RADIAL MAT GROWTH ON CEDAR CREEK BOG, MINNESOTA

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Abstract. A bog mat surveyed in 1934, and at irregular intervals since, was reexamined in 1967. After 33 years the position of the margin of the mat was essentially unchanged, but the width of the zones had changed. The *Decodon* on the aquatic margin had increased slightly, and the larch-shrub zone had expanded outward, greatly reducing the sedge mat. The indications are that the concentric zones surrounding open water expand and contract under changing conditions, principally fluctuating water levels.

INTRODUCTION

Lake-bog filling is a widely used example of ecological succession because of the spatial correlation of concentric zones with historical sequences. Unfortunately, measures of actual rates of succession are few except for long-term estimates based on organic matter accumulation since deglaciation. Leisman (1953, 1957) has provided direct measures of rates of vertical accumulation on bog mats, but less is known about radial growth. This paper describes a direct measure of radial growth over a 33-year period.

METHODS

The senior authors established a permanent transect in 1934 from an upland bench mark to the water's edge of Cedar Bog Lake, Cedar Creek Natural History Area, Anoka Co., Minn. This transect crossed four vegetational zones: a cedar bog forest dominated by *Thuja occidentalis* L., a pioneer larch (*Larix laricina* (Du Roi) Koch) and shrub zone, a sedge mat dominated by *Carex filiformis* L. and *Dryopteris thelypteris* (L.) Gray, and a pioneer mat zone composed of swamp loosestrife (*Decodon verticillatus* (L.) Ell.) along the water's edge (Buell and Buell 1941). Vegetational zonation and surface-level fluctuations were recorded from 1934 to 1936, and again in 1939. Zonation was reexamined in 1947, 1948, and 1967. In 1967 increment borings were extracted 30 cm from the ground from three larch trees of more or less the same size. Two trees (6 and 8.5 inches dbh) were located on the outer edge of the larch-shrub zone, and one (7 inches dbh) was located 24 m within this zone.

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RESULTS

The locations of vegetational zones relative to the benchmark from 1934 to 1967 are shown in Fig. 1. In spite of the rapid growth of 1 m in 5 years between 1934 and 1940 noted by Lindeman (1941), the distance to the water's edge in 1967 was virtually the same as at the beginning of the 33-year period. The inner edge of the

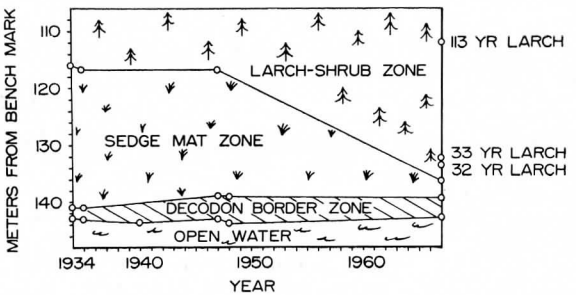

FIG. 1. Changes in the borders of the bog mat and vegetation zones of Cedar Creek Bog between 1934 and 1967. Lines demarcating zones are merely connections of measured points through time and are not intended to portray probable fluctuations between measurements, or the actual nature of zone invasion. The measure to water's edge in 1940 was made by Lindeman (1941).

Decodon zone has moved slightly inland so this zone is wider in 1967 than in 1934 but narrower than in 1947. At the water's edge, sections of *Decodon* mat were found in various stages of detachment and being moved into deeper water.

The sedge zone has been greatly reduced by the increase in width of the *Decodon* zone in small part, but chiefly by expansion of the larch-shrub zone outward.

The border between the larch-shrub zone and cedar bog forest was indistinct and could not be exactly measured, but it appeared that there may have been some landward extension of the larch-shrub zone through deterioration of the cedar forest.

Increment borings taken from larch trees near the larch-shrub border (132.5 m and 133.5 m) showed 33 and 32 annual rings respectively. Thus, at the time of the 1947 observations, these trees were pioneer saplings on the sedge mat. The vegetation adjacent to these trees was clearly dominated by shrubs, particularly speckled alder (*Alnus rugosa* (Du Roi) Spreng.), poison sumac (*Rhus vernix* L.), and red-osier dogwood (*Cornus stolonifera* Michx.), and by clumps of larch and paper

birch (*Betula papyrifera* Marsh.). A boring from the tree located at 112 m, within the area designated as larch-shrub in 1934, showed 113 annual rings.

Discussion

Two basic conclusions may be drawn from these results. (1) The bog mat has not shown any net growth along the radius studied. (2) The larch-shrub zone has advanced outward at the expense of the sedge zone. These conclusions suggest that lake-bog succession does not proceed through an orderly development of vegetation zones. The process may, in fact, be quite irregular with long periods of equilibrium. Our observations in this respect support the conclusion of Conway (1949, p. 185) based on other types of evidence in northern Minnesota.

Radial mat growth is likely to be similar to that of a glacier: it is the net difference of growth and erosion. Erosion may result from wave action, animal activity, and ice shove. These, in turn, are related to water depth, exposure to prevailing winds, and lake size. Very often lake-bog filling begins first in bays so that the original irregular outlines of the lake tend to become rounded. The edges of mats along bay mouths are constantly trimmed by erosion so that mat extension may be negligible for centuries even though actual plant growth is rapid.

Since Cedar Bog Lake is small (approximately 100 by 200 m), shallow, and fairly well protected from wind, erosional processes ought to be minimized. However, the break-up of the *Decodon* at the edge of the mat indicates that, even in this lake, mat erosion has been sufficiently severe between 1940 and 1967 to equal plant growth.

Without radial growth the sedge zone could not grow outward, and expansion by the larch-shrub zone decreased the area formerly occupied by sedges by 20 m. This suggests that the concentric zones surrounding open water do not maintain a constant width as the lake fills, but expand and contract under changing conditions. We feel that fluctuating water levels and, indirectly, climatic changes may have been the most important variables.

The climate of Minnesota was unusually dry in the 1930's (Baker, Haines, and Strub 1967), and lakes became distinctly shallower than normal. The senior authors have described Cedar Bog Lake in the fall of 1934 as having shrunk to a small, shallow pool about one-half to three-quarters its original size (Buell and Buell 1941). Possibly this dry period favored radial mat growth, perhaps due to a minimization of erosion. Under these conditions the sedge zone may have grown at a faster rate than the larch trees and expanded outward. As the water table rose, the growth rate of the sedge zone decreased and became, in fact, negative until now it is in nearly the same position in which it was found in 1934, although much narrower. Meanwhile, the shrubs and larches have continued to advance well out on the sedge mat so that the differential growth rate of this zone has been greater than that of the sedge mat.

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