# Feature of succession, Effect of imbalance on the Ecosystem

**Ecological succession** is the process of change in the species structure of an ecological community over time. The time scale can be decades (for example, after a wildfire), or even millions of years after a mass extinction. The community begins with relatively few pioneering plants and animals and develops through increasing complexity until it becomes stable or self-perpetuating as a climax community. The "engine" of succession, the cause of ecosystem change, is the impact of established organisms upon their own environments. A consequence of living is the sometimes subtle and sometimes overt alteration of one's own environment. It is a phenomenon or process by which an ecological community undergoes more or less orderly and predictable changes following a disturbance or the initial colonization of a new habitat. Succession may be initiated either by formation of new, unoccupied habitat, such as from a lava flow or a severe landslide, or by some form of disturbance of a community, such as from a fire, severe windthrow, or logging. Succession that begins in new habitats, uninfluenced by pre-existing communities is called primary succession, whereas succession that follows disruption of a pre-existing community is called secondary succession.

**Factors**

The trajectory of successional change can be influenced by site conditions, by the character of the events initiating succession (perturbations), by the interactions of the species present, and by more stochastic factors such as availability of colonists or seeds or weather conditions at the time of disturbance. Some of these factors contribute to predictability of succession dynamics; others add more probabilistic elements. Two important perturbation factors today are human actions and climatic change. In general, communities in early succession will be dominated by fast-growing, well-dispersed species (opportunist, fugitive, or r-selected life-histories). 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 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, sometimes referred to as the 'potential vegetation' of a site, and shaped primarily by the local climate. This idea has been largely abandoned by modern ecologists in favour of nonequilibrium ideas of ecosystems dynamics. Most natural ecosystems experience disturbance at a rate that makes a "climax" community unattainable. Climate change often occurs at a rate and frequency sufficient to prevent arrival at a climax state. Additions to available species pools through range expansions and introductions can also continually reshape communities. The development of some ecosystem attributes, such as soil properties and nutrient cycles, are both influenced by community properties, and, in turn, influence further successional development. This feed-back process may occur only over centuries or millennia. Coupled with the stochastic nature of disturbance events and other long-term (e.g., climatic) changes, such dynamics make it doubtful whether the 'climax' concept ever applies or is particularly useful in considering actual vegetation.

**Types**

**Primary succession**

Successional dynamics beginning with colonization of an area that has not been previously occupied by an ecological community, such as newly exposed rock or sand surfaces, lava flows, newly exposed glacial tills, etc., are referred to as primary succession. The stages of primary succession include pioneer microorganisms, plants (lichens and mosses), grassy stage, smaller shrubs, and trees. Animals begin to return when there is food there for them to eat. When it is a fully functioning ecosystem, it has reached the climax community stage.

**Secondary succession**

Successional dynamics following severe disturbance or removal of a pre-existing community are called secondary succession. Dynamics in secondary succession are strongly influenced by pre-disturbance conditions, including soil development, seed banks, remaining organic matter, and residual living organisms. Because of residual fertility and pre-existing organisms, community change in early stages of secondary succession can be relatively rapid. Secondary succession is much more commonly observed and studied than primary succession. Particularly common types of secondary succession include responses to natural disturbances such as fire, flood, and severe winds, and to human-caused disturbances such as logging and agriculture. In secondary succession, the soils and organisms need to be left unharmed so there is a way for the new material to rebuild. As an example, In the 1900s, Acadia National Park had a wildfire that destroyed much of the landscape. Originally evergreen trees grew in the landscape. After the fire, the area took at least a year to grow shrubs. Eventually, deciduous trees started to grow instead of evergreens.

**Seasonal and cyclic dynamics**

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 modify the climax concept towards one of dynamic states.

