# Plant community

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# Plant communities

Rarely is any location dominated by a single specie of plant. A **plant community** refers to the associated plant species that form the natural vegetation of any place. For instance, a midlatitude forest is comprised of a community of trees, shrubs, ferns, grasses, and flowering herbs. Plant communities provide a habitat for animals and significantly modify the local environment. Plant communities affect soil type when organic material decomposes into the soil altering soil moisture retention, infiltration capacity, soil structure and soil chemistry. Trees shade the forest floor, reducing incident solar radiation and lowering temperatures of both the soil and the air. Reduced incident light decreases evaporation keeping soils moister beneath the forest canopy. These impacts affect animal habitats and the diversity of animal species which are associated with these plant communities.

**Figure 12.8 Mixed deciduous - evergreen forest community is a transitional community between needle leaf forest and deciduous forest (Wisconsin, U.S.A.)**

An **ecotone** is a plant community in a distinct zone of transition between other more extensive communities. Ecotones vary in scale, from local (between forest and field) to global (savannas). Within an ecotone plants of different environmental tolerances often intermingle. For instance, grasses adapted to low moisture conditions intermingle with deciduous trees within a prairie - forest ecotone.

**Community structure**

A **habitat** (which is Latin for "it inhabits") is an ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a species population.

## Ecosystem

marine ecosystem

Rainforests often have a great deal of biodiversity with many plant and animal species. This is the Gambia River in Senegal's Niokolo-Koba National Park

**<u>An ecosystem</u>** is a biological environment consisting of all the organisms living in a particular area, as well as all the nonliving, physical components of the environment with which the organisms interact, such as air, soil, water, and sunlight. It is all the organisms in a given area, along with the nonliving (abiotic) factors with which they interact; a biological community and its physical environment.

**<u>An ecosystem</u>** is any natural unit that includes living and non living parts that interact to produce a stable system. In this system there is an exchange of materials between the living and nonliving components that follows a closed path; in other words, everything is recycled. The term for living components is **biotic** and the nonliving components are **abiotic**. Examples of biotic components are plants, animals, bacteria while abiotic components consist of rocks, light, temperature and water.

To date, the biotic components are divided into five kingdoms: Monera, Protista, Fungi, Plantae and Animalia. Organisms belonging to a particular kingdom share two main criteria: cellular complexity and their strategy used to obtain nutrition. An organism may be unicellular or multicellular, but complexity refers to the presence or absence of extra-cellular structures that perform a specialized function for a cell. The structures are called organelles. Organisms with cells that lack organelles are called prokaryotes; organisms with complex cells containing organelles are called eukaryotes. Two general terms can be used to describe an organism's method of obtaining nutrition. An organism that is able to manufacture its own food from simple molecules is called an autotroph; examples include all plants. If an organism must consume other organisms in order to survive, it is called a heterotroph examples include all animals.

Organisms can either be **producers**, **consumers** or **decomposers**.

1. PRODUCER - an organism that is able to produce its own food from simple, inorganic molecules, examples include photosynthetic plants and algae and chemosynthetic bacteria which use sulfur or iron as starting compounds in

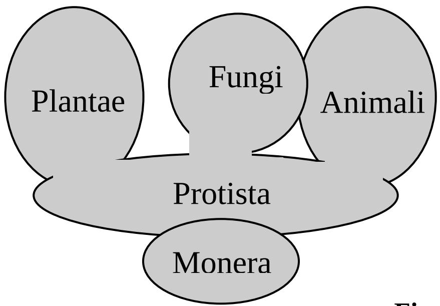



**Figure 2-1**
**FIVE KINGDOMS**

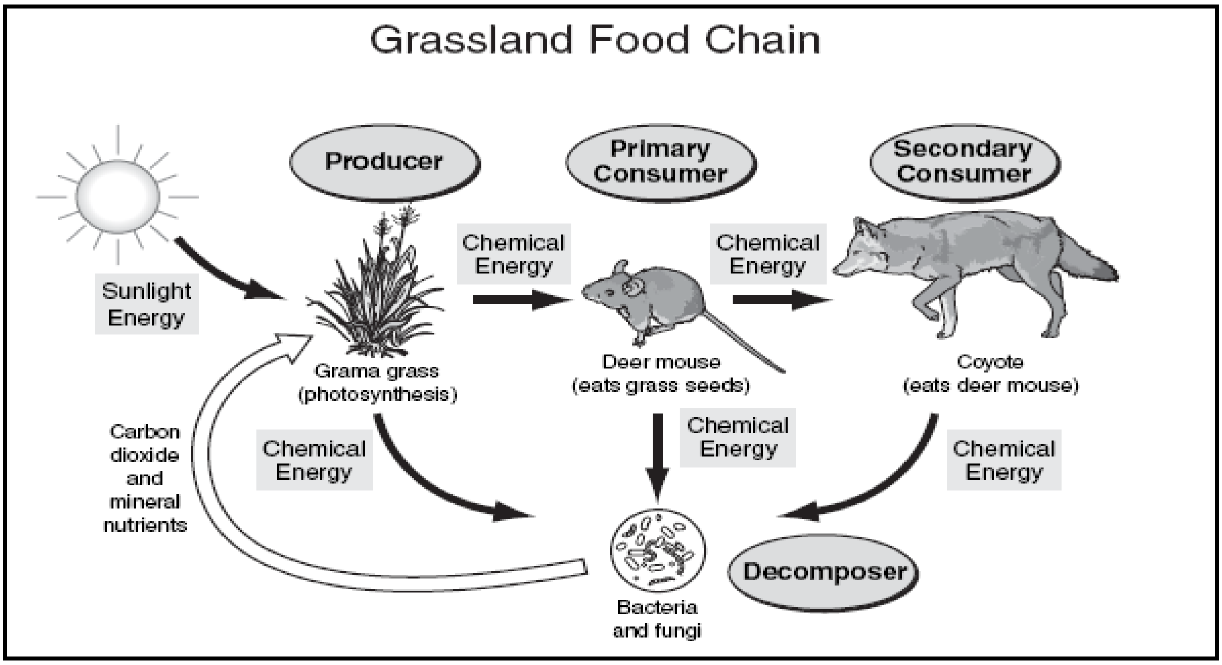
their generation of carbohydrates.

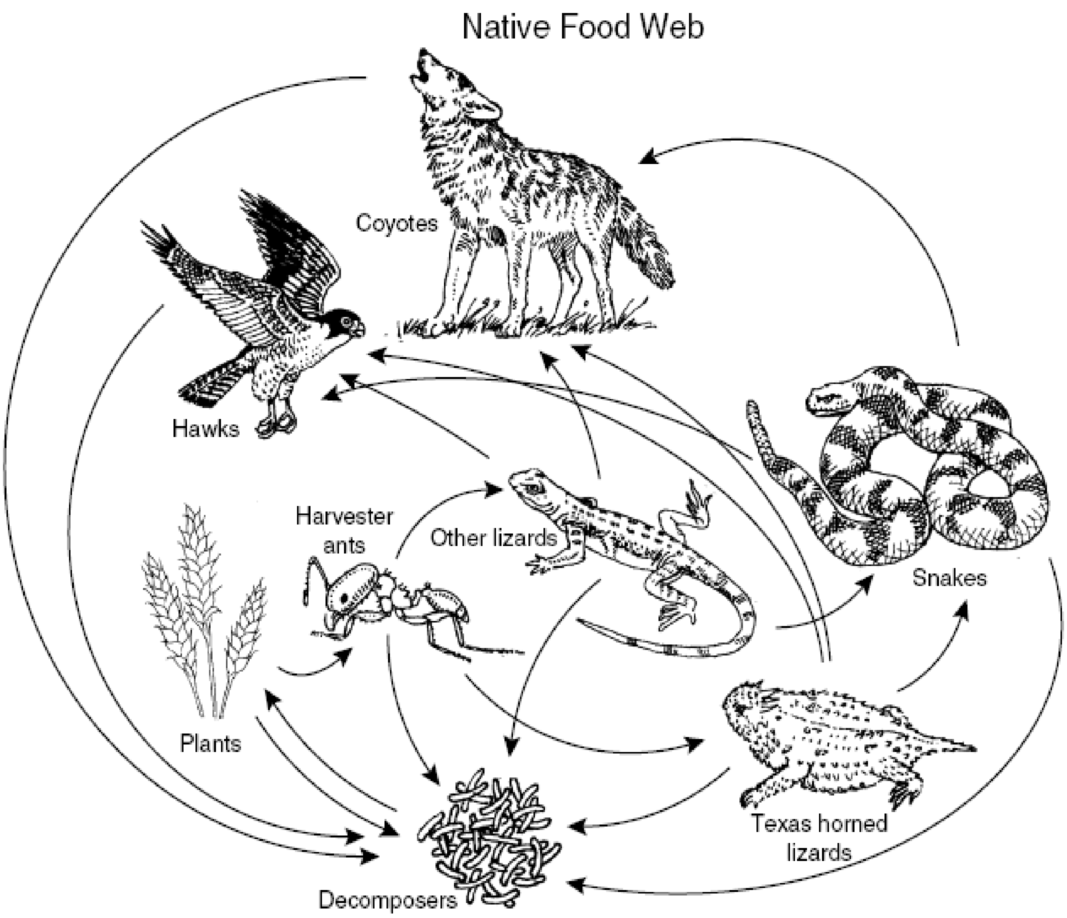
2. CONSUMER - an organism that must eat other organisms to survive. Four terms are used to describe what types of organisms a consumer eats, **herbivore**, **carnivore**, **detritovore** or **omnivore**. An herbivore eats plants, a carnivore eats meat, a detritovore eats dead or decomposing material and an omnivore eats any combination of these three.

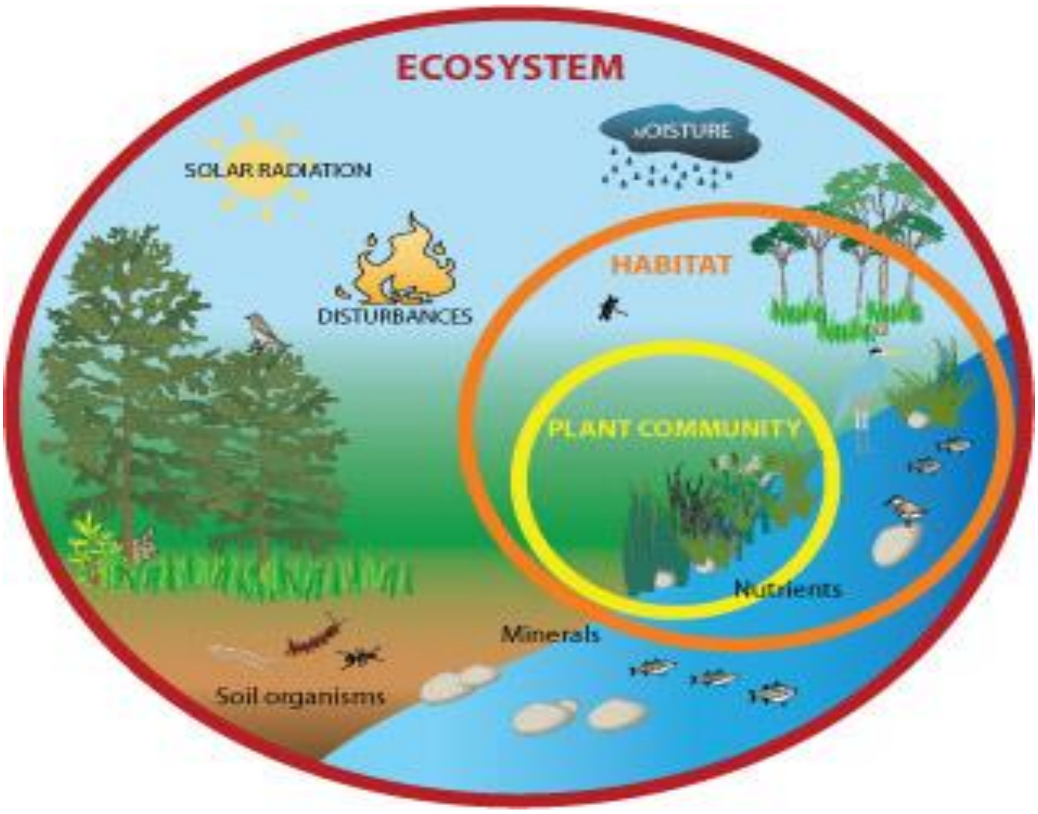
A consumer may be further classified as a **primary consumer** (which eats producers), a **secondary consumer** (which eats primary consumers), a **tertiary consumer** (which eats secondary consumers), etc. An easy example would be a human being. By eating a salad, you are a primary consumer. If you eat a steak you are a secondary consumer. To be a tertiary consumer (or higher), you would need to eat a carnivorous animal, such as a fish.

