to protect and conserve these majestic animals. Project Elephant, launched by the Government of India, is a flagship initiative aimed at ensuring the long-term survival of elephants in their natural habitats. This program focuses on habitat preservation, human-elephant conflict mitigation, and the welfare of captive elephants, reflecting India's deep-rooted cultural and ecological commitment to elephant conservation.

Key Achievements and Initiatives

- Growing Elephant Population: India’s wild elephant population has increased from 26,786 (2018 census) to 29,964 in 2022, reinforcing the country’s successful conservation efforts.
- Expanding Protected Areas: India has 33 Elephant Reserves across 14 states, covering a vast 80,777 km², ensuring elephants have safe migratory corridors and protected habitats.
- Integrated Wildlife Protection: Elephant Reserves are often overlapping with Tiger Reserves, Wildlife Sanctuaries, and Reserved Forests, ensuring comprehensive protection under multiple forest and wildlife laws.
- Financial Investment in Conservation: Under the 15th Finance Commission cycle, the Government has approved a total outlay of ₹2,602.98 crores for wildlife conservation, with ₹236.58 crores specifically allocated for Project Elephant to strengthen conservation measures and reduce human-elephant conflicts.

India has by far **the largest number of wild Asian elephants** in the world, estimated at 29,000-30,000 according to the 2017 census, about 58% of the species' global population.The distribution of wild elephants in India is currently confined to four general areas:



- North-East India,
- Central India,
- North-Western India,
- Southern India.

India has 33 elephant reserves notified under Project Elephant, spread across 14 states. These reserves are critical habitats designated to conserve elephants and their movement corridors, with the most recent addition being the Terai Elephant Reserve in Uttar Pradesh.

States with Most Reserves: Tamil Nadu and Assam have the highest number of elephant reserves, with five each.

DIRECTION

Elephant corridors are linear, narrow, natural habitat linkages that allow elephants to move between secure habitats without being disturbed by humans.

Of the 150 corridors identified, six have been secured and six more are currently in the process of being secured through an amalgam of the four models.

Secured corridors

- Thirunelli – Kudrakote, Kerala
- Edayarhalli – Doddasampige, Karnataka
- Kaniyanpura – Moyar corridor, Karnataka
- Siju – Rewak, Meghalaya
- Rewak – Emangre, Meghalaya
- Chilla – Motichur, Uttarakhand

Corridors in the process of being secured

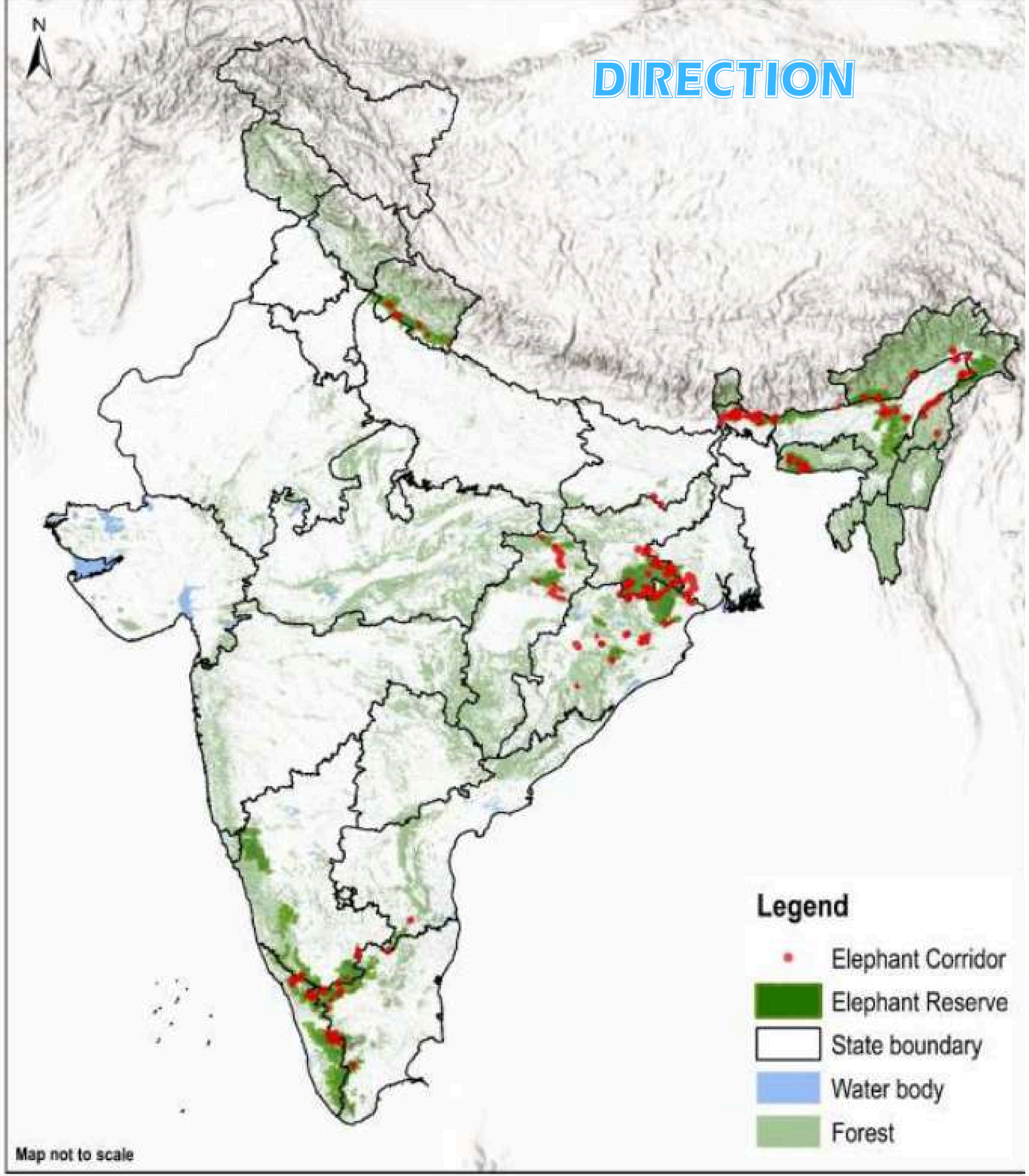
- Kalapahar – Daigrung, Karbi Anglong, Assam
- Chamrajnagar – Talamalai, Mudahalli, Karnataka
- Kaziranga – Karbi Anglong, Panbari, Assam
- Kaziranga – Karbi Anglong, Kanchanjuri, Assam
- Kaziranga – Karbi Anglong, Amguri, Assam
- Kaziranga – Karbi Anglong, Deosur, Assam

