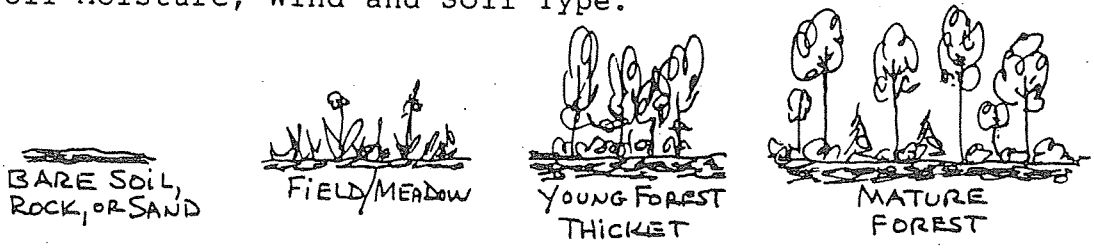
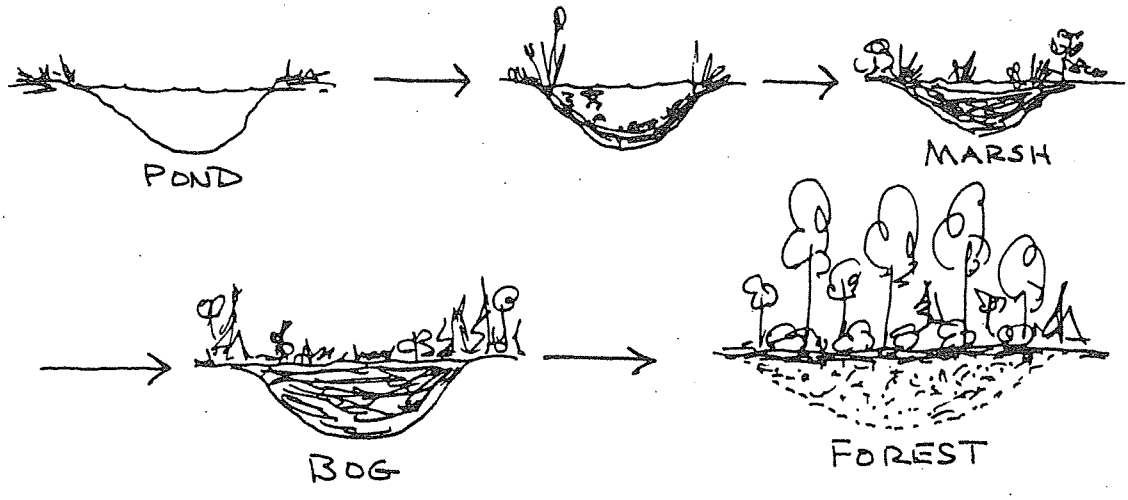
Ecological Succession

Introduction.

ECOLOGICAL SUCCESSION is a natural process in Terrestrial Ecosystems, where one Biotic Community of plants and animals is gradually replaced by a new biotic community over time. An example of succession is an agricultural field, that has been plowed and left abandoned. Over the years, natural changes in dominant plants will occur, until the area eventually becomes a forest. As the plant species change, so to do the dominant animal species change. This is due to the development of different plant habitats preferred by the animals. The changes in the biotic community also produce changes in Abiotic Factors, such as: Available Light, Air & Soil Temperatures, Humidity & Soil Moisture, Wind and Soil Type.



Ecological Succession also occurs in Aquatic Ecosystems. Over time, a pond or lake will fill in with sediment and vegetation, and will eventually become a terrestrial environment.



Types of Succession

Primary Succession

Succession that begins in an area that has not supported life within recent geological times is called **primary succession**. A sand dune succession is of this type. So too is the succession that occurs on bare rock. You have probably seen rocks covered with plants. You will see in Section 4.3 just how those plants got established on the rocks.

Secondary Succession

Succession that begins in an area that once supported life is called **secondary succession**. An abandoned field or a forest destroyed by fire or lumbering will undergo this type of succession. Secondary succession is generally more rapid than primary succession because soil is already present. Also, some forms of life are already in the area. Section 4.4 describes a typical secondary succession.