3. DECOMPOSER - an organism that feeds on dead or decomposing material. They are the recyclers of an ecosystem since they break an organism down into its elemental components so they can be reused by the next generation. Examples include fungi, molds and bacteria.

Two systems are used to describe the trophic structure of an ecosystem. A **food chain** is simply the transfer of food energy from the source of autotrophic plants and bacteria through a series of animals, such as: a blade of grass is eaten by a grasshopper which is in turn eaten by a bird. Any one species is usually represented in several food chains. A **food web** is used to describe the interlocking pattern of food chains.


Grassland Food Chain
Producer
Primary Consumer
Secondary Consumer
Sunlight Energy
Chemical Energy
Chemical Energy
Grama grass (photosynthesis)
Deer mouse (eats grass seeds)
Coyote (eats deer mouse)
Carbon dioxide and mineral nutrients
Chemical Energy
Chemical Energy
Chemical Energy
Decomposer
Bacteria and fungi

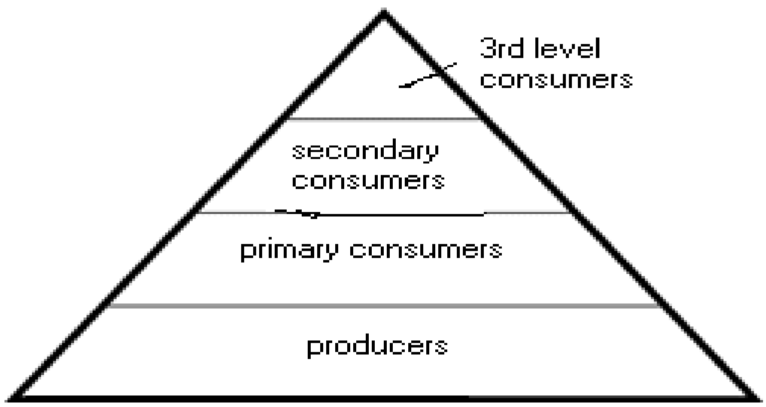

Native Food Web
Coyotes
Hawks
Harvester ants
Other lizards
Snakes
Plants
Texas horned lizards
Decomposers




Our biosphere is the global sum of all ecosystems. It can also be called the zone of life on Earth, a closed (apart from solar and cosmic radiation) and self-regulating system. From the broadest biophysiological point of view, the biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, hydrosphere and atmosphere. The biosphere is postulated to have evolved, beginning through a process of biogenesis or biopoesis, at least some 3.5 billion years ago.

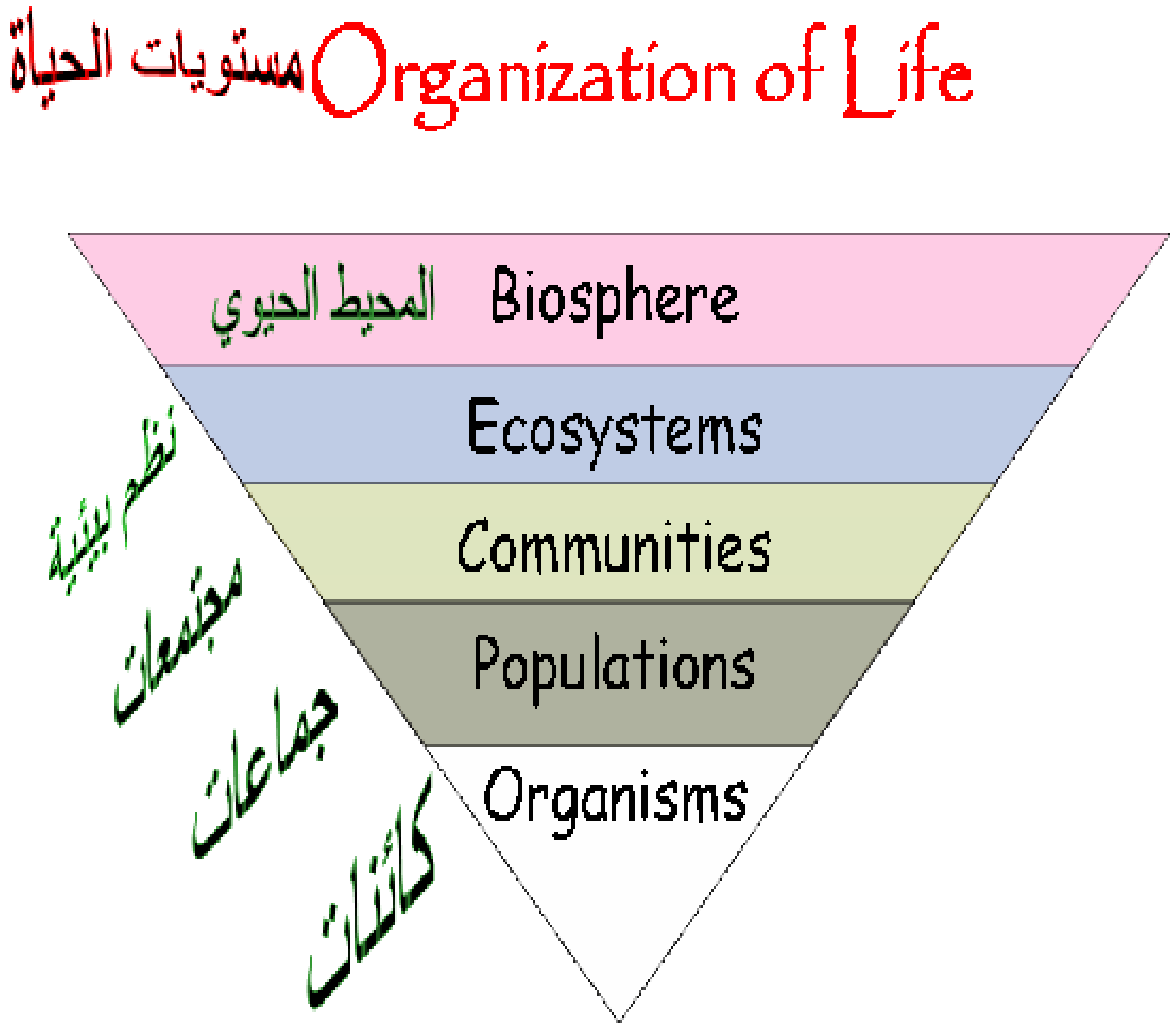
## Energy Pyramids

**An Energy Pyramid**



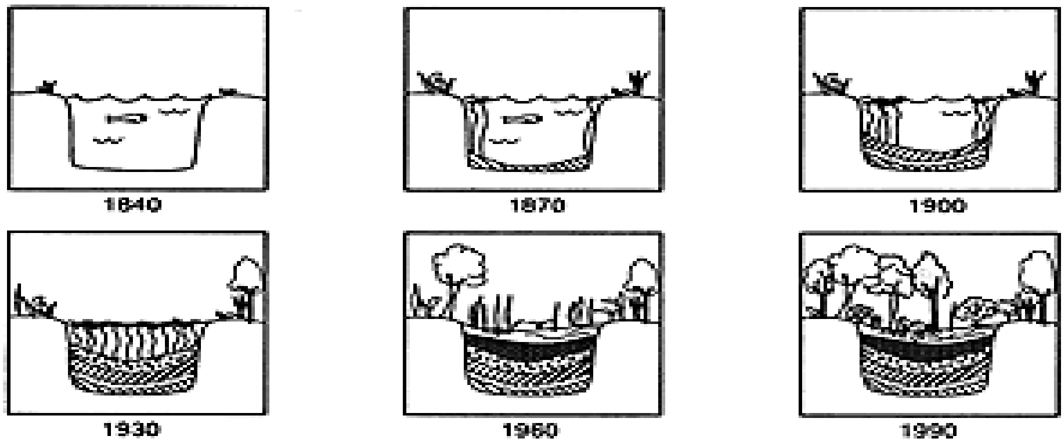

The picture at the left is an energy pyramid. Producer organisms represent the greatest amount of living tissue or **biomass** at the bottom of the pyramid. The organisms, which occupy the rest of the pyramid, belong to the feeding levels indicated in each step. On average, each feeding level only contains 10% of the energy as the one below it, with the energy that is lost mostly being transformed to heat.

An **energy pyramid** provides a means of describing the feeding and energy relationships within a food chain or web. Each step of an energy pyramid shows that some energy is stored in newly made structures of the organism, which eats the preceding one. The pyramid also shows that much of the energy is lost when one organism in a food chain eats another. Most of this energy, which is lost, goes into the environment as heat energy. While a continuous input of energy from sunlight keeps the process going, the height of energy pyramids (and therefore the length of food chains) is limited by this loss of energy.