DIRECTION

Gajah report-2023

- West Bengal has the highest number (n = 26) of identified elephant corridors in India, accounting for over 17% of all the reported elephant corridors in the country.
- About 84% (n = 126) of the identified elephant corridors occur within the state boundaries.
- About 13% (n = 19) are interstate elephant corridors that extend into two or more states. There were 6 transnational corridors between India and Nepal.
- Among the four elephant-bearing regions,

35% (n = 52) of the elephant corridors were in the East-central region,
32% (n = 48) in the North-east region.
The Southern region, 21% (n = 32) of the elephant corridors in India. harbors the largest elephant population in India
The Northern region accounting for 12% (n = 18) of all the reported elephant corridors in the country.



6,000+ elephants present

- 20 Elephant corridors
- 3,300 sq km out of 12,600 sq km is in protected area

Nilambur, Silent Valley and Coimbatore

- 2 Elephant corridors
- 2,300 sq km

Periyar - Agastyamalai landscape

1,800 elephants present

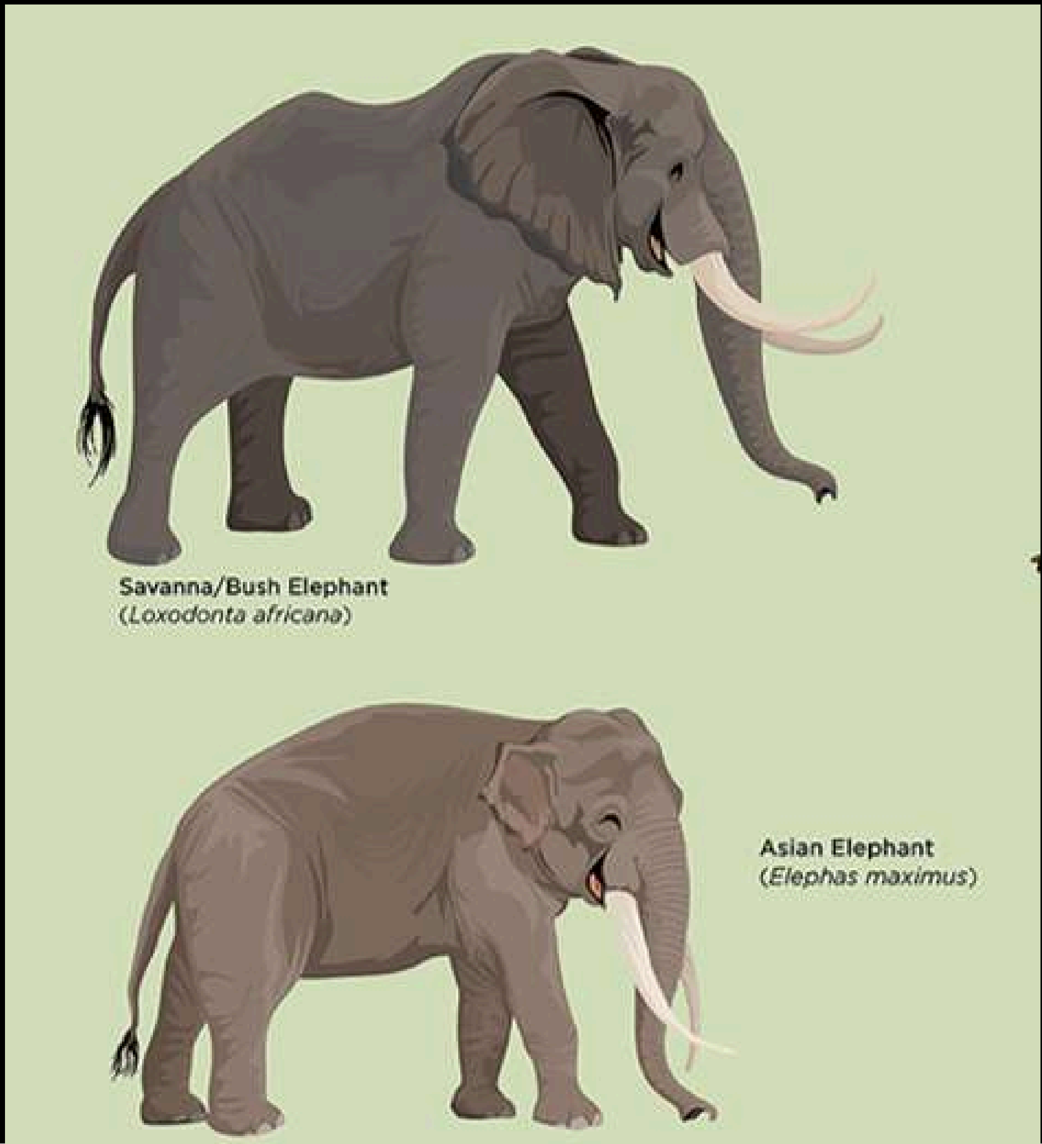
- 1 Elephant corridor
- 5,600 sq km

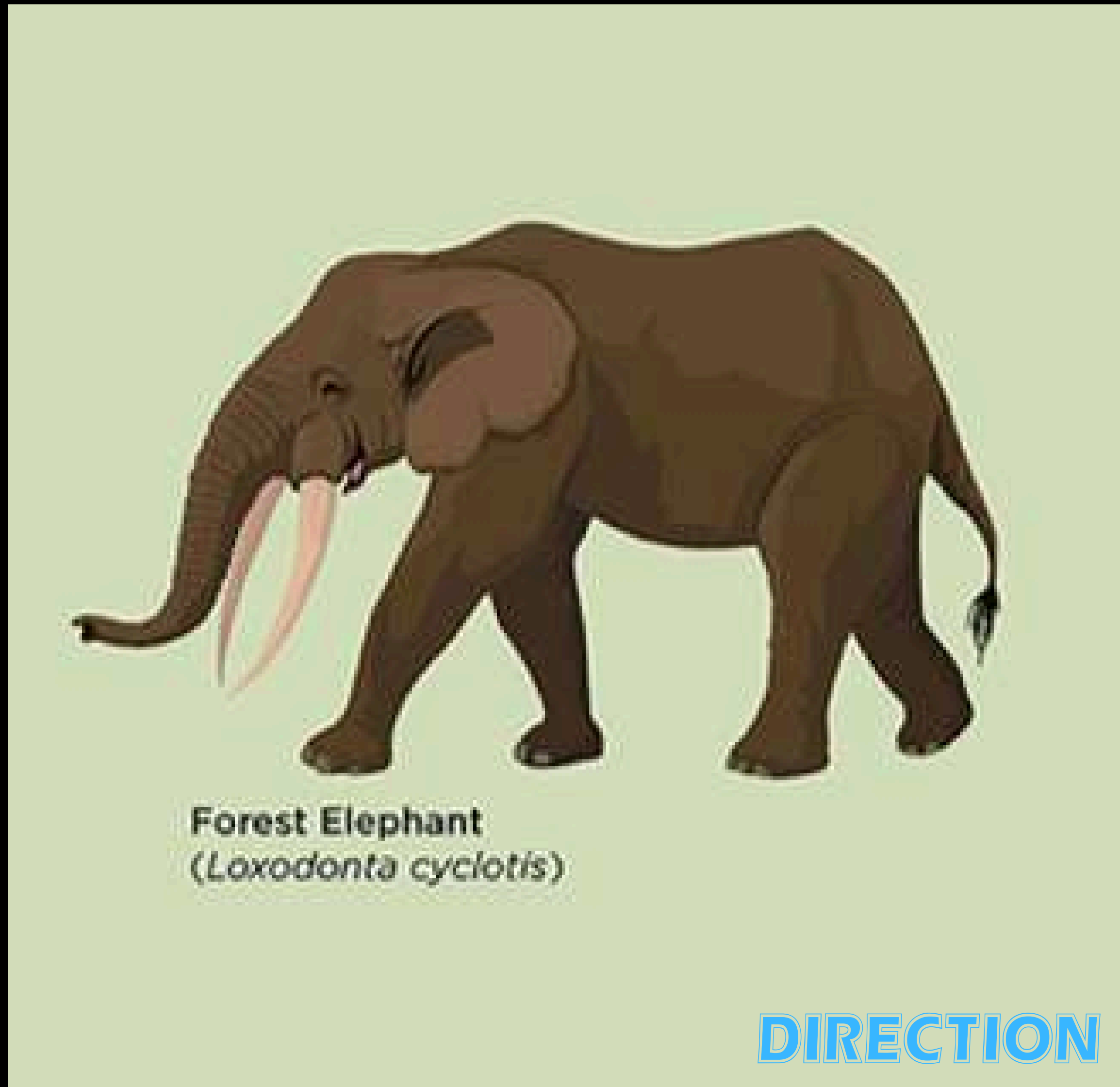
Anaimalai-Parambikulam area

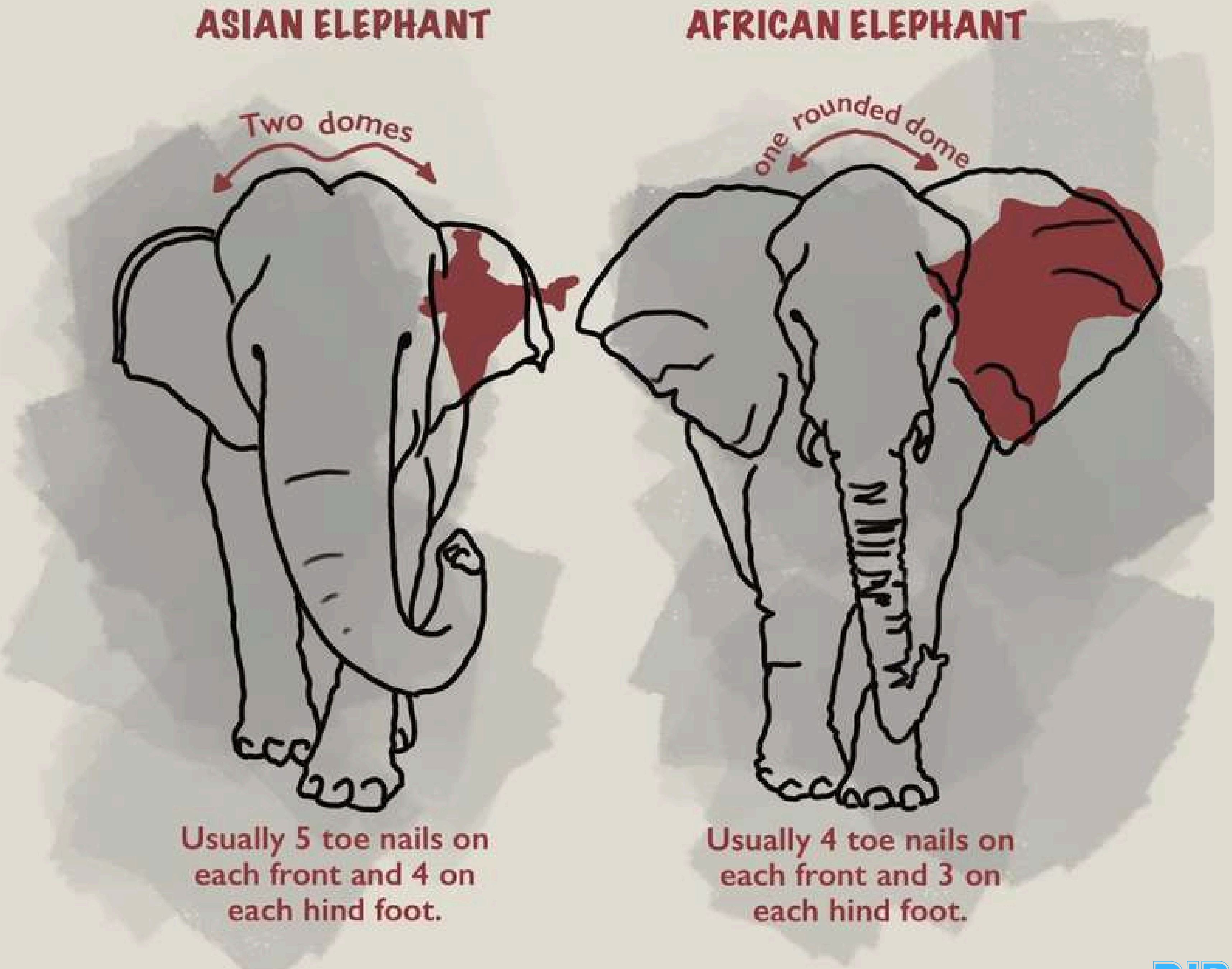
2,500 elephants present

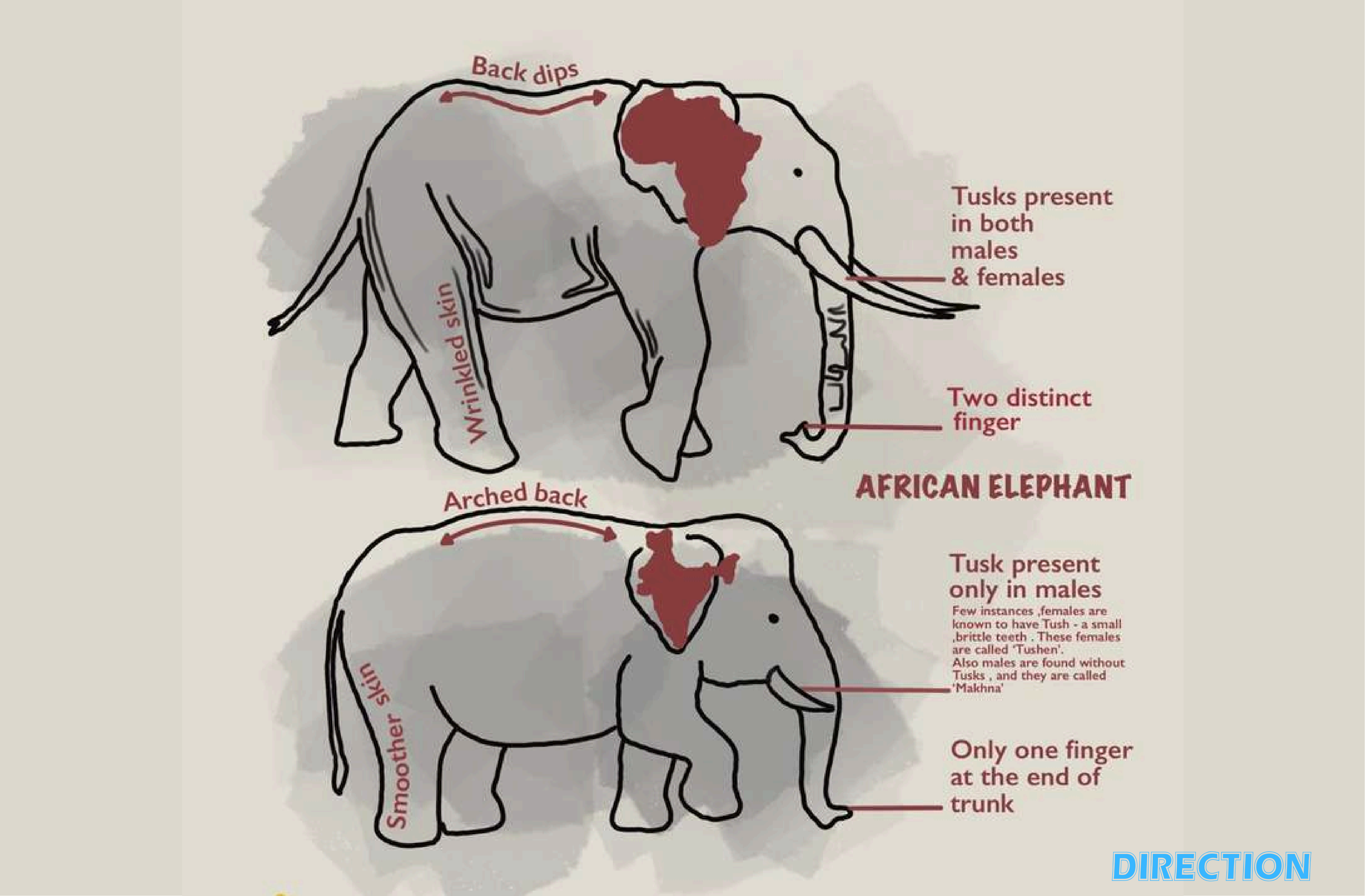
- 5 Elephant corridors
- 5,500 sq km

There are three species of elephants found in the world. Two of these are in Africa and one in Asia. The Asian elephant (Elephas maximus) is India's largest terrestrial mammal