Autotrophic and Heterotrophic Succession

You may recall from Section 2.2 that autotrophic organisms make their own food. That is, they are plants and algae. Heterotrophic organisms, on the other hand, feed on other organisms. They do not make their own food. The following discussion shows how a parallel situation exists in autotrophic and heterotrophic succession.

Both primary and secondary succession are examples of **autotrophic succession**. In both cases succession is dominated by plants. These plants are largely responsible for changing the environment. That is, they direct the succession. They are the main source of energy for organisms in the area.

Plants do not, however, dominate **heterotrophic succession**. Further, the main source of energy in this type of succession is usually non-living organic matter, not plants. For example, a **fallen log** undergoes heterotrophic succession. The energy source is the dead wood. As the log decays, it passes through a number of stages before it decays completely and becomes part of the soil.

- Beetles make tunnels in the wood and bracket fungi attack the bark (Fig. 4-9).
- Other animals and fungi enter the tunnels.
- The action of the animals and fungi loosens the bark and softens the wood.
- Slugs, snails, millipedes and other animals become established under the loose bark. Salamanders and snakes might make a home under the log.
- When the bark is all gone, many of these animals leave because their shelter is gone.
- Fungi such as moulds, and beetles which can bore into soft wood now dominate the succession. The log soon becomes a pulpy mass.
- Moulds and bacteria work on this mass and change it into humus. Earthworms, ants, millipedes and centipedes abound at this stage. These organisms help mix the humus into the soil.

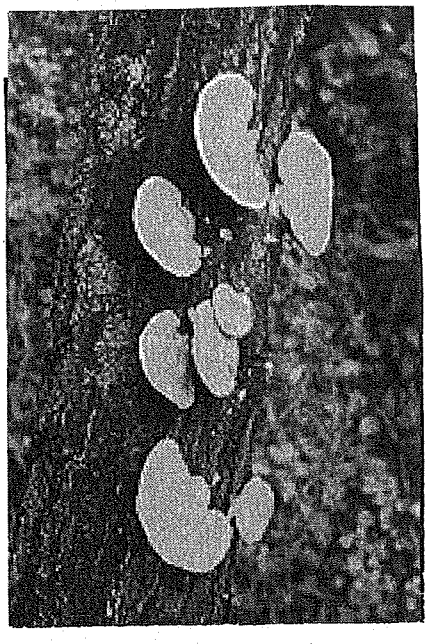


Fig. 4-9 The bracket fungus is often a pioneer in a fallen log succession.

Each stage in this succession has a special community of living things. These organisms use up their food or otherwise change their environment. Then they can no longer live there. But they are succeeded by other organisms that can live in the changed environment. In this way succession, or a gradual change in the communities, takes place.

A rotting carcass also undergoes heterotrophic succession. Bacteria are the first to colonize the carcass. Worms are next and, in turn, are followed by other invertebrates such as flies, beetles, and wasps. They complete the decomposition of the carcass.

Succession on Rocky Surfaces

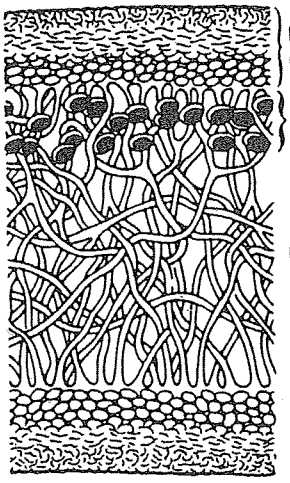


Fig. 4-10 Structure of a lichen. The hair-like fungal hyphae are wrapped tightly around the algae. Thus the lichen seems to be one organism. You can see the fungus and alga if you break a lichen into tiny pieces and look at it under a microscope.

Lichens: The Pioneer Organisms

The pioneers of succession on bare rock are **lichens**. A lichen is not a single type of organism (Fig. 4-10). Instead, it is an alga and a fungus living together in a symbiotic relationship called **mutualism**. (You may recall that mutualism is a symbiotic relationship in which both organisms benefit.) The alga is autotrophic. That is, it can make foods by photosynthesis. It then shares these foods with the fungus which cannot make its own food. The fungus, in turn, provides the alga with water, mineral nutrients, and support.