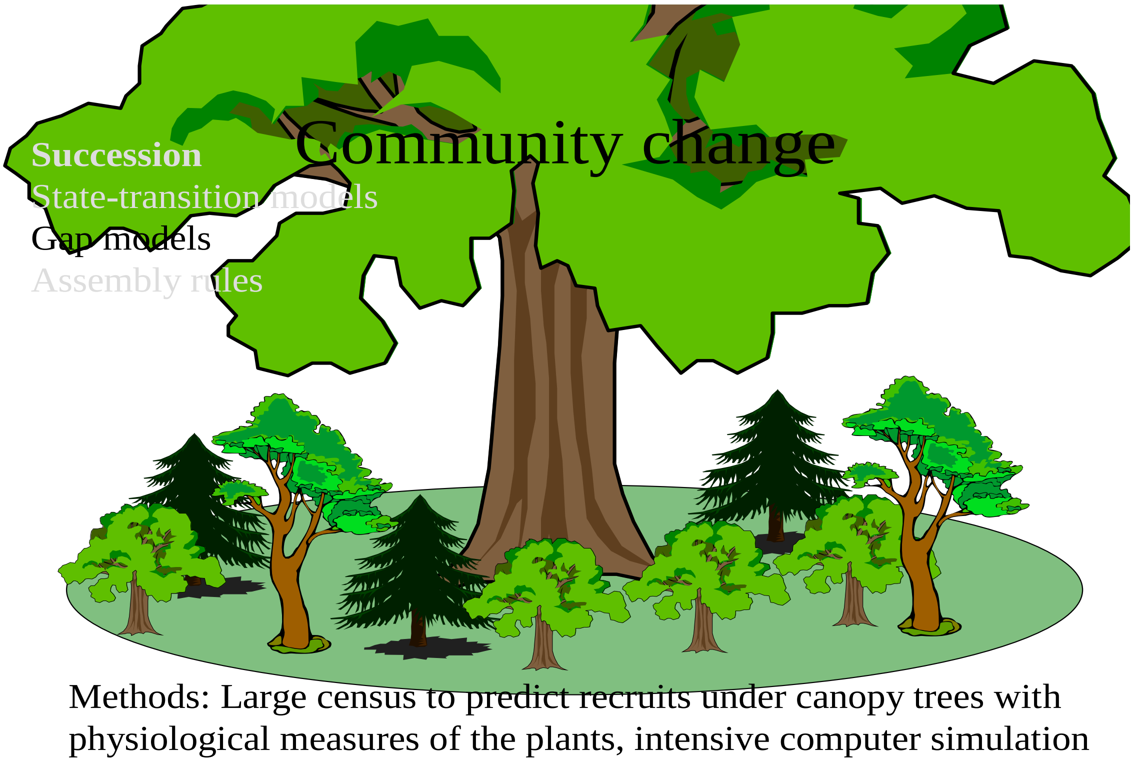



# Succession

The environment may be altered in substantial ways through the activities of humans, other living things, or when natural disasters occur, such as climate changes and volcanic eruptions. Although these changes are sometimes occur very quickly, in most cases species replace others gradually, resulting in long-term changes in ecosystems. These gradual long-term changes in altered ecosystems are called **ecological successions**. Ecosystems tend to change with time until a stable system is formed. The type of succession, which occurs in an ecosystem, depends upon climatic and other limitations of a given geographical area.




A Pond Succession Sequence




**Pioneer organisms** are the first organisms to reoccupy an area, which has been disturbed by a disruption. Typical pioneers in a succession include grasses in a plowed field or lichens on rocks. These pioneer organisms modify their environment, ultimately creating conditions which are less favorable for themselves, but establishing conditions under which more advanced organisms can live. Over time, the succession occurs in a series of plant stages, which leads to a stable final community, which is very similar to the plant community, which originally existed in the ecosystem. This final stable plant community is called a **climax community**. This community may reach a point of stability that can last for hundreds or thousands of years.

It has been observed that when natural disasters occur, such as a floods or fires, the damaged ecosystem is likely to recover in a series of successional stages that eventually result in a stable system similar to the original one that occupied the area.

## Ecological succession

Succession after disturbance: a boreal forest one (left) and two years (right) after a wildfire.

**Ecological succession**, a fundamental concept in ecology, refers to more or less predictable and orderly changes in the composition or structure of an ecological community. Succession may be initiated either by formation of new, unoccupied habitat (*e.g.*, a lava flow or a severe landslide) or by some form of disturbance (*e.g.* fire, severe wind throw, logging) of an existing community. Succession that begins in areas where no soil is initially present is called **primary succession**, whereas succession that begins in areas where soil is already present is called **secondary succession.**

In general, communities in early succession will be dominated by fast-growing, well-dispersed species. As succession proceeds, these species will tend to be replaced by more competitive (k-selected) species.

Trends in ecosystem and community properties in succession have been suggested, but few appear to be general. For example, species diversity almost necessarily increases during early succession as new species arrive, but may decline in later succession as competition eliminates opportunistic species and leads to dominance by locally superior competitors. Net Primary Productivity, biomass, and trophic level properties all show variable patterns over succession, depending on the particular system and site.

Ecological succession was formerly seen as having **a stable end-stage** called **the climax.**

## Types of succession

### 1- Primary succession

If the development begins on an area that has not been previously occupied by a community, such as a newly exposed rock or sand surface, a lava flow, glacial tills, or a newly formed lake, the process is known as primary succession.

*Secondary succession*: trees are colonizing uncultivated fields and meadows.

### 2- Secondary succession

If the community development is proceeding in an area from which a community was removed it is called **secondary succession**. **Secondary succession** arises on sites where the vegetation cover has been disturbed by humans or animals (an abandoned crop field or cut-over forest, or natural forces such as water , wind storms, and floods.) Secondary succession is usually more rapid as the colonizing area is rich in leftover soil, organic matter and seeds of the previous vegetation. In case of primary succession everything has to develop a new community.

## 3- Seasonal and cyclic succession

Unlike secondary succession, these types of vegetation change are not dependent on disturbance but are periodic changes arising from fluctuating species interactions or recurring events. These models propose a modification to the climax concept towards one of dynamic states.

## Causes of plant succession

1- **Topographic causes:**

a- Bare areas due to erosion (removal of the soil or rocks).

b- Bare areas due to deposit ( addition of soil, like Delta).

2- **Climatic causes**

a- Complete or partial destruction of existing vegetation ( by drought , fire, wind , snow and frost ) may result in bare areas.

b- Evaporation of water from ponds and lakes resulted in bare areas that may be marches ( saline or nonsaline), moist or dry.

**c-** Changes in temperature and rainfall patterns will promote changes in communities.

**3- Biotic causes**

Man and animals. Destroying or clearing the vegetation with or without disturbing the soil or water content.

## Clement's theory of succession/Mechanisms of succession

**Clement (1916)** developed a descriptive theory of succession and advanced it as a general ecological concept. His theory of succession had a powerful influence on ecological thought. Clement's concept is usually termed classical ecological theory. According to Clement, succession is a process involving several phases:

1. **Nudation**: Succession begins with the development of a bare site, called Nudation (disturbance).
2. **Migration**: It refers to arrival of propagules.
3. **Ecesis**: It involves establishment and initial growth of vegetation.
4. **Competition**: As vegetation became well established, grew, and spread, various species began to compete for space, light and nutrients. This phase is called competition.
5. **Reaction**: During this phase autogenic changes affect the habitat resulting in replacement of one plant community by another.

**Stabilization**: Reaction phase leads to development of a climax community

# Types of climax

## Climatic Climax

If there is only a single climax and the development of climax community is controlled by the climate of the region, it is termed as climatic climax.

Climatic climax is theoretical and develops where physical conditions of the substrate are not so extreme as to modify the effects of the prevailing regional climate.

## Edaphic Climax

When there are more than one climax communities in the region, modified by local conditions of the substrate such as soil moisture, soil nutrients, topography, slope exposure, fire, and animal activity, it is called *edaphic climax*. Succession ends in an edaphic climax where topography, soil, water, fire, or other disturbances are such that a climatic climax cannot develop.

## Catastrophic Climax

Climax vegetation vulnerable to a catastrophic event such as a wildfire. For example, in California, chaparral vegetation is the final vegetation. The wildfire removes the mature vegetation and decomposers. A rapid development of herbaceous vegetation follows until the shrub dominance is re-established. This is known as catastrophic climax.

## Disclimax

When a stable community, which is not the climatic or edaphic climax for the given site, is maintained by man or his domestic animals, it is designated as Disclimax (disturbance climax) or anthropogenic subclimax (man-generated). For example, overgrazing by stock may produce a desert community of bushes and cacti where the local climate actually would allow grassland to maintain itself.

### Subclimax

The prolonged stage in succession just preceding the climatic climax is *subclimax*.

### Preclimax and Postclimax

In certain areas different climax communities develop under similar climatic conditions. If the community has life forms lower than those in the expected climatic climax, it is called *preclimax*; a community that has life forms higher than those in the expected climatic climax is *postclimax*. Preclimax strips develop in less moist and hotter areas, whereas Postclimax strands develop in more moist and cooler areas than that of surrounding climate.

## Theories regarding nature of climax

There are three schools of interpretations explaining the climax concept:

- **Monoclimax** or **Climatic Climax Theory** was advanced by **Clements (1916)** and recognizes only one climax whose characteristics are determined solely by climate (climatic climax). The processes of succession and modification of environment overcome the effects of differences in topography, parent material of the soil, and other factors. The whole area would be covered with uniform plant community. Communities other than the climax are related to it, and are recognized as subclimax, postclimax and disclimax.

- **Polyclimax Theory** was advanced by **Tansley (1935)**. It proposes that the climax vegetation of a region consists of more one vegetation climaxes controlled by soil moisture, soil nutrients, topography, slope exposure, fire, and animal activity.
- **Climax Pattern Theory** was proposed by **Whittaker (1953).** The climax pattern theory recognizes a variety of climaxes governed by responses of species populations to biotic and abiotic conditions. According to this theory the total environment of the ecosystem determines the composition, species structure, and balance of a climax community. The environment includes the species responses to moisture, temperature, and nutrients, their biotic relationships, availability of flora and fauna to colonize the area, chance dispersal of seeds and animals, soils, climate, and disturbance such as fire and wind. The nature of climax vegetation will change as the environment changes. The climax community represents a pattern of populations that corresponds to and changes with the pattern of environment. The central and most widespread community is the climatic climax.

More recently another possible idea has been put forward called the theory of alternative stable states which suggests that there is not one end point but many which transition between each other over ecological time.

# Seral communities

A seral community is an intermediate stage found in an ecosystem advancing towards its climax community. In many cases more than one seral stage evolves until climax conditions are attained. A *prisere* is a collection of seres making up the development of an area from non-vegetated surfaces to a climax community. Depending on the substratum and climate, a seral community can be one of the following:

A hydrosere community.

**Hydrosere**

Community in freshwater

**Lithosere**

**C**ommunity on rock

**Psammosere**

Community on sand

**Xerosere**

Community in dry area

**Halosere**

Community in saline body (e.g. a marsh)

## Hydrosere

A **hydrosere** is a plant succession which occurs in a freshwater lake. In time, an area of open freshwater will naturally dry out, ultimately becoming woodland. During this change, a range of different land types such as swamp and marsh will succeed each other.

Mute Swan (*Cygnus olor*) in a hydrosere community at sunrise.

The succession from open water to climax woodland is likely to take at least two hundred years. Some intermediate stages will last a shorter time than others. For example, swamp may change to marsh within a decade or less. How long it takes will depend largely on the amount of siltation occurring in the area of open water.

**Stages**

Hydrosere is the primary succession sequence which develops in aquatic environments such as lakes and ponds. It results in conversion of water body and its community into a land community. The early changes are allogenic as inorganic particles such as sand and clay are washed from catchments areas and begin filling the basin of the water body. Later, remains of dead plants also fill up these bodies and contribute to further changes in the environment.

If water body is large and very deep, a strong wave action is at work, therefore in these bodies a noticeable change cannot easily be observed. However, in smaller water body such as a pond the succession is easily recognizable. Different plant communities occupy different zones in a water body and exhibit concentric zonation. The edges of the water body are occupied by rooted species, submerged species are found in the littoral zone and plankton and floating species occupy the open water zone.