and requires large forest areas to manage and maintain. Therefore, there is no doubt that elephant conservation clearly depends on securing large forest areas. **All of the 3 elephant species face endangerment.**





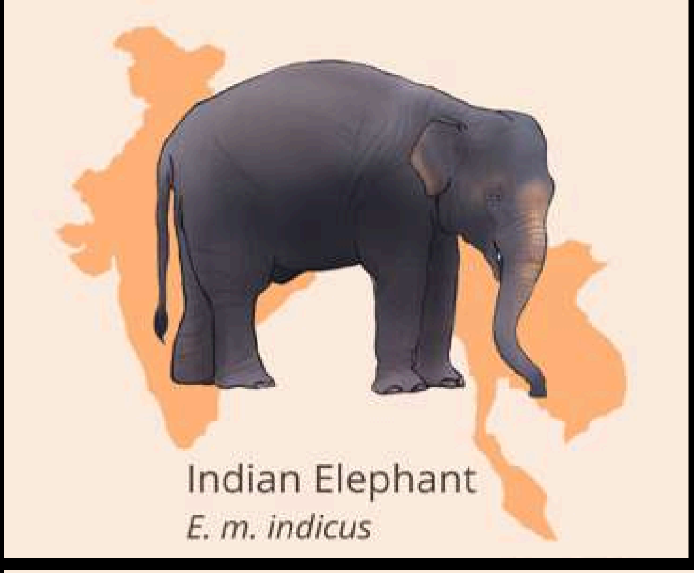

ASIAN ELEPHANT
AFRICAN ELEPHANT
Two domes
one rounded dome
Usually 5 toe nails on each front and 4 on each hind foot.
Usually 4 toe nails on each front and 3 on each hind foot.


Back dips
Wrinkled skin
Tusks present in both males & females
Two distinct finger
AFRICAN ELEPHANT
Arched back
Smoother skin
Tusk present only in males
Few instances ,females are known to have Tush - a small ,brittle teeth . These females are called 'Tushen'.
Also males are found without Tusks , and they are called 'Makhna'