Succession From Bare Rock to Forest

The first lichens to colonize a rocky surface are **crustose** lichens (Fig. 4-11, A). They usually appear as finely textured coloured patches that are difficult to remove by hand. These lichens send **hyphae** several millimetres into the rocky surface to obtain nutrients. They do this by secreting acid onto the rock. This action starts the breakdown of the rock.

Foliose lichens often join the crustose lichens (Fig. 4-11, B). These leaf-like lichens are not so firmly attached. In fact, large pieces can be easily pulled off the rocks. The crustose and foliose lichens weaken the rock. The weakened rock crumbles, forming parent soil material. Weathering (the freeze-thaw cycle) helps break up the rock.

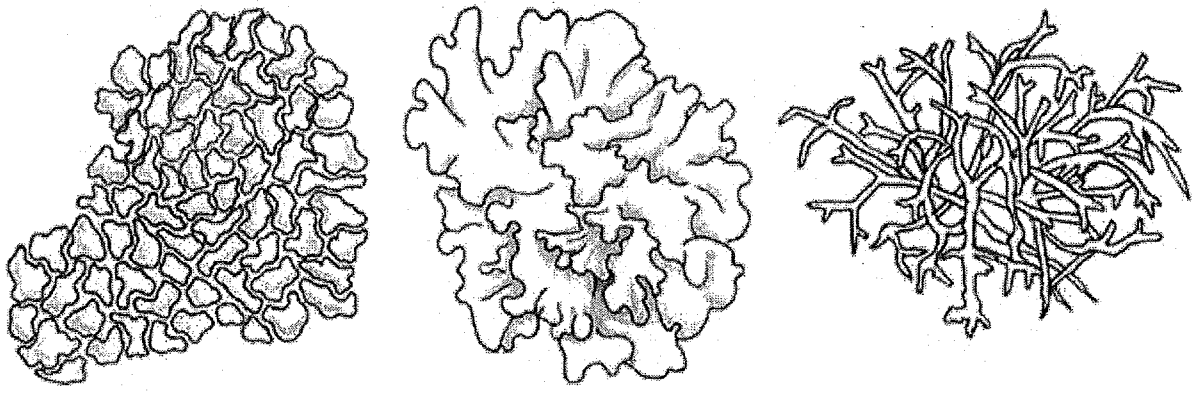


Fig. 4-11 The three general types of lichens: crustose (A), foliose (B), and fruticose (C).

Pioneer mosses usually invade the area at this stage. They grow in clumps which help develop the soil by trapping wind-blown earth and organic matter. Soil continues to build as mosses and lichens die and decay.

Fruticose lichens like *Cladonia*, reindeer moss, may now appear (Fig. 4-11, C). These lichens are accompanied by larger mosses. These larger plants trap still more wind-blown material. Also, their great bulk quickly builds up the organic portion of the soil. Ferns often appear at this stage if the area is moist. Then seed-bearing plants, usually hardy annual weeds and grasses, begin to grow in the area. Biennials and perennials follow. Among the perennials are grasses. By now the soil can be up to 30 cm deep on the rock. Sun-loving shrubs like the sumac can grow in this soil. They provide the environment needed by the seedlings of sun-loving trees such as poplars and white birch.

Once sun-loving trees have become established, a succession of trees follows (Fig. 4-12). In the Great Lakes region this succession often resembles that of sand dunes. It may not, however, reach the maple-beech climax stage. That's because maple and beech are not native species in those parts of the country where succession begins on bare rock.