**Causes of plant succession**

Autogenic succession can be brought by changes in the soil caused by the organisms there. These changes include accumulation of organic matter in litter or humic layer, alteration of soil nutrients, or change in the pH of soil due to the plants growing there. The structure of the plants themselves can also alter the community. For example, when larger species like trees mature, they produce shade on to the developing forest floor that tends to exclude light-requiring species. Shade-tolerant species will invade the area. Allogenic succession is caused by external environmental influences and not by the vegetation. For example, soil changes due to erosion, leaching or the deposition of silt and clays can alter the nutrient content and water relationships in the ecosystems. Animals also play an important role in allogenic changes as they are pollinators, seed dispersers and herbivores. They can also increase nutrient content of the soil in certain areas, or shift soil about (as termites, ants, and moles do) creating patches in the habitat. This may create regeneration sites that favour certain species. Climatic factors may be very important, but on a much longer time-scale than any other. Changes in temperature and rainfall patterns will promote changes in communities. As the climate warmed at the end of each ice age, great successional changes took place. The tundra vegetation and bare glacial till deposits underwent succession to mixed deciduous forest. The greenhouse effect resulting in increase in temperature is likely to bring profound Allogenic changes in the next century. Geological and climatic catastrophes such as volcanic eruptions, earthquakes, avalanches, meteors, floods, fires, and high wind also bring allogenic changes.

**Mechanisms**

In 1916, Frederic Clements published a descriptive theory of succession and advanced it as a general ecological concept. His theory of succession had a powerful influence on ecological thought. Clements' concept is usually termed classical ecological theory. According to Clements, succession is a process involving several phases:

1. Nudation: Succession begins with the development of a bare site, called Nudation (disturbance).
2. Migration: refers to arrival of propagules.
3. Ecesis: involves establishment and initial growth of vegetation.
4. Competition: as vegetation becomes well established, grows, and spreads, various species begin to compete for space, light and nutrients.
5. Reaction: during this phase autogenic changes such as the build-up of humus affect the habitat, and one plant community replaces another.
6. Stabilization: a supposedly stable climax community form.

**Seral communities**

**Changes in animal life**

Succession theory was developed primarily by botanists. Animal life also exhibit changes with changing communities. In lichen stage the fauna is sparse. It comprises few mites, ants and spiders living in the cracks and crevices. The fauna undergoes a qualitative increase during herb grass stage. The animals found during this stage include nematodes, insects, larvae, ants, spiders, mites, etc. The animal population increases and diversifies with the development of forest climax community. The fauna consists of invertebrates like slugs, snails, worms, millipedes, centipedes, ants, bugs; and vertebrates such as squirrels, foxes, mice, moles, snakes, various birds, salamanders and frogs.

**Micro-succession**

Succession of micro-organisms including fungi and bacteria occurring within a microhabitat is known as micro-succession or serule. Like in plants, microbial succession can occur in newly available habitats (primary succession) such as surfaces of plant leaves, recently exposed rock surfaces (i.e., glacial till) or animal infant guts, and also on disturbed communities (secondary succession) like those growing in recently dead trees or animal droppings. Microbial communities may also change due to products secreted by the bacteria present. Changes of pH in a habitat could provide ideal conditions for a new species to inhabit the area. In some cases, the new species may outcompete the present ones for nutrients leading to the primary species demise. Changes can also occur by microbial succession with variations in water availability and temperature. Theories of macroecology have only recently been applied to microbiology and so much remains to be understood about this growing field. A recent study of microbial succession evaluated the balances between stochastic and deterministic processes in the bacterial colonization of a salt marsh chrono-sequence. The results of this study show that, much like in macro succession, early colonization (primary succession) is mostly influenced by stochasticity while secondary succession of these bacterial communities was more strongly influenced by deterministic factors.

**Climax concept**

According to classical ecological theory, succession stops when the sere has arrived at an equilibrium or steady state with the physical and biotic environment. Barring major disturbances, it will persist indefinitely. This end point of succession is called climax.

Climax community

The final or stable community in a sere is the *climax community* or *climatic vegetation*. It is self-perpetuating and in equilibrium with the physical habitat. There is no net annual accumulation of organic matter in a climax community. The annual production and use of energy is balanced in such a community.

Characteristics

- The vegetation is tolerant of environmental conditions.
- It has a wide diversity of species, a well-drained spatial structure, and complex food chains.
- The climax ecosystem is balanced. There is equilibrium between gross primary production and total respiration, between energy used from sunlight and energy released by decomposition, between uptake of nutrients from the soil and the return of nutrient by litter fall to the soil.

- Individuals in the climax stage are replaced by others of the same kind. Thus, the species composition maintains equilibrium.
- It is an index of the climate of the area. The life or growth forms indicate the climatic type.

**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. For example, development of Maple-beech climax community over moist soil. 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 post-climax strands develop in more moist and cooler areas than that of surrounding climate.