**Phytoplankton stage**

Unicellular floating algal plants such as diatoms are pioneer species of a bare water body, such as a pond. Their spores are carried by air to the pond. The phytoplankton are followed by zooplankton. They settle down to the bottom of the pond after death, and decay into humus that mixes with silt and clay particles brought into the basin by run off water and wave action and form soil. As soil build up, the pond becomes shallower and further environmental changes follow.

**Submerged stage**

As the water body becomes shallower, more submerged rooted species are able to become established due to increasing light penetration in the shallower water. This is suitable for growth of rooted submerged species such as Myriophyllum, Vallisneria, Elodea, Hydrilla, and Ceratophyllum. These plants root themselves in mud. Once submerged species colonize the successional changes are more rapid and are mainly autogenic as organic matter accumulates. Inorganic sediment is still entering the lake and is trapped more quickly by the net of plant roots and rhizomes growing on the pond floor. The pond becomes sufficiently shallow (2-5 ft) for floating species and less suitable for rooted submerged plants.

## Floating stage

The floating plants are rooted in the mud, but some or all their leaves float on the surface of the water. These include species like Nymphaea, Nelumbo and Potamogeton. Some free-floating species also become associated with root plants. The large and broad leaves of floating plants shade the water surface and conditions become unsuitable for growth of submerged species which start disappearing. The plants decay to form organic mud which makes the pond more shallow yet (1-3 ft).

## Reed swamp stage

The pond is now invaded by emergent plants such as Phragmites (reed-grasses), *Typha* (cattail), and *Zizania* (wild rice) to form a reed-swamp (in North American usage, this habitat is called a marsh). These plants have creeping rhizomes which knit the mud together to produce large quantities of leaf litter. This litter is resistant to decay and reed peat builds up, accelerating the autogenic change. The surface of the pond is converted into water-saturated marshy land.

**Sedge-meadow stage**

Successive decreases in water level and changes in substratum help members of Cyperaceae and Graminae such as *Carex spp*. and *Juncus* to establish themselves. They form a mat of vegetation extending towards the centre of the pond. Their rhizomes knit the soil further. The above water leaves transpire water to lower the water level further and add additional leaf litter to the soil. Eventually the sedge peat accumulates above the water level and soil is no longer totally waterlogged. The habitat becomes suitable for invasion of herbs (secondary species) such as Mentha, Caltha, Iris, and Galium which grow luxuriantly and bring further changes to the environment. Mesic conditions develop and marshy vegetation begins to disappear.

## Woodland stage

The soil now remains drier for most of the year and becomes suitable for development of wet woodland. It is invaded by shrubs and trees such as Salix (willow), Alnus (alders), and Populus. These plants react upon the habitat by producing shade, lower the water table still further by transpiration, build up the soil, and lead to the accumulation of humus with associated microorganisms. This type of wet woodland is also known as carr.

**Climax stage**

Finally a self perpetuating climax community develops. It may be a forest if the climate is humid, grassland in case of sub-humid environment, or a desert in arid and semi-arid conditions. A forest is characterized by presence of all types of vegetation including herbs, shrubs, mosses, shade-loving plants and trees. Decomposers are frequent in climax vegetation.

The overall changes taking place during development of successional communities are building up of substratum, swallowing of water, addition of humus and minerals, soil building and aeration of soil. As the water body fills in with sediment, the area of open water decreases and the vegetation types moves inwards as the water becomes shallower. Many of the above mentioned communities can be seen growing together in a water body. The center is occupied by floating and submerged plants with reeds nearer the shores, followed by sedges and rushes growing at the edges. Still further are shrubs and trees occupying the dry land.

**Examples**

An example is a small kettle lake called **Sweetmere**, in Shropshire, UK. Sweetmere is one of many small kettle lakes which formed at the end of the last glacial period when the temperatures began to increase. The ice began to melt and retreat approximately 10,000 years ago.

As the climate slowly began to warm this allowed algae, water lillies and floating aquatic plants to begin to colonise the lake. These, in essence, were the pioneer species. Once these began to die it provided organic matter to the lake bed sediment and therefore increased fertility and reduced depth. As a result this allowed deeper rooted species to develop such as reeds and bullrushes. At this point there is a growing floating raft of thick organic matter within the lake.

Because the bulrushes and reeds have relatively deep roots, this encouraged **bioconstruction** which traps more sediment, allowing sedges, willow and alder to become established. This process further decreased the water depth and raised the lakebed thus making it drier.

Drier conditions now meant that a wider range of species could inhabit the area. Birch and alder came into dominance. All species which have grown have occurred because of seed transfer either by animals, birds, wind, or water transfer. Water level is further reduced as a result of further bioconstruction and also due to **increasing temperatures** there is increased evaporation from the lake.

Underneath the birch canopy developed terrestrial shrubs and grasses. This then increased the acidity which increased the rates of nutrient exchange. The area has been artificially drained and this allowed the oak and ash community to develop. This is the seral stage.

The lake is now being managed by cutting down certain species in order to stop the whole lake becoming dried up and dominated by the oak and ash woodland.

Another example of a hydrosere is **Loch a' Mhuilin**, located on the Isle of Arran, Scotland. This small lake lies behind a ridge of material deposited towards the end of the last Ice Age. The lake exhibits characteristic features of a hydrosere, the succession from a fresh water surface with small pioneer plant species to a sub-climax vegetation of alder and willow. The climax vegetation of oak and thomas beech woodland has not been achieved due to the impact of human activities of clearing grazing land, as well as grazing by red deer and rabbits.

# Xerosere

**Xerosere** is a plant succession which is limited by water availability. It includes the different stages in a *xerarch succession*. Xerarch succession of ecological communities originated in extremely dry situation such as sand deserts, sand dunes, salt deserts, rock deserts etc. A xerosere may include lithoseres (on rock) and psammoseres (on sand).

## Stages

### Bare rocks

Lava enters the Pacific at the Big Island of Hawaii.

Bare rocks are produced when glaciers recede or volcanoes erupt. Erosion of these rocks is brought by rain water and wind loaded with soil particles. The rain water combines with atmospheric carbon dioxide that corrodes the surface of the rocks and produce crevices. Water enters these crevices, freezes and expands to separate boulders. These boulders move down under the influence of gravity and wear particles from the rocks. Also when the wind loaded with soil particles strikes against the rocks, it removes soil particles. All these processes lead to formation of a little soil at the surface of these bare rocks.

Animals such as spiders which can hide between boulders or stones invade these rocks. These animals live by feeding on insects which have been blown in or flown in. Algal and fungal spores reach these rocks by air from the surrounding areas. These spores grow and form symbiotic association, the lichen, which act as pioneer species of bare rocks. The process of succession starts when autotrophic organisms start living in the rocks.

**Crustose lichen stage**

A bare rock consists of solid surface or very large boulders and there is no place for rooting plants to colonize. The thalli of crustose lichens can adhere to the surface of rock and absorb moisture from atmosphere; therefore, these colonize the bare surfaces of rocks first. The propagules of these lichens are brought by air from the surrounding areas. These lichens produce acids which corrode the rock and their thalli collect wind blown soil particles among them that help in formation of a thin film of soil. When these lichens die their thalli are decomposed to add humus. This promotes soil building and the environment becomes suitable for growth of foliose and fruticose type of lichens.

**Foliose and fruticose lichen stage**

*Foliose* lichens have leaf-like thalli, while the *fruticose* lichens are like small bushes. They are attached to the substratum at one point only, therefore, do not cover the soil completely. They can absorb and retain more water and are able to accumulate more dust particles. Their dead remains are decomposed to humus which mixes with soil particles and help building substratum and improving soil moisture contents further. The shallow depressions in the rocks and crevices become filled with sold and topsoil layer increases further. These autogenic changes favor growth and establishment of mosses.

**Moss stage**

The spores of xerophytic mosses, such as Polytrichum, Tortula, and Grimmia, are brought to the rock where they succeed lichens. Their rhizoids penetrate soil among the crevices, secrete acids and corrode the rocks. The bodies of mosses are rich in organic and inorganic compounds. When these die they add these compounds to the soil, increasing the fertility of the soil. As mosses develop in patches they catch soil particles from the air and help increase the amount of substratum. The changing environment leads to migration of lichens and helps invasion of herbaceous vegetation that can out-compete mosses.

**Herb stage**

Encroaching herbs and shrubs  See also: Herb

Herbaceous weeds, mostly annuals such as asters, evening primroses, and milk weeds, invade the rock. Their roots penetrate deep down, secrete acids and enhance the process of weathering. Leaf litter and death of herbs add humus to the soil. Shading of soil results in decrease in evaporation and there is a slight increase in temperature. As a result the xeric conditions begin to change and biennial and perennial herbs and xeric grasses such as Aristida, Festuca, and

Poa, begin to inhabit. These climatic conditions favor growth of bacterial and fungal populations, resulting in increase in decomposition activity.

**Shrub stage**

The herb and grass mixture is invaded by shrub species, such as Rhus and Phytocarpus. Shrub consists of densely packed bushes with growth stunted by want of water and high transpiration rate. Early invasion of shrub is slow, but once a few bushes have become established, birds invade the area and help disperse scrub seeds. This results in dense scrub growth shading the soil and making conditions unfavorable for the growth of herbs, which then begin to migrate. The soil formation continues and its moisture content increases. The environment becomes mesic (moderately moist).

View from Connors Hill in East Gippsland Shire, Victoria, Australia.

**Tree stage**

Change in environment favors colonization of tree species. The tree saplings begin to grow among the scrubs and establish themselves. The kind of tree species inhabiting the area depends upon the nature of the soil. In poorly drained soils oaks establish themselves. The trees form canopy and shade the area. Shade-loving scrubs continue to grow as secondary vegetation. Leaf litter and decaying roots weather the soil further and add humus to it making the habitat more favorable for growth to trees. Mosses and ferns make their appearance and fungi population grows abundantly.

**Climax stage**

The succession culminates in a climax community, the forest. Many intermediate tree stages develop prior to establishment of a climax community. The forest type depends upon climatic conditions. The climax forest may be:

Oak-Hickory Climax Forest

In dry habitat oaks and hickories are climax vegetation. There is only one tree stage and forests are characterized by presence of scrubs, herbs, ferns, and mosses.

Beech-Hemlock Climax Forest

These climax forests develop in mesic climates. The dominant vegetation is Beech and Hemlock. There are many intermediate tree stages. The other vegetation types include herbs, ferns, and mosses.

American Beech-Sugar Maple Climax Forest

These climax forests develop in mesic climates in the Northeastern United States. The dominant vegetation is American Beech and Sugar Maple.

Spruce-Alpine Fir Climax Forest

At high altitudes in Rocky Mountains the climax forest is dominated by spruces and alpine firs.

## Lithosere

A **lithosere** (a sere originating on rock) is a plant succession that begins life on a newly exposed rock surface, such as one left bare as a result of glacial retreat, tectonic uplift as in the formation of a raised beach, or volcanic eruptions. For example, the lava fields of Eldgjá in Iceland where Laki and Katla fissures erupted in the year 935 and the solidified lava has, over time, begun to form a lithosere.