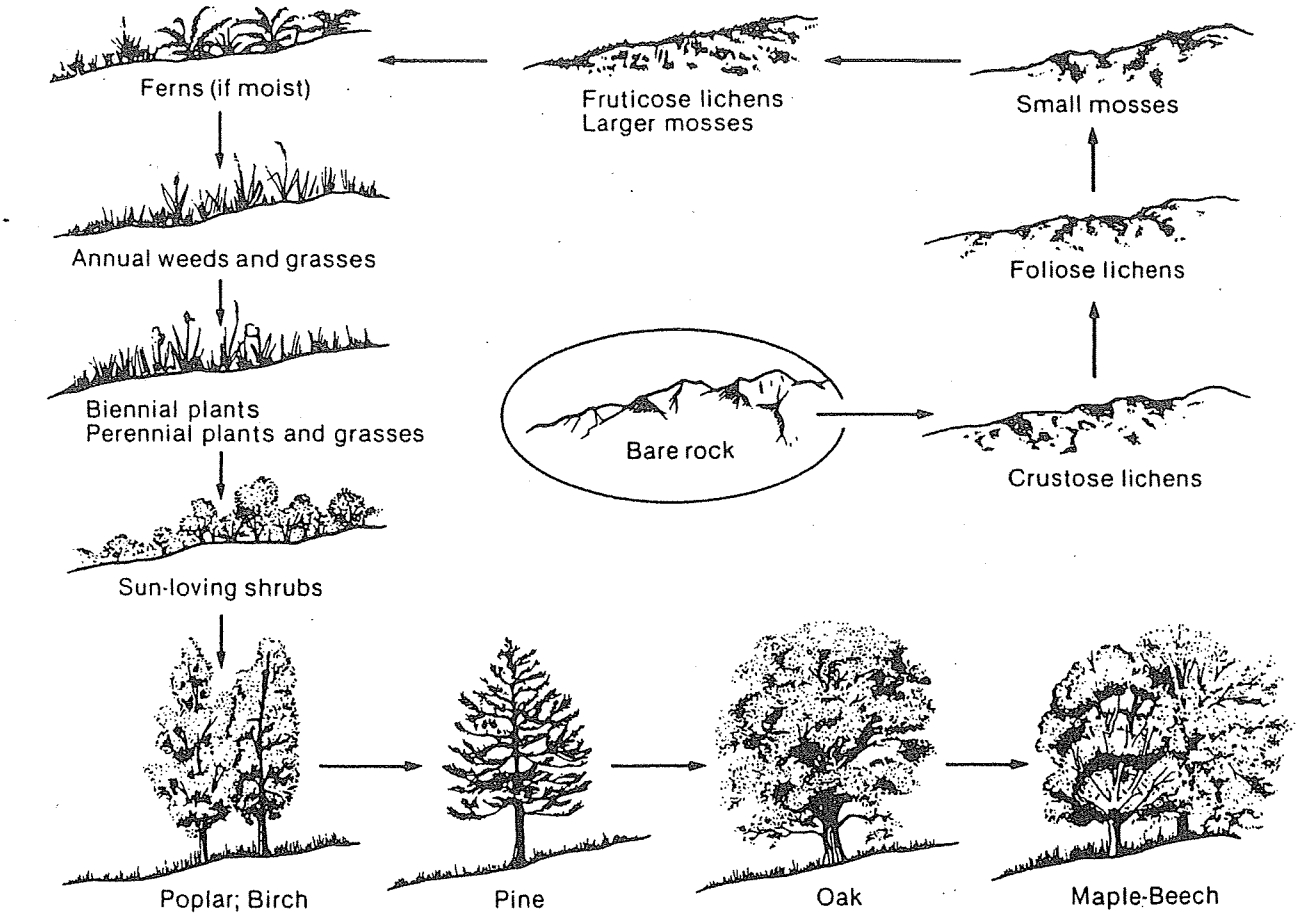
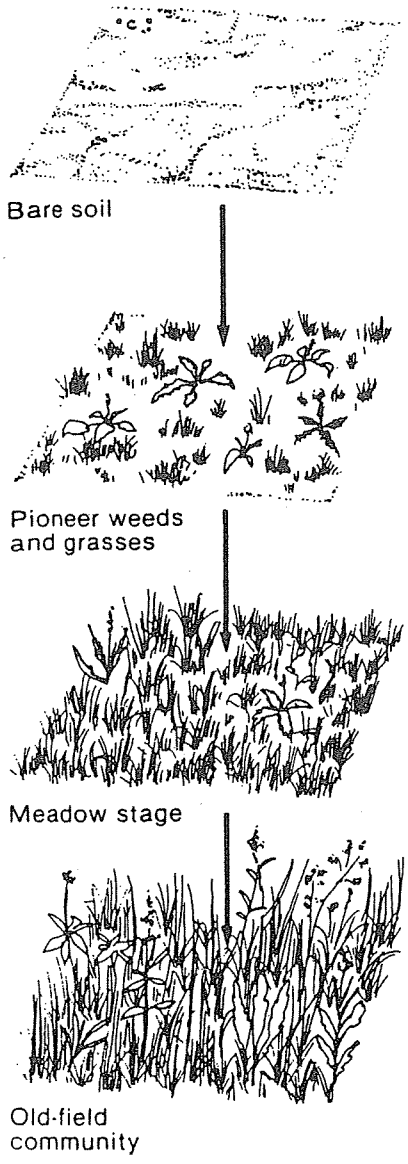