Only one finger at the end of trunk
DIRECTION

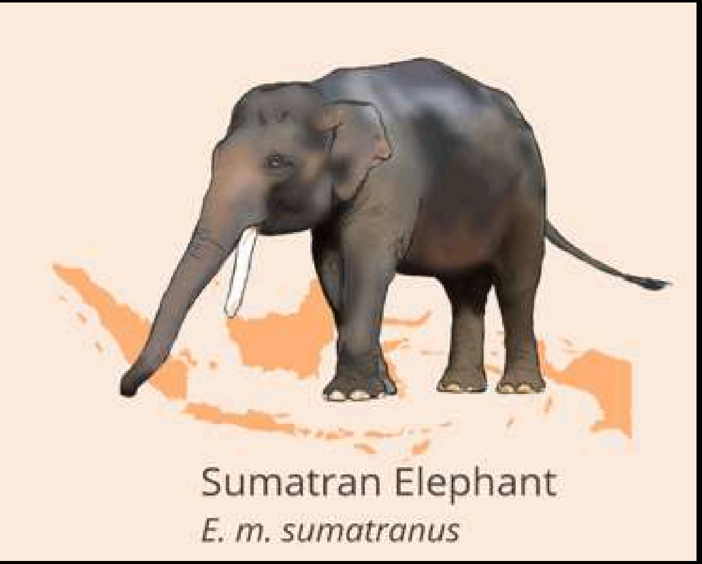
Asian Elephants (Elephas maximus):

The Asian elephant, though distinct from its African counterparts, exhibits its own remarkable diversity. Over time, geographical isolation and varying environmental pressures have led to the evolution of several subspecies:

Indian Elephant (Elephas maximus indicus): Characterized by their larger size, relatively wide bodies, and rounded backs. Indian elephants are a prominent presence across the Indian subcontinent.



Sumatran Elephant (Elephas maximus summatranus): The smallest of the Asian elephant subspecies. Sumatran elephants possess larger ears, a straight back, and a rounder body, uniquely adapted to the lush forests of Sumatra.



