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ABSTRACT: The bog meadow association, a fen at Cedar Bog Nature Preserve in W-central Ohio, was studied to determine the short range establishment potential of woody species, especially arbor vitae *(Thuja occidentalis)*. The presence of numerous arbor vitae seedlings and saplings, a 54% winter survival rate of seedlings, and possible invasion of the meadow by peripheral arbor vitae via branch-layering suggest that this tree species is invading the bog meadow. This vegetation change is thought to be recent and indicates succession of the bog meadow toward an arbor vitae forest. Active management of the vegetation in the preserve is recommended to maintain the bog meadow association as an herb-dominated fen.

INTRODUCTION

Cedar Bog Nature Preserve, Champaign Co., Ohio, contains a 20-ha relict of what was formerly a 2800-ha complex of wetlands and forest in W-central Ohio. Many of the plant species in the preserve occur S of their normal range, and Braun (1950) considered Cedar Bog to be the most southerly of the well-preserved bog remnants in North America. It is the only remaining alkaline fen in Ohio (Forsyth, 1974). As such, the area is an important relict of the rapidly disappearing northern wetlands.

Frederick (1974) identified six plant associations in the preserve: bog meadow, marl meadow, arbor vitae, swamp forest, shrub and hardwood forest. The most ubiquitous tree species is arbor vitae (*Thuja occidentalis*[1]) which is present in all associations except the hardwood forest. Frederick (1974) found small arbor vitae trees growing on many of the larger hummocks near the margins of the bog meadow. Braun (1928) hypothesized that portions of Cedar Bog were undergoing succession from bog meadow through an arbor vitae stage, and eventually developing into hardwood forest. If this is true, arbor vitae should be successfully invading "treeless" associations such as the bog meadow.

The soil of the bog meadow association is an alkaline, wet marl resulting from groundwater which surfaces after passing through dolomitic glacial deposits (Forsyth, 1974). Therefore, this association is correctly classified as a fen, a type of vegetation which has been considered a precursor to bog and swamp forest communities (Moore and Bellamy, 1974). The meadow contains closely spaced hummocks of low elevation ($<$ 0.5 m high) and 0.5-1.5 m in diam, which produce microenvironmental gradients from wet marl between hummocks to *Carex-Sphagnum* covered hummock tops. Invasion and establishment of woody species may be related to the microenvironmental gradients associated with these hummocks.

The purposes of our study were to: (1) describe the woody vegetation in the bog meadow association; (2) evaluate the potential increase of woody species, especially arbor vitae, in the meadow, and (3) relate distribution of woody species to microtopographic position.

MATERIALS AND METHODS

Six belt transects 2 m wide and varying in length from 7.5-45 m were located

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[1] Nomenclature follows Weishaupt (1971).

perpendiclar to Cedar Run Creek which traverses the bog meadow. The transects were divided into a total of 60 2 x 2.5 m contiguous quadrats. All woody individuals were recorded as present and trees were recorded by size class: seedling, ≤30 cm tall; sapling, >30 cm tall and ≤10.2 cm dbh; and trees, >10.2 cm dbh. Frequency was determined for all woody species and for individual size classes of tree species.

Microelevation, soil *p*H and soil temperature were measured along transects 2 (27.5 m long) and 5 (30.0 m long) in July 1976 to determine relationships between these parameters and vegetation. Microelevation was measured with a topograph (Boorman and Woodell, 1966), using the east bank of Cedar Run as a base line. Elevations were recorded at 10-cm intervals along each transect. Soil *p*H (15-cm depth) and temperature (15- and 30-cm depths) were measured at 1-m intervals along the two transects. Correlation analysis was used to determine significant relationships between the soil parameters and microelevation.

Invasion and survival of tree species in the bog meadow were estimated by presence and topographic location of young tree seedlings. Six 1 m^2 quadrats (each approximately the size of a hummock) were established in the bog meadow in September 1976. Each quadrat was centered on a hummock (with at least some tree seedlings) nearest a randomly selected point. All seedlings were identified and mapped to provide data for measurement of winter survival. The elevational position of arbor vitae seedlings was measured with the topograph relative to the lowest point in each sample quadrat. The quadrats were resampled in April 1977 to determine seedling survival relative to microelevation. Relationships between microtopography and arbor vitae seedling survival were determined by regression analysis.

RESULTS

Woody vegetation. — The woody vegetation of the meadow contained 11 species, five of which had a total frequency of 25% or greater (Table 1). Few woody species had individuals in more than one size class, except arbor vitae which had individuals in all size classes. Its seedlings and saplings were found in over half of the quadrats. Tulip tree *(Liriodendron tulipifera)* had seedlings in 68% of the quadrats, saplings in 5%, but no tree-sized individuals. Red maple *(Acer rubrum)* had seedlings in 25% of the quadrats, but no saplings or trees.

