# TwoOldGuys™ Study Guides
## BI114 Biological Concepts for Teachers
# Chapter 6. Ecology, Advanced
# 6.1. Succession

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
*Numbers refer to the age-appropriate grade-level for the content.*

## Review

We have explored the population as a potentially growing, but usually stable, thing. We have assembled populations into communities, then observed the movement of energy and nutrients between trophic levels.

## Succession

We suggested in the last chapter that the numbers of individuals in a population do not change much from year to year. In this section we are going to see how these numbers do change over time measured in decades.

*grades 5: to 6:*

### Communities may change over short times (decades)

- abandoned farm fields grow to weed-lots, then brush
- communities recover after forest fires

Farm fields may be planted to the same crop for several consecutive years, although good farming practices currently recommend annual

rotation of crops. Between the Ohio and Mississippi river valleys and the upper Great Lakes, the rotating crops are typically corn, soybeans, and hay. If one of these fields were abandoned after harvest one year, and not planted to hay, the following year it is likely that the field will grow mostly weeds and some "volunteer" crops from previous plantings [soybeans, corn, timothy and alfalfa]. During year two, the volunteer crops will mostly disappear and weeds will dominate. During year two, the majority of the weeds will be annual plants. In year three, perennial weeds begin replacing the annual weeds. Sometime between year five and year ten, woody plants [sumac, multiflora rose, raspberry, etc] may begin invading. Within five or so years after woody species appear, trees will begin to invade. After a few decades, the former field will have become a woodlot.

In western North America, forest fires seem to be a annual event, frequently [based on news coverage] involving major fires. Following a very major [the news called it "devastating"] forest fire, there will be weeds [specifically fireweed, *Epilobium angustifolium*] growing in the next full growing season. For example in a 'devastating' late summer fire in Yellowstone National Park [2002], the news reported that scientists were surprised to find weeds growing in the following summer [2003]. In the spring of 2003, there was a large fire in southern Colorado, with re-growth of weeds in the summer of 2003! Even after the eruption of Mount St. Helens on May 18, 1980, with 230 square miles [500 sq km] of forest destroyed, fireweed was found growing from the volcanic ash during the summer of 1980! [Peter Frenzen, Monument Scientist, USDA Forest Service, Mount St. Helens National Volcanic Monument]. While it is true that the news reported that scientists were surprised by the rapid recovery from these 'devastating' events, those scientist familiar with these ecosystems were not surprised at all. We knew at the time of the fires that the normal functioning of "fire ecology" includes the ability of the natural communities to begin recovery in the next growing season

following the fire. We also knew at the time of the fires that fireweed would most likely be the first plants to appear. Some of us also suspected that the volcano eruption would be followed within a few growing seasons by similar recovery, starting with the invasion of fireweed.

*grades 7: to 8:*

## short-term (decade long) changes are succession or community development

- primary succession = site never occupied [no soil development]
- secondary succession = regrowth over site previously supporting a community

The process by which natural communities can recover from disturbance [natural disturbances such as fire or wind storms, including hurricanes and tornados, and man-made disturbances, such as logging and agriculture] is called succession. Succession is understood to be a relatively orderly progression of different plants [and associated animals] over time following the disturbance. Succession is generally divided into two separate types: primary succession and secondary succession.

Primary succession occurs only on sites which have never been occupied by living organisms. The usual example of primary succession is volcanic lava flows as seen on the big island of Hawai'i (Mt. Kilauea), or on the island of Surtsey (a volcano which rose above sea level off the coast of Iceland on November 15, 1963). Lava flows result when magma rises through rocks to the Earth's surface, then flows away from the volcano crater. After the lava cools, there is newly formed rock – rock which has never had a single living creature living on it. One would think that there would have to be some soil formation by chemical and mechanical weathering before anything could grow. In reality, however,

there are plants which can germinate and grow in cracks [which form as the lava cools] in the rock, and these plants can cause rock to crumble to soil. The ash of Mount St. Helens is considered to be another example of primary succession [in most cases, but not all regrowth is primary]. Less spectacular examples include rock outcrops exposed by earthquakes or floods. Technically an abandoned paved parking lot returning to vegetation would also be primary succession.