Pioneer species are the first organisms that colonise an area, of which lithoseres are an example. They will typically be very hardy (*i.e.*, they will be xerophytes, wind-resistant or cold-resistant). In the case of a lithosere the pioneer species will be cyanobacteria and algae, which create their own food and water—*i.e.*, they are autotrophic and so do not require any external nutrition (except sunlight). For example, the first lithosere observed after the volcanic explosion of Krakatau was algae. Other examples of lithoseres include communities of mosses and lichens, as they are extremely resilient and are capable of surviving in areas without soil.

As more mosses and lichens colonize the area, they, along with natural elements such as wind and frost shattering, begin to weather the rock down. This over time creates more soil, leading to increased water retention. Early on, when there is little water, lichens dominate as they are more suited to a lack of water; but as water retention increases, mosses become more dominant as they are faster growing, and these further break the rocks down. The amount of soil is also increased by the decaying mosses and lichens. This improves the fertility of the soil as humus is increased, allowing grasses and ferns to colonise. Over time, flowering plants will emerge, followed by shrubs. As the soil gets progressively deeper, larger and more advanced plants are able to grow. This is the case in Surtsey, a "new," small volcanic island located off the south coast of Iceland. Surtsey was "created" in the 1960s and currently its plant succession has reached the stage where ferns and grasses have begun to start growing in the south of the island where the lava cooled first.

As the plant succession develops further, trees start to appear. The first trees (or pioneer trees) that appear are typically fast growing trees such as birch, willow or rowan. In turn these will be replaced by slow growing, larger trees such as ash and oak. This is the climax community on a lithosere, defined as the point where a plant succession does not develop any further—it reaches a delicate equilibrium with the environment, in particular the climate.

In the off chance of a phenomenon which effectively removes most of the life forms in these areas, the resultant landscape is considered to be a *disclimax*, where there is a loss of the previous climax community. In most cases, should the area be left to regenerate as normal, the area eventually becomes a *climax community* again.

## Psammosere

A **psammosere** is a seral community, an ecological succession that began life on newly exposed coastal sand. Most common psammoseres are sand dune systems.

In a psammosere, the organisms closest to the sea will be pioneer species: salt-tolerant species such as littoral algae and glasswort with marram grass stabilising the dunes. Progressing inland many characteristic features change and help determine the natural succession of the dunes. For instance, the drainage slows down as the land becomes more compact and has better soils, and the pH drops as the proportion of seashell fragments reduces and the amount of humus increases. Sea purslane, sea lavender, meadow grass and heather eventually grade into a typical non-maritime terrestrial eco-system. The first trees (or pioneer trees) that appear are typically fast-growing trees such as birch, willow or rowan. In turn these will be replaced by slow-growing, larger trees such as ash and oak. This is the climax community, defined as the point where a plant succession does not develop any further because it has reached equilibrium with the environment, in particular the climate.

In an idealised coastal psammosere model, at the seaward edge of the sand dune the pH of the soil is typically alkaline/neutral with a pH of 7.0/8.0 particularly where shell fragments provide a significant component of the sand. Tracking inland across the dunes a podsol develops with a pH of 5.0/ 4.0 followed by mature podsols at the climax with a pH of 3.5 - 4.5.

## Halosere

A salt marsh.

The term **Halosere** is an ecological term which describes succession in a saline environment. An example of a **halosere** would be a salt marsh.

In a river estuary, large amounts of silt are deposited by the ebbing tides and inflowing rivers.

The earliest plant colonizers are algae and eel grass which can tolerate submergence by the tide for most of the 12-hour cycle and which trap mud, causing it to accumulate. Two other colonisers are *salicornia* and *spartina* which are **halophytes** -i.e. plants that can tolerate saline conditions. They grow on the inter-tidal mudflats with a maximum of 4 hours' and exposure to air every 12 hours.

*Spartina* has long roots enabling it to trap more mud than the initial colonizing plants and *salicornia*, and so on. In most places this becomes dominant vegetation. The initial tidal flats receive new sediments daily, are waterlogged to the exclusion of oxygen, and have a high pH value.

The sward zone, in contrast, is inhabited by plants that can only tolerate a maximum of 4 hours submergence every day (24 hours). The dominant species here are sea lavender and other numerous types of grasses.

# Vegetation

**Vegetation** is a general term for the plant life of a region; it refers to the ground cover provided by plants. It is a general term, without specific reference to particular taxa, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics. It is broader than the term *flora* which refers exclusively to species composition. Perhaps the closest synonym is plant community, but *vegetation* can, and often does, refer to a wider range of spatial scales than that term does, including scales as large as the global. Primeval redwood forests, coastal mangrove stands, sphagnum bogs, desert soil crusts, roadside weed patches, wheat fields, cultivated gardens and lawns; all are encompassed by the term *vegetation*.

**Importance**

Vegetation supports critical functions in the biosphere, at all possible spatial scales. **First**, vegetation regulates the flow of numerous biogeochemical cycles (see biogeochemistry), most critically those of water, carbon, and nitrogen; it is also of great importance in local and global energy balances. Such cycles are important not only for global patterns of vegetation but also for those of climate. **Second**, vegetation strongly affects soil characteristics, including soil volume, chemistry and texture, which feed back to affect various vegetational characteristics, including productivity and structure. **Third**, vegetation serves as wildlife habitat and the energy source for the vast array of animal species on the planet (and, ultimately, to those that feed on these).Perhaps most importantly, and often overlooked, global vegetation (including algal communities) has been the primary source of oxygen in the atmosphere, enabling the aerobic metabolism systems to evolve and persist.

**Development of vegetation**

Development of vegetation consists of number of closely related processes :-

1- **migration**

This includes all movements by means of which plants are carried away from the parent their original home. The distance may be short , barely outside the area dominated by the parent, or very great often occurs with the wind blown or water carried them. The fundamental process is moving seeds, spores and runners, etc. away from the old and into the new area.

2- **Ecesis**

Migration alone cannot produce vegetation. The seeds must germinate in the new area, the seedlings grow into mature plants and these, in turn, must reproduce if the area is to be vegetated. The migrant must make themselves at home, is expressed in a single term **ecesis**.

**3- Aggregation**

After the establishment of the first scattered invaders, the individuals come to be grouped, as a result of propagation.

**4- Competition**

Aggregation sooner or later results in competition. Competition is an interaction between organisms or species, in which the fitness of one is lowered by the presence of another. Limited supply of at least one resource (such as food, water, and territory) used by both is required. Competition both within and between species is an important topic in ecology, especially community ecology. Competition is one of many interacting biotic and abiotic factors that affect community structure. Competition among members of the same species is known as **intraspecific competition**, while competition between individuals of different species is known as **interspecific competition**.

5- **Reaction**

When plants grow together and compete for the necessary factors, they affect or react upon the place in which they grow. Competition results in reaction.

**How vegetation shows structure**

Vegetation like all organisms, not only undergoes development but also has structure. Depending upon climate, it is differentiated into large natural units such as forest , grassland, tundra, etc. Structure of each type differs from the others.

**Minimal sample area**

**Minimal area** of a community is defined as " **the smallest area on which the species composition of the community in question is adequately represented** "

## Vegetation Analysis and sampling

## The Quadrat Method

Many questions come to mind as we set out to study the importance of a particular species of plant in a community:

1- How widely distributed is this species?

2- How many plants of this species are present in the community?

3- How much of the total available space does this species occupy? **If you can answer these questions, you can conduct some interesting and important studies**. For example, you can compare the vegetation in one region with that in another: you can study seasonal changes in vegetation within a given area: you can determine the relationships between plant populations and abiotic factors: you can investigate ecological plant succession.

If you require only a rough idea of the contribution of each plant species to a community, a quantitative study is often sufficient. For example, to estimate the abundance of each species you simple prepare a list of the species present and categorize each as abundant, frequent, occasional or rare. It is difficult, however, to remain objective when using such an approach. The observer may list a species as abundant because of its height or color make sit quite easy to spot when, in actual fact, other less obvious species are more abundant. Thus, for precise work, quantitative methods must be used.

Very accurate quantitative information could be obtained if a team of observers went into the study area and identified, counted, and measured every plant. In large areas this would obviously be impractical, if not impossible. Besides, it is unnecessary, since ecologists have developed sampling techniques that give equally valid results in much shorter time periods. The most commonly used techniques are described in this section and the next three.

Although these studies yield interesting information on there own, they are best performed in conjunction with such things as animal population studies, soil studies, and measurement of the appropriate physical factors. The approach to use in such combined studies is outlined in Unit 5. The methods of vegetation analysis are described separately so that you can conveniently select and study then most suitable method to use on a field trip. Where possible, you should rehearse the method near school before you go on an outing. **The quadrat method** is one of the most widely used means of attaining quantitative information about the compositions and structure of plant communities. In, principle, the method appears quite simple. You merely sample the study area at several sites using quadrats. You then assume these sample plots give a reliable picture of the vegetation overt the total study area. This assumption is true only if you have picked the proper size and shape of quadrat and if you use a suitable number of and arrangement of quadrats. The following description of the quadrat method considers these factors:

**Shape of Quadrat**

As the word “quadrat” implies a square plot is often used in this method of vegetation analysis. However, circular and rectangular plots are often used. The choice of shape depends largely on the nature of the vegetation being investigated. Circular plots generally give more valid results with low vegetation than will a similar number of square plots of the same area. Also, circular plots are easier to lay out. If small plots are required, a series of hoops can be tossed in random directions from a central point. Larger circular plots can be laid out. **Circular plots can be used effectively only on areas of low vegetation.**

**Square and rectangular** plots can be used in vegetation of any height. **Rectangular** plots usually give more accurate results than an equal number of square plots of the same area. This because rectangular plots sample a greater length of the vegetation and are, as a result, more likely to detect variations in it. Because of this, they are particularly useful in areas such as **sand dunes** where a gradient in environmental conditions and vegetation types occur. In such cases the long axis of the plot should be oriented parallel to the direction of the gradient. Rectangular quadrats having a width-to-length ratio of 1:2, 1:4, and 1:8 are commonly used.

**Size of Quadrat**

Both the height and the density of the plants in the study area should be considered when you are deciding what size quadrat to use. The quadrat must be large enough to contain a significant number of plants yet small enough to permit you to identify, count and measure the plants in a reasonable length of time. In general, the following quadrat areas are satisfactory:

| | |
|---|---|
| Mosses and lichens | 0.1 square meter |
| Herbs (including grasses) and tree seedlings | 1 square meter |
| Shrubs and samplings | up 10 – 20 square meters<br>To 10 feet |
| Trees | 100 square meters |

Therefore, if you are sampling the vegetation of a forest using square quadrats, you could use plots 10m by 10m for thew trees 4m by 4m for the shrubs and saplings, and plots 1m by 1m for the grasses, other herbs and tree seedlings. You can reduce the considerably the amount of work involved in setting up the quadrats for a forest study by “nesting” them.

You can avoid such human error quite easily. Lay out a series of grid lines on a map or aerial photograph of the study area. Number the gird lines on both the horizontal and vertical axes. Now record these numbers on small pieces of paper. Close your eyes, mix up the papers, and pick out enough until you are satisfied with the amount.