Transect 2 increased 95 cm in elevation from the stream edge to the E end of the transect near a hardwood forest. Soil temperatures ranged from 15.5-17 C and 14-15 C, at 15 and 30 cm depth, respectively. They showed no significant differences in relation to either elevation or distance from the stream (Table 2). However, soil *p*H decreased significantly (6.8 to 6.2) with increasing elevation and distance from the stream, suggesting that as distance from soil surface to water table increases, *p*H is less influenced by the alkaline groundwater.

Woody vegetation in transect 2 changed slightly with elevation and distance from the stream. No red maple or arbor vitae seedlings were observed in the last 15 m of the transect, and no tulip-tree seedlings were recorded in the last 7.5 m. One large arbor vitae tree (16.8 cm dbh) and individuals of hardwood forest species such as sugar maple *(Acer saccharum)* and hop hornbeam *(Ostrya virginiana)* were recorded at the higher E end of the transect. Finally, shrubby cinquefoil *(Potentilla fruticosa)* was generally absent from the highest elevations of the transect. These vegetation changes appear to be associated with the increase in microelevation along this transect since the mesic hardwood species were found only in the highest portions of the transect.

In contrast, the eastern edge of transect 5 (adjacent to an arbor vitae stand) was only 27 cm above the stream edge; the highest elevation (51 cm) occurred 6-7 m from the beginning of the transect. Soil *p*H tended to decrease (6.6 to 5.8) with distance from the stream (Table 2), but no correlations were significant at the $\alpha = .05$ level. The vegetation was similar throughout this transect. However, two medium-size arbor vitae (12.8 and 9.5 cm dbh) were growing at the eastern edge of the transect, and shrubby cinquefoil was again absent in the region of highest elevation. In general, woody plants were most commonly found on hummocks, except red maple which primarily occurred in the wet marl between hummocks.

Hummock elevation-seedling relationships.—Seedlings of three species were found in the bog meadow in seedling-survival study samples. Thirteen tulip-tree seedlings were counted in the 1 m² quadrats in September 1976, and none were alive the following April. Only one of four red maple seedlings survived the winter. However, 46 arbor vitae seedlings occurred in the quadrats in September, and 54% survived until April. The total number of arbor vitae seedlings found in September decreased significantly from the bottom to the top of a hummock (Fig. 1a). However, percent survival in the following spring showed no relationship with microelevation (Fig. 1b). Therefore, germination is related to location on a hummock, perhaps simply the greater surface area of lower elevations, whereas survival is random with regard to elevation.

DISCUSSION

The presence of numerous arbor vitae seedlings and saplings, 54% winter survival rate of seedlings, and potential encroachment by peripheral arbor vitae via branch layering (Collins, 1977) suggest that the bog meadow is being invaded by this tree species. Successional studies based on a single year's data are faced with the alternative explanation for the presence of tree seedlings in that they form a natural, transitory part of the community. Braun (1928), Forsyth (1974) and Frederick (1974) provide evidence for arbor vitae presence in the bog meadow representing a successional trend.

TABLE 1.—Frequency (%) of woody species in the bog meadow

Species	Total	Size class[a] Seedling	Size class[a] Sapling	Size class[a] Tree
Potentilla fruticosa	90.0			
Thuja occidentalis	85.0	56.7	71.7	8.3
Liriodendron tulipifera	68.3	68.3	5.0	0
Betula pumila	68.3			
Acer rubrum	25.0	25.0	0	0
Rhus vernix	10.0			
Lindera benzoin	3.3			
Acer saccharum	1.7	0	1.7	0
Ostrya virginiana	1.7	0	1.7	0
Carpinus caroliniana	1.7	1.7	0	0
Quercus bicolor	1.7	1.7	0	0

[a]Tree species only

TABLE 2.—Correlation coefficients (R^2) for soil temperatures and *p*H compared with microtopography in transects 2 and 5

Microtopography	Correlation coefficients: Temperature 15 cm	Temperature 30 cm	*p*H
Transect 2			
Average elevation/quadrat	.051	.046	+.853**
Distance from stream (m)	.124*	.028	+.941**
Transect 5			
Average elevation/quadrat	.035	.018	+.741
Distance from stream (m)	.009	.000	+.870*

*Differs at the $\alpha = .1$ level
**Significant at the $\alpha = .05$ level

Dachnowski (1910, 1912) did not include arbor vitae in either his species' list or description of the bog meadow. Also, he found arbor vitae logs preserved in soil cores underneath the arbor vitae forests, but not under the bog meadow. Presumably, then, these changes in the composition of the bog meadow vegetation are of recent origin since the relict plant communities of the preserve have existed since the last glacial epoch (Forsyth, 1974).