Fig. 4-12 Succession from bare rock to forest.

Succession from Bare Soil to Woodlot



The succession which occurs in bare rock or sand is a primary succession. It begins where there has been little life in recent times. Such areas have no soil. Therefore succession moves slowly in the early stages as soil is developed. In old fields and meadows, however, soil is already present. Therefore succession usually proceeds much more quickly. Let's see how this secondary succession proceeds.

Succession in the Great Lakes and mid-Atlantic Regions

Imagine that you have just cultivated a garden or field. It is completely weedfree. Then suppose you decided not to plant this garden or field after all. You are just going to let it sit untouched. What will happen?

All of us know that, in a matter of weeks, or just days, weeds will invade the garden. These **pioneers** are usually grasses and annual plants such as pigweed, ragweed, sow thistle, and lamb's quarters. Later in the season these will be joined by biennial and perennial plants such as dandelions and thistles. Often perennial grasses such as quack grass dominate the area. The area could stay in this grassy or **meadow stage** for two or three years. Usually, though, it quickly moves into a stage called an **old-field community** (Fig. 4-13). This community is dominated by biennials and perennials such as goldenrod, milkweed, asters, fireweed, cinquefoil, yarrow, and wild carrot.

Sun-loving shrubs appear in the old-field community as soon as the tall plants provide the needed environment, usually a year or so after the old-field community is established. Among the sun-loving shrubs are sumac, red osier, dogwood, and ninebark. Then sun-loving trees invade the area. Hawthorn, a shrubby tree, and apple often dominate. Soon after, however, poplars and birches move in. Then the succession follows a path similar to that on sand dunes or bare rocks and a climax forest of maple and beech stands where once there was a field or garden.

Fig. 4-13 Formation of an old-field community.

Fig. 4-6 The climax forest in much of the Great Lakes region is dominated by maple and beech trees.

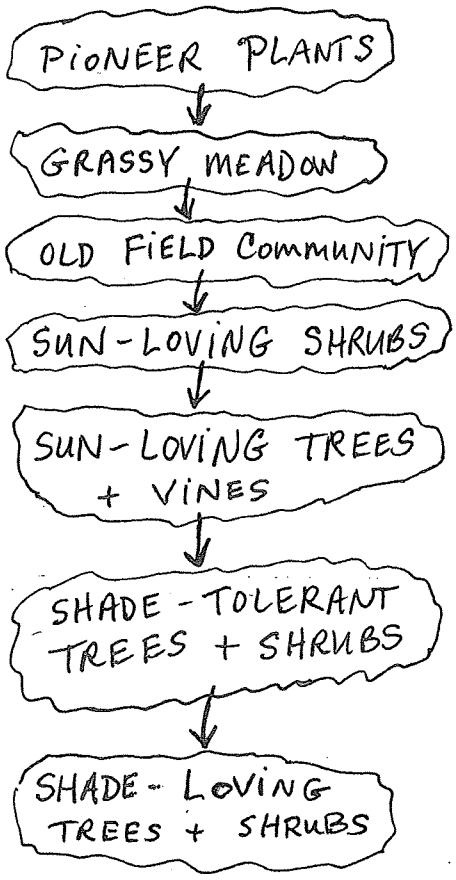


Fig. 4-14 The general path of succession. In your area, the succession may not go all the way to maple-beech climax forest because of temperature and rainfall differences.