B). Systematic. Systematic sampling uses quadrats that are spaced as widely and evenly as possible through the study area. This can be accomplished satisfactory by a combination of measurement and pacing. A series of evenly spaced transects are run through the study area using a compass. The plots are located at equal intervals along these lines. Pacing off a predetermined distance is usually sufficient. You need not measure accurately the distance between each plot, provided you resist the temptation to shift the location of the plot a few feet one way or another to include some feature that you find attractive. Systematic location of plots is generally easier than random location. It is particularly useful when you are studying an area where succession changes occur.

**Kinds of Quadrats**

Once quadrats have been selected, various types of information can be within them. Quadrats are named according to the type of information sought and the uses to which it is put.

**a). List quadrat**. In this type of quadrat the plants within the frame are identified and listed by name. No count of numbers is made. If sufficient list quadrats are used over the study area, you can calculate the frequency of occurrence of each species, that is, the number of quadrats in which each species occurs.

**b). The permanent quadrat**. This refers to the limiting area of the quadrate for a long time without changing in location of quadrate when there is a need to visit these sample areas for several times over a long period. In these cases it is possible to review the changes in the types of plants, the number of individuals belonging to each kind, their relative distribution and changes in the cover of different species.

**c). Cover (Basal- area) quadrat**. In ecological studies it is often desirable to know what percentage of the land surface in the study area is “covered’ by a certain species. A cover quadrat is performed to determine this. The total basal cover is different according to the age of stand; young or old. The total basal area increases by developing the community towards the climax.

**d). Chart quadrat.** A chart quadrat is a map to scale of the plot, showing the positions of the various plants. Although this is a very time consuming thing to do, the chart quadrat is useful if you plan to conduct studies of the same area over a long period of time. Changes in vegetation patterns with time are best followed with the chart quadrat.

**E). Denuded quadrate.** This quadrate is generally used for determining the rate of invasion and establishment of vegetation on badly depleted areas. The quadrate may be placed in area entirely or nearly denuded by grazing animals, burning, flooding or any kind of disturbances. When a portion of soil surface is removed or disturbed the quadrate become partially denuded.

**Materials**

a) tree caliper
b) diameter or basal area tapes (or conversion tables)
c) measuring tapes

d) string and pegs

e) hammer

f) identification guides

g) data sheets

**Procedure**

a) Define the purpose of the study. Then decide upon the shape, size, number, arrangement and kind of quadrat.

b) Make up a class rule regarding whether you include plants on the plot boundary as being in the plot.

c) Go to the study area and locate the quadrats. For large areas or when time is limited, this step is being performed by a small group in advance of the main field trip.

d) Identify the species within your quadrats and make any required measurements of the plans and their positions.

e) Record your results. For frequency studies, simply tick the appropriate box if the species is present. For count quadrats, place a tally mark in the appropriate box every time you see the species in a particular quadrat.

**Calculations**

The data from a quadrat study can be used to calculate many factors of importance in ecological studies.

a) The frequency of quadrats occupied by a given species. It is calculated with this formula:

$$\frac{\text{number of plots in which species occurs}}{\text{Total number of plots}} \times 100$$

Thus, if 20 plots were used and oak trees were found in 5 of these, the frequency of occurrence would be 5/20 X 100, or 25%. In general, the higher the frequency, the more important the plant is in the community. A better idea of the importance of a species with the frequency can be obtained by comparing the frequency of occurrences of all of the species present. The result is called the relative frequency:

$$\frac{\text{frequency of a species}}{\text{total frequency of all species}} \times 100$$

b) The abundance of a species compares the number of plants of that species with the total number of plants of all species in the study area:

$$\frac{\text{number of plants of a certain species}}{\text{total number of plants}} \times 100$$

Although a high frequency value means that the plant is widely distributed through the study area, the same is not necessarily true for a high abundance value. This abundance is not always an indicator of the importance of a plant in a community.

c) Density. Closely related to abundance but more useful in estimating the importance of a species is the density. It is defined as the number of plants of a certain species per unit area:

$$\frac{\text{number of plants of a certain species}}{\text{total area sampled}} \times 100$$

Relative density: $\frac{\text{density of a species}}{\text{total density for all species}} \times 100$

d) Cover. In areas inhabited by both small plants like grasses and large plants like trees, frequency, abundance, and density values could suggest that the more numerous grasses are more important than the trees. Yet, because of their size, the trees probably determine the character of the community and are, as a result, more important than the grasses. Thus a further factor needs to be considered when the importance of a species is being determined. This factor is the cover, the proportion of the total area occupied by the species. Since many ecologists use cover as a means of identifying the dominant species, it is also commonly called dominance:

$$\frac{\text{total area covered by a species}}{\text{total area sampled}} \times 100$$

Relative cover, like relative frequency and relative density, gives a better indication of the importance of a species than does the absolute value:

$$\frac{\text{cover for a species}}{\text{Total cover for all species}} \times 100$$

The method is used to determine cover depends on the type of plant. If the plant is a circular one that hugs the ground, you simply measure its diameter and then use arithmetic to determine the area that it covers. If the plant is a tall herb or shrub, you can measure the downward projection of the crown on the ground. Again, you convert diameter to areas. For trees, you obviously have to determine cover by using the downward projection of the crown. Much time will be saved if you do this. Foresters commonly measure the diameter of a tree trunk 4.5 feet from the ground. This value is called the dbh (diameter, breast height). Tree calipers measure dbh directly. Diameter tapes, wrapped around a tree, give the diameter. Regardless of how you obtain the diameter, you convert it to area and use the area to calculate cover. You merely wrap the basal area tape around a tree at the 4.5 foot level and read the basal area directly.

Importance value. Relative frequency, relative density, and relative dominance each indicate a different aspect of the importance of a species in a community. Therefore, the sum of these three values should give a good overall estimate of the importance of a species. This sum is called the importance value. You can summarize all of the calculations performed during a quadrat study in a table with column headings for species of plant, frequency, relative frequency, abundance, density, relative density, cover, relative cover, and importance value.

**5- Transect**

A **transect** is a path along which one records and counts occurrences of the phenomena of study (e.g. plants noting each instance).

It requires an observer to move along a fixed path and to count occurrences along the path and, at the same time, obtain the distance of the object from the path. This results in an estimate of the area covered, an estimate of the way in which detectability increases from probability 0 to 1 as one approaches the path. Using these two figures one can arrive at an estimate of the actual density of objects.

The estimation of the abundance of biological populations (such as terrestrial mammal species) can be achieved using a number of different types of transect methods, such as strip transects, line transects, belt transects, point transects and curved line transects.

**The Line Intercept Method**

The line intercept method differs from the quadrat method in that, instead of laying out plots, you run several lines through the plant community. You then identify, count, and measure the plants that intercept each line. Using the data obtained, you can calculate most of the same quantities as in a quadrat study. Density cannot be obtained by this method, but relative density can be. On the credit side, the line intercept method is usually more rapid and more objective. It is widely used in sampling non-forest vegetation like grasslands and low shrubs. Although it has been used successfully in forests, other methods are generally easier to use and more accurate. This method is particularly useful in studying succession changes such as those, which occur in sand dunes, from the flood plain of a river to the adjacent upland area, or from the margin of a pond to the surrounding forest. It is also useful for studying the ecotone regions.

**Materials**

a) long tape measure (at least 20m) or lengths of strong cords or rope
b) meter sticks or short tape measures
c) compass
d) identification guides
e) data sheets

**Procedure**

a) Define the purpose of the study.

b) Lay out transect lines. The length of the line depends upon the conditions. Usually a length of 20- 30-m is sufficient. A shorter line will do if you are studying the transition from one small plant community to another. A line 200-

300m long might be required to study succession from a lake margin to the surrounding forest. If you wish to determine the direction of the line randomly, close your eyes rotate two or three times and toss a stick. The lay out the line along the direction in which the stick points. To adequately sample an area, 20-20 lines are usually sufficient. All lines should be the same lengths.

If the purpose of the study is to investigate successions, the transect lines should run parallel to one another and to the direction of the environmental. They should be spaced throughout the study area.
A long measuring tape makes an effective transect line. However, strong cord or rope is marked off in equal intervals of known length is a good substitute.

c) Consider the line to be strip 1 cm wide along one side of tape cord.

d) To calculate the frequency, divide the transect line into several intervals of equal length. The record whether or not a species occurs in each of these intervals.

e) Now move along the transect line with a meter stick or short tape. For each plant that touches, overlies, or underlies the 1cm strip, record the name and the distance along the line that is intercepted by the plant. It is usually best to study each stratum of vegetation separately. Study the ground stratum first so that your movement through the area will not have trampled it. The distance intercepted by the species in this stratum can be measured directly. For tall herbs, shrubs, and trees, the distance intercepted must be determined by measuring the downward projection of the crowns onto the strip. Record all data as they are obtained. The use of symbols for species name will speed up your work.

**Calculations**

a) Determine the number of intervals in which each species occurred, the total number of individuals of each species, and the total intercept length for each species.

b) $\text{Frequency} = \frac{\text{number of intervals containing the species}}{\text{Total number of intervals}} \times 100$

c) $\text{Relative frequency} = \frac{\text{frequency of a species}}{\text{total frequency of all species}} \times 100$

d) $\text{Relative density} = \frac{\text{total number of individuals of a species}}{\text{total number of individuals of all species}} \times 100$

e) $\text{Cover} = \frac{\text{total intercept length of a species}}{\text{total length of transect(s)}} \times 100$

f) $\text{Relative cover} = \frac{\text{total intercept length of a species}}{\text{total intercept length of all species}} \times 100$

## The Belt Transect Method

A belt transect is a long, narrow, rectangular plot that is divided into regular blocks for the purpose of studying the vegetation and its associated biotic and abiotic factors. It is, in effect, an elongated quadrat. Thus since the belt transect method has most of the advantages of the quadrat method. Since the length far exceeds the width, a belt transect also has most of the length of the line transect method. It can be used to study changes in vegetation from one point to another.

This method is widely used to study the vegetation changes that occur because of some gradual change in environmental conditions. For example, it is used to study succcesional changes. It is also used to study vegetation changes that occur because of a change in wind velocity, are temperature or soil temperature from one point to another. Such changes occur between cut and uncut regions of a forest or meadow. A belt run from a sunny to a shady area gives interesting information regarding the light preferences of plants. A belt run up the south slope of a hill and down the north slope will detect great changes in vegetation. Where a marked chemical gradient occurs, a belt transect gives rich results over a very short distance. In all of these cases, the belt must run parallel to the environment gradient if you are to gather meaningful data.