**Forest succession**

Forests, being an ecological system, are subject to the species succession process. There are "opportunistic" or "pioneer" species that produce great quantities of seed that are disseminated by the wind, and therefore can colonize big empty extensions. They are capable of germinating and growing in direct sunlight. Once they have produced a *closed canopy*, the lack of direct sun radiation at the soil makes it difficult for their own seedlings to develop. It is then the opportunity for shade-tolerant species to become established under the protection of the pioneers. When the pioneers die, the shade-tolerant species replace them. These species are capable of growing beneath the canopy, and therefore, in the absence of disturbances, will stay. For this reason, it is then said the stand has reached its climax. When a disturbance occurs, the opportunity for the pioneers opens up again, provided they are present or within a reasonable range.

An example of pioneer species, in forests of north-eastern North America are *Betula papyrifera* (White birch) and *Prunus serotina* (Black cherry), that are particularly well-adapted to exploit large gaps in forest canopies, but are intolerant of shade and are eventually replaced by other shade-tolerant species in the absence of disturbances that create such gaps. In the tropics, well known pioneer forest species can be found among the genera *Cecropia*, *Ochroma* and *Trema*. Things in nature are not black and white, and there are intermediate stages. It is therefore normal that between the two extremes of light and shade there is a gradient, and there are species that may act as pioneer or tolerant, depending on the circumstances. It is of paramount importance to know the tolerance of species in order to practice an effective silviculture.

**Effect of imbalance on the Ecosystem**

**Human activities**

Human activities are important in almost all ecosystems. Although humans exist and operate within ecosystems, their cumulative effects are large enough to influence external factors like climate.

<u>Ecosystem goods and services</u>

Ecosystems provide a variety of goods and services upon which people depend. Ecosystem goods include the "tangible, material products" of ecosystem processes such as food, construction material, and medicinal plants. They also include fewer tangible items like tourism and recreation, and genes from wild plants and animals that can be used to improve domestic species. Ecosystem services, on the other hand, are generally "improvements in the condition or location of things of value". These include things like the maintenance of hydrological cycles, cleaning air and water, the maintenance of oxygen in the atmosphere, crop pollination and even things like beauty, inspiration and opportunities for research. While material from the ecosystem had traditionally been recognized as being the basis for things of economic value, ecosystem services tend to be taken for granted.

**Ecosystem management**

When natural resource management is applied to whole ecosystems, rather than single species, it is termed ecosystem management. Although definitions of ecosystem management abound, there is a common set of principles which underlie these definitions. A fundamental principle is the long-term sustainability of the production of goods and services by the ecosystem; "intergenerational sustainability [is] a precondition for management, not an afterthought". While ecosystem management can be used as part of a plan for wilderness conservation, it can also be used in intensively managed ecosystems.

**Ecosystem degradation and decline**

As human population and per capita consumption grow, so do the resource demands imposed on ecosystems and the effects of the human ecological footprint. Natural resources are vulnerable and limited. The environmental impacts of anthropogenic actions are becoming more apparent. Problems for all ecosystems include: environmental pollution, climate change and biodiversity loss. For terrestrial ecosystems further threats include air pollution, soil degradation, and deforestation. For aquatic ecosystems threats include also unsustainable exploitation of marine resources (for example overfishing of certain species), marine pollution, microplastics pollution, water pollution, the warming of oceans, and building on coastal areas.

These threats can lead to abrupt transformation of the ecosystem or to gradual disruption of biotic processes and degradation of abiotic conditions of the ecosystem. Once the original ecosystem has lost its defining features, it is considered *collapsed*. Ecosystem collapse could be reversible and is thus not completely equivalent to species extinction. Quantitative assessments of the risk of collapse are used as measures of conservation status and trends. Society is increasingly becoming aware that ecosystem services are not only limited but also that they are threatened by human activities. The need to better consider long-term ecosystem health and its role in enabling human habitation and economic activity is urgent and global advocacy associated to targets of the Sustainable Development Goal 15 on sustainable ecosystem is growing. To help inform decision-makers, many ecosystem services are being assigned economic values, often based on the cost of replacement with anthropogenic alternatives. The ongoing challenge of prescribing economic value to nature, for example through biodiversity banking, is prompting transdisciplinary shifts in how we recognize and manage the environment, social responsibility, business opportunities, and our future as a species.

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