Succession Where You Live

Secondary succession where you live may not be the same as that in the Great Lakes Region. It will probably, however, proceed along the same general path (Fig. 4-14). Just how far it goes on this path depends on where you live. In other words, climax communities may differ from place to place. Therefore the species at each stage may also differ.

If you live in the prairies, succession usually stops at the grassy meadow or old-field community stage. In wetter places, however, it may proceed to the shrub or even the poplar stage. In the St. Lawrence River valley, the climax community consists largely of white spruce and balsam fir. Minnesota has a climax community of maple and basswood. The tops of the Smoky Mountains in Tennessee and North Carolina have a climax community of red spruce and Frasier fir. The rest of those states have a pine-oak climax. Giant redwoods dominate the climax forest of California. Douglas firs and sitka spruce dominate the climax forest of British Columbia. (Douglas fir only dominates where forest fires occur frequently.) And black spruce make up the climax forest in the northern boreal forest of the United States and Canada.

All of these climax communities developed from a primary or secondary succession and all followed the same general path. Wherever you live, you are never far from an example of succession.

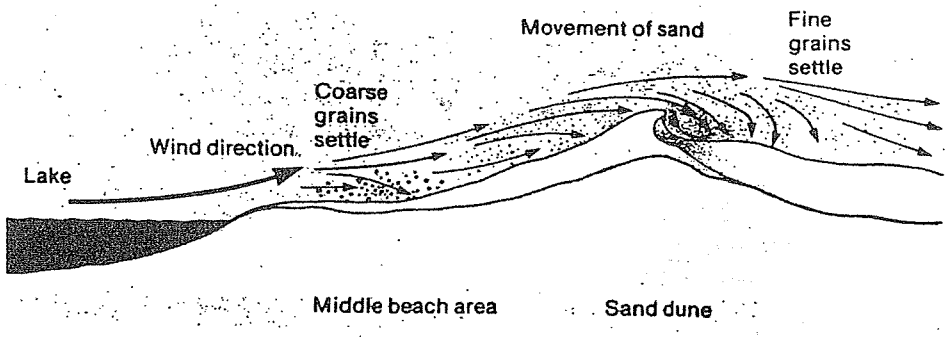
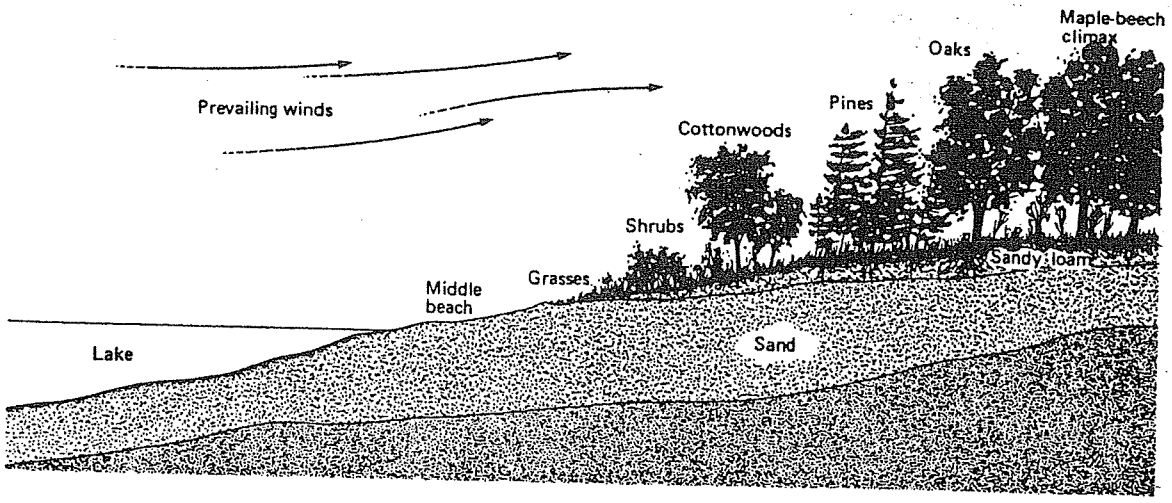


Fig. 4-7 Succession on a sand dune in the Great Lakes Region.