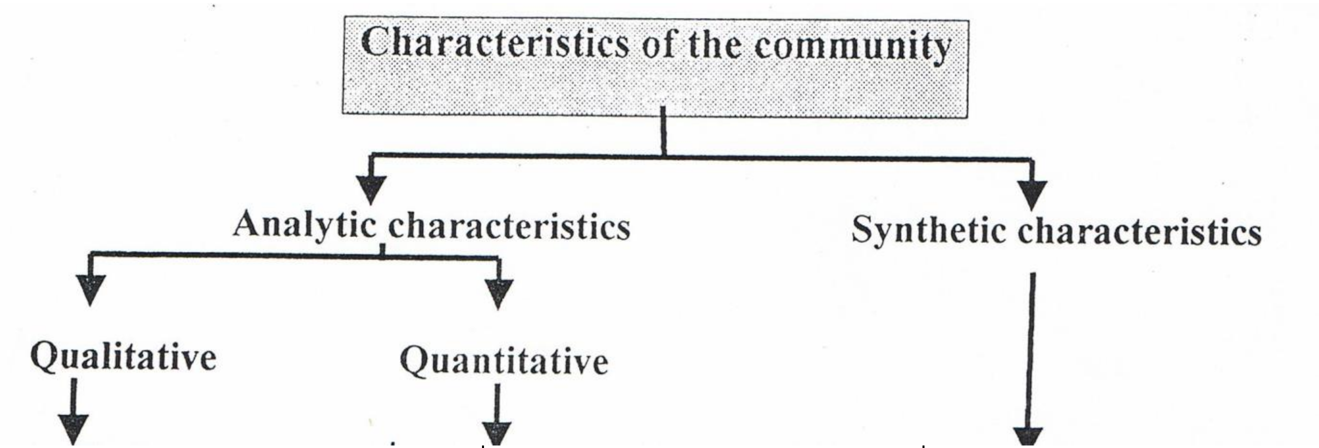
**Materials**

a) long tape measure
b) strong cord or rope
c) stakes
d) hammers
e) meter sticks or short tape measures
f) compass
g) identification guides
h) data sheets

**6- Mapping techniques**

This method is used more in description of the vegetation. The mapped areas are in the form of permanent quadrats. Each individual plant, or shoot is recorded accurately. The method should be limited to the problems where the vegetation change is rapid and at the same time very marked.

Characteristics of the community




1- Presence and constancy
2-j Fidelity
3- Dominance
4- Physiognomy and pattern
5- Association index
6- Index of similarity

1- Abundance
2- Cover
3- Height of plants
4- Weight of plants
5- Volume occupied by plans
6- Frequency

1- Floristic composition
2- Stratification
3- Periodicity
4- Vitality
5- Life-form
^- Sociability
7- Association of species

In the stable community, no two species will occupy the same niche or utilize the same resources at the same time and place. A community has a life span, and the nature and number of organisms in any community are controlled by the environment

## Qualitative characteristics

1- Floristic composition = Kinds of species occurring in the community. Besides the higher plants, the lower groups like the ferns, mosses, liverworts, lichens, epiphytes should also be listed. Because each species has its own range of ecological amplitude, and has its particular relationships to the environment and to other species, the floristic lists indicate the conditions of the habitat

- Mosses and lichens are valuable as indicators of soil microclimatic conditions.

- A decline in the number of species from one area to another may indicate increasingly adverse conditions.

**2- Stratification = Layering = Vertical disposition of plant parts = the occurrence of organisms or their parts at different levels in a stand.** Stratification is present in the above ground as well as in the underground and unseen root systems and rhizomes. Stratification is caused by various factors: -

1- Life forms such as trees, shrubs, herbs and mosses which differ in their requirements and amplitudes, and therefore grow at various levels.

2- Differences in height of plants.

3- The plant branching system.

4- The kind of community (number of strata).

5- Layering of root systems due to differences in moisture content of the soil and the concentration of salts at various depths.

**3-Periodicity = Phenology = Aspectionp = Time relations or temporal behaviors.**

Periodicity refers to the regular seasonal occurrence of various processes such as photosynthesis, growth, pollination, flowering, and ripening of fruits and seeds and the manifestations of these processes, such as formation of leaves, elongation of shoots, appearance of flowers, maturation of fruits. All these features depend on the genetic characteristics for every species and the effects of overlapping of the environmental conditions.

- Periodicity = The recurrence at certain times of these processes and their manifestation.

- Phenology = refers to the appearance of the manifestations at certain seasons of the year.

- Aspection = The appearance of aspect of the community as a whole at different seasons.

**Different seasons and phenology**

Prevernal ------------------------▶ Early spring

Vernal ------------------------▶ Spring

Aestival --------------------------▶ Summer

Serotinal ---------------------------------▶ Autumn

Hiemal or Hibernal--------------------------▶ Winter

Phenologic behavior influences competition and association of species. Periodicity also reflects the adaptation to seasonal changes in the physical environment.

**4-Vitality (Vigor):**

Vitality relates to the condition of plant and its capacity to complete the life cycle, while vigor indicates the state of health.

- Vitality" and vigor may give some information about the competative status of a species in the plant community.

- Also, it may indicate the developmental trend of the species in a community in comparison to other communities.

**Braun-Blanquet (1932) has used the following classification of vitality: -**

Class 1: Well developed plants which regularly complete their life cycles (exceptionally vigorous

Class 2: Vigorous plants which usually do not complete their life cycles or are poorly developed and sparsely distributed plants that do spread vegetatively (normal).

Class 3: Feeble plants that never complete their life cycles but do spread

vegetatively.

Class 4: Plants occasionally appearing from seed but which do not increase in number (very feeble and not fruiting). The plants of class 1 and 2 are much dominant and adapted to the environment of the community.

**5-Life - form = Life- form spectrum = Biological spectrum.**

Raunkiaer (1934) categorized the species into life-forms based on the position of renewable buds or organs on the plants. The buds or plant propagules are either located on aboveground or underground plant parts and their positior or location in relation to the ground has been taken as a criterion for classification of plants into different life forms.

**Raunkiaer's life-forms as modified by Braun-Blanquet (1951) are as under: -**

1- Phytoplanktons:----- The microorganisms which occur in water, air or ice.

2- Phytoedaphon:------ The soil microorganisms.

3-Endophytes:----------Plants that live in the body of some other plant like Lichen and Mycorrhiza.

4-Therophytes:---------The seasonal plants which propagate through seeds and complete their life history within a short period; e.g., annuals, liverwort, mosses.

5- Hydrophytes:-------- All water plants whose buds are located in the water.

6- Geophytes or Cryptophytes -------Are the earth plants in which the buds or rhizomes are located below the soil surface.

7-Hemicryptophytes: - Are perennial plants with buds in or just below the soil surface.

8-Chamaephytes: ------Are surface plants with prostrate habit and the buds are found at the surface of the ground or to 25 cm above the soil Surface.

9-Phanerophytes: ------Are trees, shrubs, climbers, etc., where the buds exposed on upright shoots at least 25 cm above the surface.

10- Epiphytes: ——------ Plants that grow on other plants (not parasite) and their roots do not reach the soil.

- Most of these classes have subdivisions.

In order to prepare the biological spectrum of a community we have to note the number of species belonging to each life-form. The percentage composition of species in each life-form: -

$$\% \text{ Life form} = \frac{\text{Number of species in any life form}}{\text{Total number of species of all life forms}} \times 100$$

**6- Sociability = Gregariousness.**

Sociability refers to the proximity of plant species to one another. It depends upon:-

a- Life-form

b- Vigor of the plants

c- Habitat conditions

d- competative ability of the individuals.

**Braun-Blanquet (1951) has classified the species into five classes: -**

Class 1: Growing solitarily or single.

Class 2: Forming small groups or clumps of plants.

Class 3: Forming small scattered patches or cushions.

Class 4: Forming large patches or colonies or broken mats.

Class 5: Growing in large patches of nearly pure populations covering large areas.

The distance between individuals of a species is often a characteristic property of that species.

- However, sociability is an indication of dispersion.
- The ability of plants to form dense groups is related to: -

- the number of seeds produced,
- the mobility of seeds or fruits,
- the rate of germination, and
- the ability of seedlings to survive disease and intense competition.

**7- Association of species = Interspecific association**.

In a community of plants, several species grow near each other and such association is possible under the following conditions:-

1- When two species can grow in similar environment.

2- When the geographical distribution of the two species is similar and both occur in the same area.

3- When they differ in life-form so that there is no competition

4- When one species is dependent on the other for food, support or mutual benefit; e.g. parasite, epiphyte and lichens with symbiotic relations.

5- When one plant provides protection to the other plant growing near it. A good parameter for evaluating interspecific association between two species is through "association index": -

Example: assume that 100 quadrats examined in a community.

- Occurrence of species A, say in 80 quadrats.
- Occurrence of species A and B, say in 60 quadrats.

Association index of A= 60/80= 0.75

# Quantitative characteristics

**1- Abundance: - = Population density = number of individuals.**

It refers to the number of individuals in a unit of space. Abundance is one of the quantitative analytic concepts which express the number and in winch actual accounts are not made but for which each species are estimated as belonging to one of a limited number of abundance classes.

When actual account are made of the plants on a sample units, the data can be expressed as Density (= the average number of individuals per unit area of the sample). Density values are show the relative importance of each species in a stand when the species are similar in life-form and size. The dry matter content per plant increases at lower density, while at higher density the dry matter content decreases. Also, the seed output per plant and reproductive capacity decreases considerably with increasing density.

**The abundance scale of the species includes five categories:**

Category 1: The individuals of the species represent less than 5% of the total number of plants.

category2: 5 % - 25 %

Category 3: 25 % - 50 %

Category 4: 50 % - 75 %

category5: 75 % - 100 %

**2- Cover =Area occupied.**

Cover is either the foliage (canopy or herbage) cover or the basal area or cross-section area.

1- Canopy or foliage cover refers to the area of ground occupied by the above ground parts of plants (leaves, stems and inflorescences) as viewed from above.

2- Basal area refers to the portion near the ground surface occupied by stems only or actually penetrated by the stem.

Stratification causes increase in canopy cover, and in forests the canopy cover may be more than 150-200%) of the ground area

**Measurements of basal area may vary for the same plant, depending upon:**

a- the height at which the measurements are taken, b- the age of the plant, and it increases with age up to a certain extent.

Basal area is always low in relation to the canopy cover, and it indicates the dry matter accumulation in the shoot and their relative importance in the community. On the other hand, plants with greater canopy cover are capable of intercepting more solar energy and cause deeper shade which influences the plant distribution of the ground flora especially in the forest.

On bases of foliage cover in a community, species are grouped into five classes:

Class A: species with 5 % foliage cover or less.

Class B: species with 6 - 25% foliage cover.

Class C: species with 26 - 50% foliage cover.

Class D: species with 51 - 75% foliage cover.

Class E: species with 76 - 100 % foliage cover.

**3- Height of plants:-**

The height of plants is a good indicator to their condition or vigor, and can be used as a criterion of the success of a species in various habitats, and also as a measure of the favorableness of the environment. There is a significant positive correlation between the rate of growth in height and growth in weight.

Also, there is a relationship between the height of the herbage and the depth of the rot system. On the other hand, height measurements may reflect the effects of the competition upon different species.

**4- Weight of plants = Biomass. = Weight per unit area.**

Green plants assimilate and transform the light energy into potential food energy.

The plants use a part of this potential energy during respiration and whatsoever is left behind into the plants adds to the biomass. Biomass is a manifestation of net production. All the species do not have the same metabolic rate, hence their production performance within (he community differs. The differences are also influenced by the age 'of the plant, their leaf area and the seasonal changes which affect the physiological processes of the organisms. An increase in dry weight is a best measure of growth.

Species which possess more biomass and have higher production rate are dominant in the community /and they also influence the appearance or physiognomy of the vegetation.

The weight is not uniformly distributed throughout the plant body. Much of the matter is stored storage organs of the plants like tubers, corms, rhizomes and stem.