Sri Lankan Elephant (Elephas maximus maximus): They are found exclusively on the island of Sri Lanka. This subspecies is distinguishable by its darker skin, a more pronounced forehead, and larger ears.

African Savanna or Bush Elephants (Loxodonta africana):

As the largest land animals on Earth, African savanna elephants are an iconic sight across various African habitats, from vast savannas to dense bushlands. Their impressive size, large ears and imposing tusks are vital for adapting to diverse environmental and survival needs. They are known for their incredible endurance, capable of traversing vast distances in search for food and water, playing a crucial role in shaping the landscapes they inhabit.

DIRECTION

African Forest Elephants (Loxodonta cyclotis):

In contrast to their savanna-dwelling cousins, African forest elephants are smaller and more elusive. They thrive within the dense, verdant forests of Central and West Africa. Their adaptation to forested environments makes them indispensable to the health and biodiversity of these vital ecosystems. Sadly, their relatively smaller, straighter tusks make them a target for poaching, further exacerbating the threats they face from habitat loss and fragmentation. Protecting these forest architects is paramount to preserving the intricate web of life within their rainforest homes.

India's Species Recovery Programme

Based on India's Species Recovery Programme, there is a focused conservation effort to aid the recovery of 22 critically endangered species.
Part of the Integrated Development of Wildlife Habitats scheme, this program targets 16 terrestrial and 6 aquatic species.

Terrestrial species

The terrestrial species prioritized for conservation include:

Asiatic Lion: Found in Gujarat's Gir forest, the population of these lions has been growing due to conservation efforts.

Snow Leopard: Project Snow Leopard aims to protect this species and its high-altitude habitat across the Himalayas

Vultures: A Vulture Action Plan was launched to prevent the poisoning of vultures from the veterinary drug diclofenac, which caused a drastic population decline.

Asian Wild Buffalo: With fewer than 2,000 individuals left, the wild buffalo is also the subject of captive breeding and conservation by the Wildlife Trust of India.

Brow-Antlered Deer (Sangai): This species is found only in Manipur and was once considered almost extinct. The Wildlife Institute of India has developed an integrated conservation action plan.

Caracal: This small wild cat is native to parts of Africa and Asia. The Indian government included it in the species recovery program in 2021.

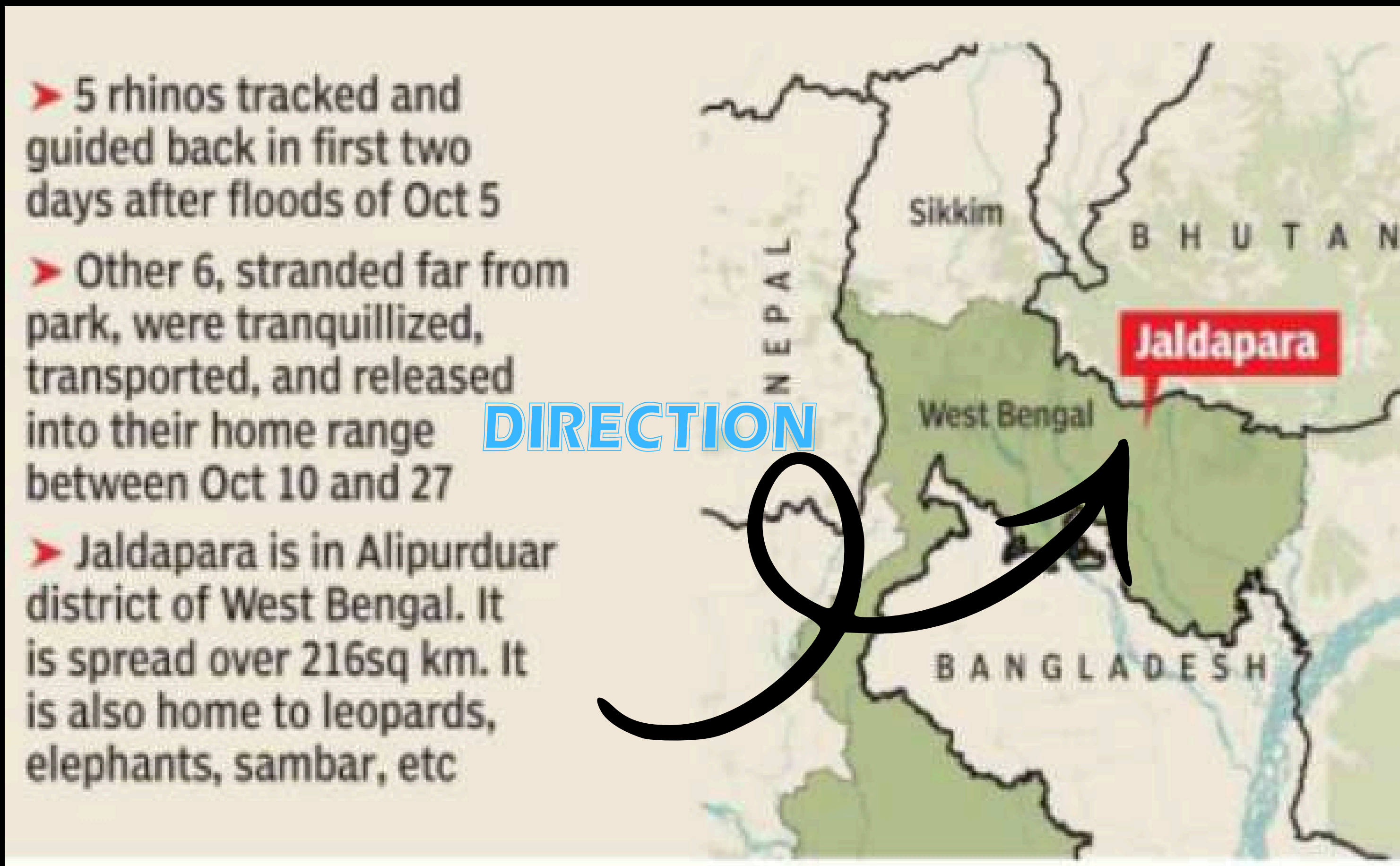
Indian Rhinoceros: Indian Rhino Vision 2020 successfully grew the rhino population, particularly in Assam, which now has over 4,000 rhinos.