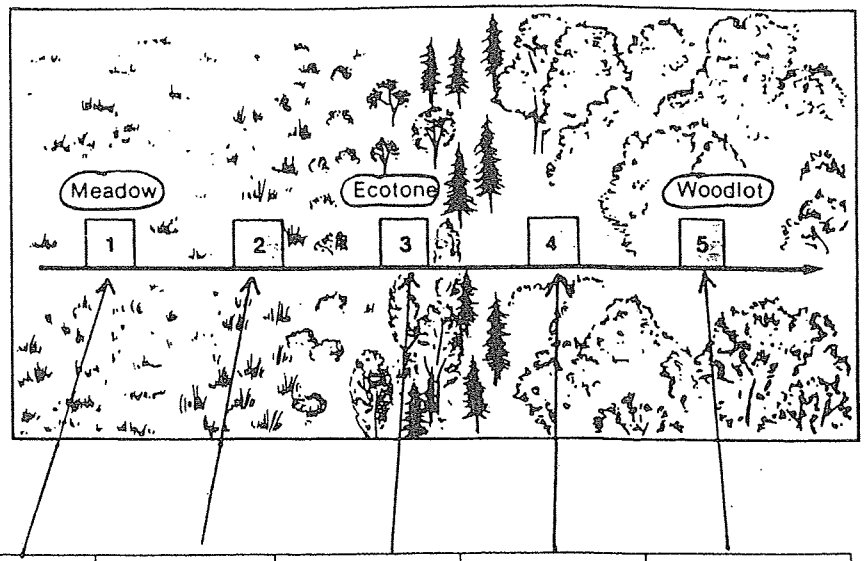


Fig. 4-15 Selection of plots for a study of secondary succession. If you can find an undisturbed meadow next to a woodlot, the plots may be located on a straight line. Put one plot in the ecotone, the region between the two communities.

Table 4-4 Secondary Succession

Factor	*Plot 1*	*Plot 2*	*Plot 3*	*Plot 4*	*Plot 5*
Air temperature (1.5 m)	26°C	26°C	25°C	22°C	22°C
Relative humidity (1.5 m)	42%	44%	51%	72%	81%
Wind speed (1.5 m)	9.5 km/h	8.5 km/h	7.0 km/h	2.2 km/h	1.8 km/h
Light intensity (1.0 m)	1300 hlx	800 hlx	180 hlx	70 hlx	51 hlx
Soil pH	7.9	7.9	7.2	7.1	7.3
Percolation rate	0.2 L/min	0.3 L/min	0.4 L/min	0.9 L/min	1.2 L/min
Undecomposed litter	3.0 cm	5.0 cm	7.5 cm	11.0 cm	15.0 cm
Decomposing litter	0.0 cm	0.5 cm	2.5 cm	3.5 cm	5.0 cm
Humus	15 cm	17 cm	20 cm	29 cm	32 cm
Soil temperature (2 cm)	31°C	31°C	26°C	22°C	22°C
Soil organic content	3.0%	3.2%	3.8%	4.2%	4.8%
Grass plants/m^2	38	19	2	0	0
Aster plants/m^2	0	3	0	0	0
Goldenrod plants/m^2	1	5	1	0	0
Cottonwood trees/100 m^2	0	0	4	0	0
Pine trees/100 m^2	0	0	2	3	0
Bracken ferns/100 m^2	2	35	3	0	0
Oak ferns/100 m^2	0	0	0	10	14
Maple trees/100 m^2	0	0	0	0	4
Earthworms/m^2	81	90	61	50	135
Sow bugs/m^2	0	0	2	18	31
Millipedes/m^2	0	0	1	6	17
Web-building spiders/10 m^2	1	3	5	8	12