Hence, accumulation of dry matter, in the aboveground or underground plant parts should be estimated and biomass profile for the community may be prepared. **The biomass profile** indicates the amount of dry matter present at different heights of the vegetation cover. Such profiles differ in different communities and are influenced by the life-form of the plant.

Growth performance has been taken as a parameter to evaluate the competitive ability of plant; and a greater production of matter relative to the competitor is correlated with increased ability to compete. Thus we can evaluate competition quantitatively in term of **growth capacity** among species of equivalent life-form using the following formula:-

GA/B = MA:MB or GB/A = MB:MA

Where

G= Growth capacity.

M= Dry matter per plant.

A= Species A.

B= Species B.

This calculation holds good for plants of the same life-form and with upright growth habit

**5- Volume occupied by plants- :**

Volume refers to the three-dimensional space occupied by plants. The space occupied by the aboveground parts is of greater important in understanding the structure of the vegetation.

**6- Frequency: -**

Frequency indicates dispersion of species in a community, and it is concerned with the uniformity or regularity with individuals of species are distributed through the community. In other words, frequency is concerned with the degree of uniformity of occurrence of individuals of species within an area.

Variation in distribution is caused by several factors like:

1- Soil condition and topography,

2- Vegetative propagation,

3- Quantity and dispersal of seeds,

4- Time of invasion of one species as compared to others,

5- Grazing or other biotic activities and predation by insects or diseases.

Frequency is expressed as a percentage, and the frequency index or percentage frequency is as following: -

$$\%\text{Frequency of species A} = \frac{\text{Number of quadrats in which A specie occurs}}{\text{Total number of quadrats examined}} \times 100$$

The species may have high frequency if:

1- the species have uniform distribution, and

2- the cover and population density the species are high.

• Raunkiaer (934) classified the species in a community into five classes as under: -

Class A: species present in 1 - 20% of quadrats.

Class B: species present in 21 - 40%" of quadrats.

Class C: species present in 41 - 60% of quadrats.

Class D: species present in 61 - 80% of quadrats.

Class E: species present in 81 - 100% of quadrats.

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- The normal distribution of frequency percentages derived from such classification is expressed as: A> B> C ≤ D< E

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and has been named Raunkiaer's "law of frequency" .

In a uniform vegetation class E is always larger than class D, **when it is not so and E is smaller, the community indicates considerable disturbance**. Such a situation occurs at early stages of succession or when a community is subjected to severe biotic influence or fire.

**j-shaped frequency-class curve: -**

The curve with a high peak in class A, formed by a large number of species of low frequencies; and a second peak in class E formed by species of high frequencies. However, the most species are belong to A class which represent to those that not adapted to the environment of the community. These community not reach to the stable state, so the number of species adapted is less than that not adapted. Such community is called "the starting community".

**U-shaped frequency-class curve: -**

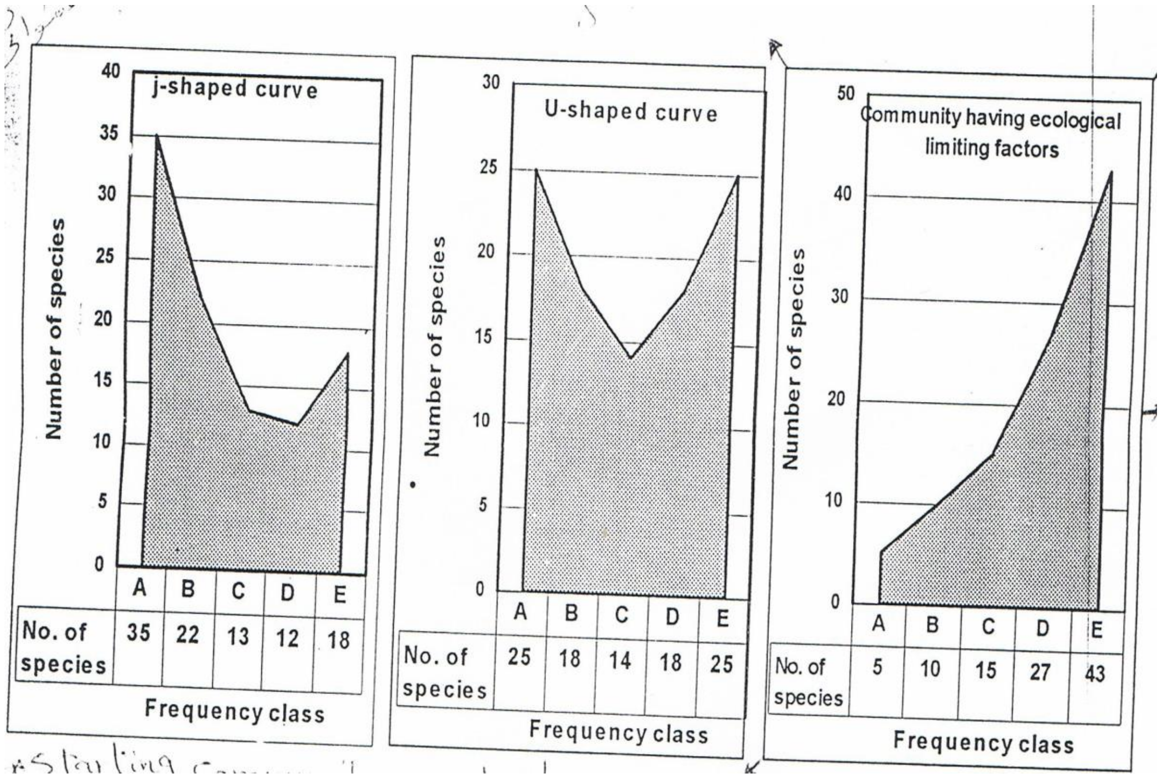
Class-A represents the species which newly invade the community environment, then these species gradually adapted and as they appeared in most quadrats, they transferred into D or E class. However, the community reaches into a state more stable than the first one. This community is called "the adapting community".

**L- shaped frequency-class curve: -**

The more stable community in which most species present closely in all the quadrats, so the most species represents in E-class. 'Such community may be present in an environment have one or more limiting factor. Therefore, the species present in about all the quadrats or not present.

Such this community called "community of well defined habitat factors, or community having ecological limiting factors"

Frequency is not depended only upon numbers of individuals of a kind, and the unit by which they are samples; it is also a function of dispersion. Mean the numbers can be large and hyperdispersed or clumped and the frequency will be low relative to another species with smaller abundance and hypodispersed or more regular than random arrangement




**Synthetic characteristics of the community**

**1- Presence and constancy:**

Presence and constancy refer lo how uniformly a species occurs in a number of stands of the same type of community.

**-Constancy** is employed when equal measured sample areas are used in each stand.

**-Presence** is used when the area of the sampling unit varies form stand to stand, and especially when it is not measured.

**Species may be grouped into five classes of constancy according to percentage of stands in which they occur:-**

Class 1: species are present in less than 20% of the stands.

Class 2: species are present 21 - 40% of the stands.

Class 3: species are present in 41 - 60% of the stands.

Class 4: species are present in 61 - 80% of the stands.

Class 5: species are present in 81 - 100% of the stands.

- Large number of species in class 4 and 5 indicate floristic homogeneity of the community type.

**2- Fidelity:**

There are some species represented only in one kind of community, others can be represented in more than one kind, and others in any kind of community fidelity refers to the degree that a species is restricted in its occurrence to a particular kind of community, and those with low fidelity occur in a number of different communities, those with high fidelity in a few or in only one kind.

**Fidelity depends on the following principles:-**

1- Species differ in ecological amplitude or in capacity to grow in a wide range of ecological conditions.

2- Because some species arguable to associate with others or are prevented from doing so because of inability to compete.

3- Another cause is dissimilarities in adaptation from migration and invasion.

4- The distribution area to each species differs from the others but two or more may be has the same area.

# Notes:-

| Frequency | Presence and constancy | Fidelity |
|---|---|---|
| Refers to the degree of uniformity of distribution of a species within one stand. | Refers to how uniformity of species occurs in number of stands of the same type of community . | Being concerned with the occurrence of species in different kinds of community types. |

It is clear, however, that fidelity and constancy are independent characteristics.

**3- Dominance**

Dominance is the characteristic of vegetation that expresses the predominating influence of one or more species in a stand so that population of other species are more or less suppressed or reduced in number or vitality.

Species with exert major controlling influence on the community by virtue of their size; number, production or other activities are called dominant

The species which control the energy flow of the community are blown as ecological dominants.

**Dominants are those species which are:-**

1- Highly successful ecologically in their relations lo the environment meaning that their range of tolerance corresponding to the environmental conditions.

2- Predominants in competition for limiting supplies of the necessities of life.

3- Highly successful ecologically in their telethons with other species that they determine to a considerable extent the conditions under which associated species must grow.

4- Dominants have root system which enough adapted to enable them to dominate and grow densely.

**Also, there are five categories of dominance:-**

Category 1: Individuals of the species cover less than 5% of the sample unit area "quadrat".

Category 2: Individuals of the species cover 5 - 25%.

Category 3: Individuals of the species cover 25 - 30%.

Category 4: Individuals of the species cover 50 - 75%.

Category 5: Individuals of the species cover 75 - 100%.

**4- Physiognomy and pattern:-**

Physiognomy, the appearance or "look" of a stand and which is based on all qualitative and quantitative characteristics.

Pattern in vegetation is the spatial arrangement of individuals of a species.

A very wide range of pattern scales is present in vegetation:

1- Ecological pattern: in which competition and association of species are of great importance.

2- Morphological pattern: in which the growth of a propagative organ such as a rhizome is very important.

3- Environmental pattern: in which the environmental factors, microclimatic or edaphic are concerned.

**6- Index of similarity:-**

$$S = \frac{2C}{A + B}$$

Where A= number of species in sample or community A.

B= number of species in sample or community B.

C= number of species common in both communities A and B

S= Index of similarity.

Index of dissimilarity= 1- S.

**7- Index of species organization:-**

In order to evaluate the concentration of dominance m a species within a community, the following formula have been derived for calculating index of dominance which showing the importance of each species in relation to the community as a whole.

$$C = \Sigma \left( \frac{ni}{N} \right)^2$$

Where:

C = index of dominance.

ni = importance value of each species or number of individuals or biomas of each species.

N = total importance value of all the species or total number of plants or total biomass.

When the dominance is more concentrated in one species the value will be high and when several species contribute equally well the index will be low.

**8- Index of diversity:-**

In any plant community we find a number of species. The species diversity is higher in the older and more stable community.

Developing communities at serial stages of succession have less number of species than the developed climax communities which possess maximum number of species and have high species diversity. Species diversity is a very useful parameter for comparison of two communities especially to study the influence of biotic disturbances or to know the state of succession and stability in the community.

Species diversity is quantified by calculating "species diversity index", which is the ratio between the number of species and importance value or number or biomass or productivity of the individuals. The following formula can be used for calculating the "Index of General Diversity."

$$H = - \Sigma \left\{ \left( \frac{ni}{N} \right) \log \left\{ \left( \frac{ni}{N} \right) \right\} \right.$$

Where:

H =Index of General Diversity

ni = importance value or relative dominance or biomass of each species N= total importance value or total biomass of all the species.

**Criteria of classification of communities "Synsystematics"**

1- Floristic or species composition.

2- Ecological relations or habitat.

3- Successional status.

4-Physiognomy