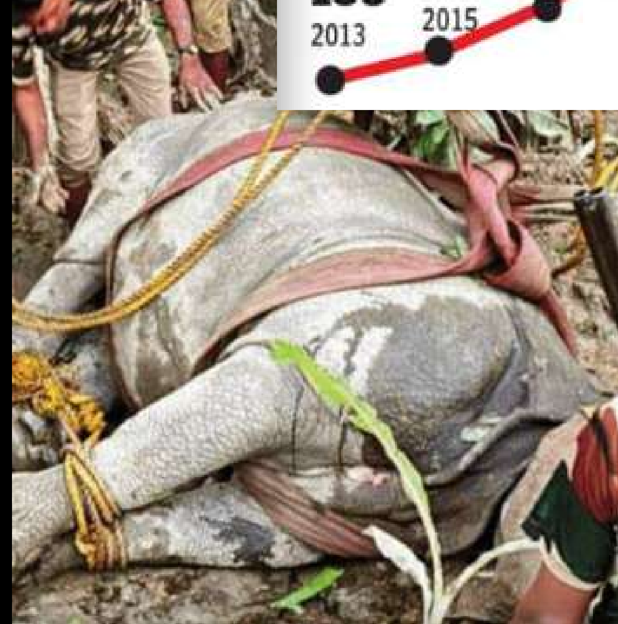
Jerdon's Courser: This nocturnal bird is endemic to India's Eastern Ghats and is extremely rare.

Malabar Civet: This small carnivore is endemic to the Western Ghats of India.

The operation to save north Bengal's rhinos has been launched to rescue 11 of them — all residents of Jaldapara National Park, which boasts **India's second-largest rhino population (330+) after Assam's Kaziranga.**

Jaldapara was severely affected because major flooding occurred in the Torsa river, which flows through the national park. It is the lifeline of Jaldapara, and of the large population of rhinoceroses that inhabits it. While major damages have been caused to park





Clouded Leopard: Habitat loss and poaching threaten this species found in the Himalayan foothills and Southeast Asia.

Hangul (Kashmir Stag): This critically endangered subspecies of red deer is confined to the Kashmir Valley, primarily in Dachigam National Park.

Nicobar Megapode: This bird, found in the Nicobar Islands, builds large mound nests to incubate its eggs

Nilgiri Tahr: A mountain goat species native to the Nilgiri Hills in southern India.

Red Panda: An indicator species for the Eastern Himalayas, the red panda is threatened by habitat loss and fragmentation.

Swamp Deer: Barasingha

The Wildlife Trust of India translocated a sub-species of swamp deer from Kaziranga National Park to help with its recovery.

DIRECTION

Bustard (including Floricans): The critically endangered Great Indian Bustard, along with Lesser and Bengal Floricans, faces threats from habitat degradation.

all critically endangered species endemic to the Indian subcontinent

DIRECTION

Aquatic species

The six aquatic species receiving focused conservation are:

Arabian Sea Humpback Whale: A small, isolated, and endangered population of humpback whales in the northern Indian Ocean.

Dugong: The only strictly marine herbivorous mammal, it is vulnerable to anthropogenic pressures on its seagrass habitat.

Gangetic River Dolphin: India's national aquatic animal, Project Dolphin, was announced to help conserve both marine and river dolphins.