Secondary succession occurs where there is still soil remaining in spite of the disturbance, and thus seeds and roots may be left behind in the soil after the disturbance. Typical events which lead to secondary succession are wind storms, tornados and hurricanes, and fires [forest fires, brush fires and prairie fires]. Most human driven disturbances such as logging, agriculture and surface mining, will revert to secondary succession as soon as the disturbance ends. Even a city which has been abandoned will gradually crumble to ruins as succession restores natural communities on the site of the city. The key features of secondary succession are the presence of residual soil and live seeds and roots from the previous natural communities.

A colleague of mine did a study of secondary succession along road cuts in Illinois, showing that about 60% of milkweed growth came from previously buried root stock, and only 40% grew from seed. The sites he looked at were locations where a highway had been widened after the original highway was constructed by cutting through a hillside. The results were surprising because milkweed is a weed which produces a large number of seeds with tufts of cottony material serving as parachutes for wind transport. Published discussions had hypothesized that weeds reproduce primarily by seeds which are produced in large quantities, are easily dispersed to new sites, and will germinate and grow where soil development is minimal; and suggested that as the definition of a 'weed.' The data from the field test proved the hypothesis to be false. Another example which I was able to observe involved the widening of an

asphalt-surfaced road in Indiana where dandelions [another classic example of a weed] were able to grow from roots which had been buried under 3 – 4 inches [75 – 100 mm] of hot asphalt, and the asphalt compressed by road rollers. Within about two weeks after the asphalt cooled, the dandelions pushed through the asphalt.

The studies of milkweeds [ca. 1970] and dandelions [ca. 2003] described above differed from most previous studies of secondary succession because the previous studies looked at sites where the soil structure exhibited minimal disturbance. For the milkweed study, the top soil had been completely removed, exposing the subsoil. For the dandelions, the soil had been 'replaced' [actually covered] by a lava-like substance. In both cases many professional ecologists [including my colleague and I] would have expected primary succession rather than secondary succession.

*grades secondary: to college:*

## Succession is a series of seral stages

- pioneer
- weedy
- shrubby
- sub-climax woods
- climax forest

each stage modifies environment favoring the next seral stage species
disturbance returns to earlier seral stage

Classic succession, originally described by H. Cowles (1934) based on his observations on the dunes of the Indiana shore of Lake Michigan, portrays the process as a series of seral stages: pioneer, weedlot, shrub, shrubby woods, sub-climax woods, and climax forest. This model lead to the description of plant species as weedy or climax [or a continuum from weed to climax] based on where in the seral stages the plant generally

occurs. The pioneer species are pure weeds, with high seed production, high dispersal of seed and ability to colonize new [primary] sites. As the system moves from the pioneer stage to the climax stage, the species present become progressively less weedy and therefore more climax. The weedy species were also called "r-selected" referring their high reproduction [reproductive rate, or r], while climax species were called "K-selected" referring to their ability to maintain stable populations [carrying capacity, or K]. It is not recommended that the terms 'r-selected' and 'K-selected' be introduced to secondary or lower grades as the terms tend to be confusing to upper class (junior, senior) college students of Biology.

An alternative hypothesis to describe succession relies on the probabilities that any given species could become established on the site. The premise is that these probabilities change over time as specific species become established, thereby driving the observed changes in the community over time. There are elaborate mathematical models to describe such processes. The good news is that these mathematical models will not be introduced here, on the premise that they are "beyond the scope of this text."

## Theory of Island Biogeography

A variant of the probability based succession model attempts to incorporate the concepts of Island Biogeography to the successional process. This has also been described as an extension of the Theory of Island Biogeography. The underlying goal of these efforts has been to develop a unified theory of ecology.

In highly superficial terms, this “theory” [actually developing theory, not current theory] can be summarized as the following outline:

- There is an annual emigration of individuals from occupied habitats [emigration refers to migration from a site; the mnemonic to remember this is that **E**migration occurs out the **E**xit]
- immigrants arrive by chance; first come – first 'served' [immigration refers to migration to the site; the mnemonic to remember this is that **I**mmigration comes through the **I**n door]
- Only current and next seral stage species can become established (this part of the developing theory is controversial, and may be unnecessary)
- Later immigrants meet competition unless local extinction has occurred
- or seral changes in environment have occurred (again controversial, and perhaps unnecessary)
- Composition of community is therefore dynamic
    - short term: succession
    - long-term: adaptation
- Plant populations, once established, may persist for centuries
    - therefore animals' habitats/niches persist for centuries also