DIRECTION

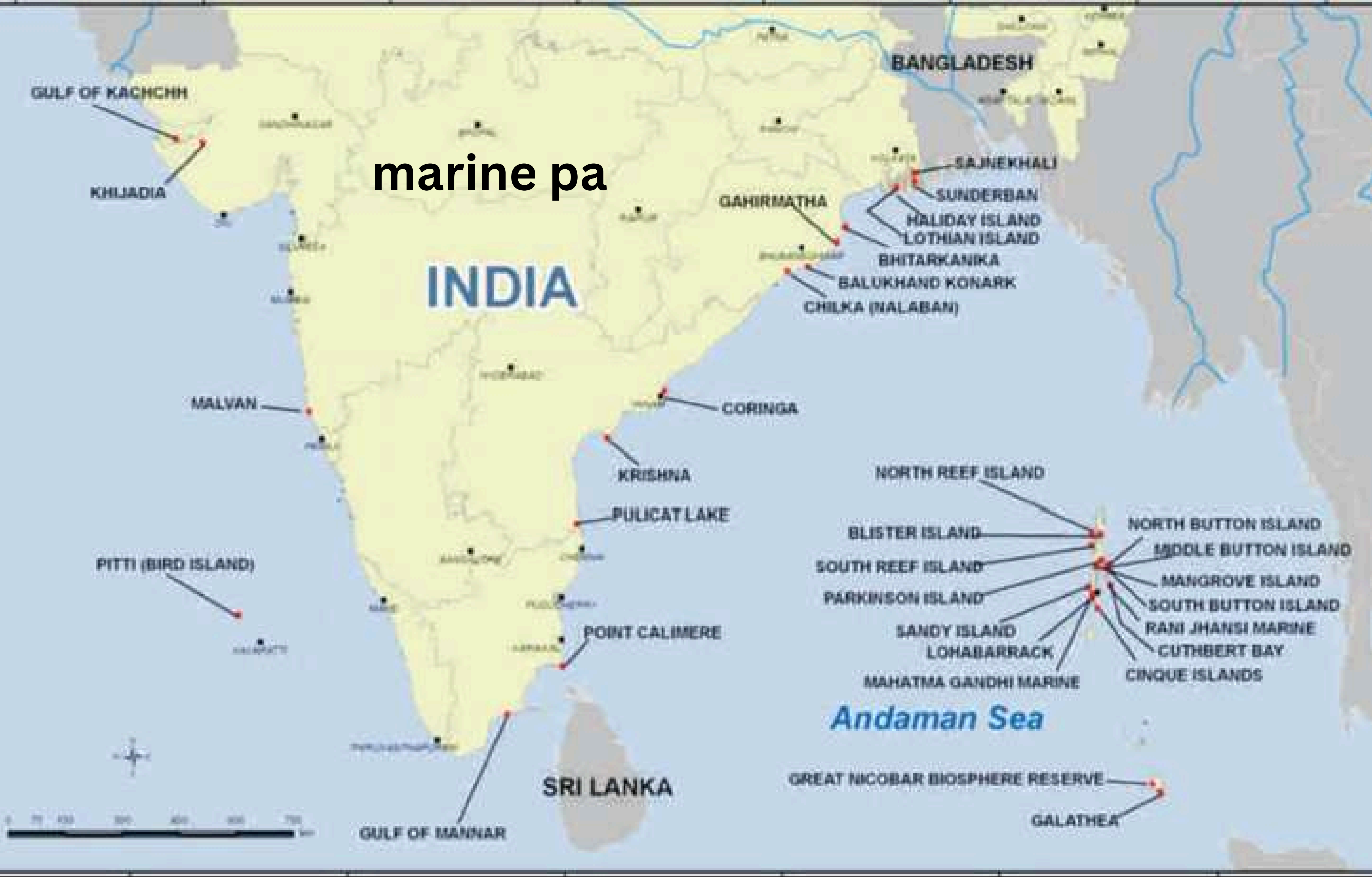
Edible Nest Swiftlet: This bird's nests, built with its saliva, are considered a delicacy, but the species is under protection.

Marine Turtles: Conservation efforts focus on protecting marine turtles like the Olive Ridley, especially along the coasts of Odisha.

Northern River Terrapin: This critically endangered turtle, one of the world's largest freshwater turtles, is found in the Sundarbans. **Batagur baska** has been considered a local delicacy, only a few individuals remained in captivity.

Key Announcements by the Government of India on World Wildlife Day 2025

- Release of India's first-ever riverine dolphin estimation report, covering 28 rivers across eight states. Encouragement of local community participation in dolphin conservation.
- Foundation stone laid for the National Referral Centre for Wildlife at Junagadh to enhance coordination in wildlife health management.
- Establishment of a Centre of Excellence at the Wildlife Institute of India (WII) , Coimbatore to tackle human-wildlife conflict.
- Deployment of Rapid Response Teams with advanced tracking technology, surveillance systems, and AI-driven intrusion detection.
- Collaboration between Forest Survey of India, Dehradun, and BISAG-N to enhance forest fire prediction, detection, prevention, and control using space technology.
- Integration of Artificial Intelligence (AI) and Machine Learning (ML) for wildlife conservation and conflict mitigation.
- New sites identified for cheetah reintroduction, including Gandhisagar Sanctuary (Madhya Pradesh) and Banni Grasslands (Gujarat).
- Announcement of a Tiger Conservation Scheme focused on protecting tigers and co-predators outside traditional tiger reserves.
- Launch of a dedicated Project on Gharials to address their dwindling population.
- Announcement of a National Great Indian Bustard Conservation Action Plan to upscale conservation efforts.
- Documentation and research on India's traditional forest and wildlife conservation practices using AI.
- Expansion of India's engagement with the United Nations Convention on the Conservation of Migratory Species of Wild Animals (CMS) for enhanced international cooperation.


marine pa
INDIA
BANGLADESH
SRI LANKA
Andaman Sea
GULF OF KACHCHH
KHIJADIA
MALVAN
PITTI (BIRD ISLAND)
GULF OF MANNAR
POINT CALIMERE
PULICAT LAKE
KRISHNA
CORINGA
SAJNEKHALI
SUNDERBAN
HALIDAY ISLAND
LOTHIAN ISLAND
GAHIRMATHA
BHITARKANIKA
BALUKHAND KONARK
CHILKA (NALABAN)
NORTH REEF ISLAND
BLISTER ISLAND
SOUTH REEF ISLAND
PARKINSON ISLAND
SANDY ISLAND
LOHABARRACK
MAHATMA GANDHI MARINE
NORTH BUTTON ISLAND
MIDDLE BUTTON ISLAND
MANGROVE ISLAND
SOUTH BUTTON ISLAND
RANI JHANSI MARINE
CUTHBERT BAY
CINQUE ISLANDS
GREAT NICOBAR BIOSPHERE RESERVE
GALATHEA