Many natural factors such as ground water flow, nutrient levels and fire have contributed to the maintenance of the vegetation associations in the preserve. However, these factors have been altered by man's activities. Prior to the acquisition of Cedar Bog by the State of Ohio in 1941, streams were dredged, some arbor vitae were cut and fires were used to clear and maintain pastures (Clark County Audubon Society, 1972).

Dredging of streams associated with Cedar Bog to improve drainage occurred in the early 1900s and lowered the water table. Depth to the water table has been reported

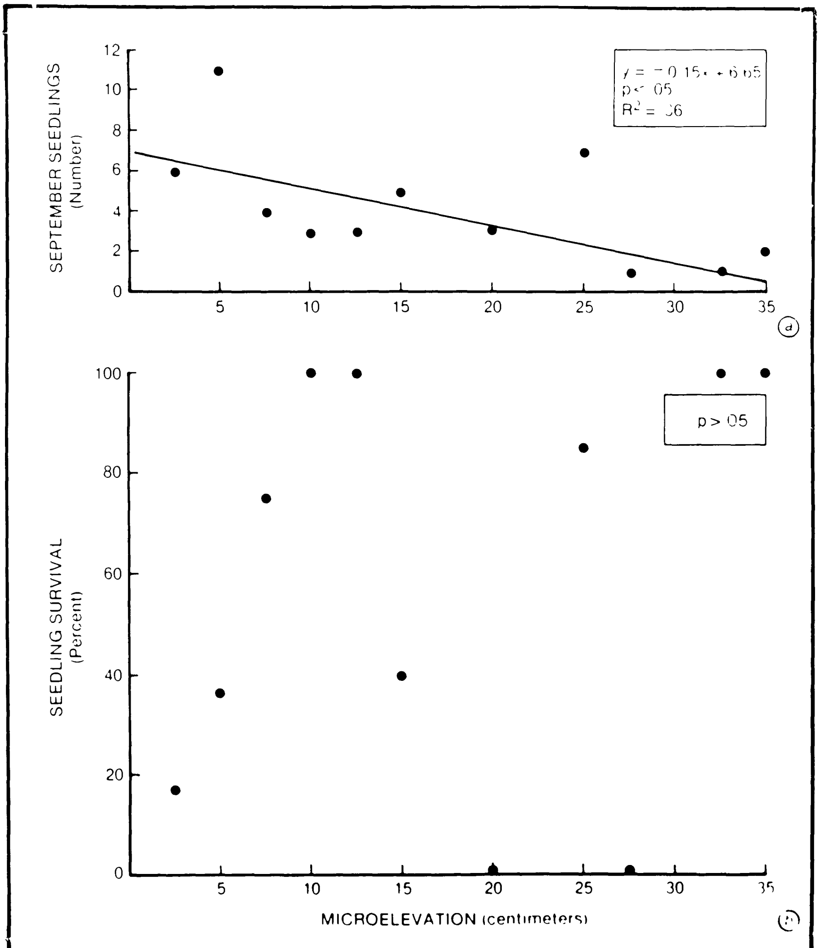

Fig. 1.—The relationships between the initial autumn seedling number (a) and the number of seedlings surviving until spring with regard to microelevation are shown. Only the initial distribution shows a significant relationship

as an important factor affecting changes in wetland vegetation (van der Valk, 1981). Our detailed study of two transects indicated that bog meadow vegetation generally occurred on wet lower-elevation soils; while adjacent forest stands occupied slightly higher elevations. Isaac *et al.* (1959) and Beals (1965) reported that a rise in the water table resulted in retrogression in northern bogs. Further changes in groundwater conditions in the vicinity of Cedar Bog may affect successional patterns in the bog meadow as well as other associations in the preserve (Collins *et al.,* 1979; Forsyth, 1974).

Unfortunately, little is known about the influence of natural fires on bog and fen vegetation. Curtis (1959) hypothesized that fire preserved the grassy fens of Wisconsin, and Erman (1976) reported that fire may have been involved in regenerating Sierra Nevada fens. Since small arbor vitae are susceptible to fire damage (Fowells, 1965), it seems likely that fire may have been an important factor in keeping the bog meadow association free of tree-size arbor vitae.

We conclude that unless measures are taken to limit the establishment of arbor vitae, the unique bog meadow vegetation may eventually be replaced by an arbor vitae forest. If arbor vitae continues to increase, experimentation with flooding, burning and cutting may be necessary to develop a management plan to maintain the bog meadow as an herb-dominated fen.

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LITERATURE CITED

BEALS, E. W. 1965. An anomalous white cedar-black spruce swamp in northern Wisconsin. *Am. Midl. Nat.,* **74**:244.

BOORMAN, L. A. AND S. R. J. WOODELL. 1966. The topograph, an instrument for measuring microtopography. *Ecology,* **47**:869-870.

BRAUN, E. L. 1928. Glacial and post-glacial plant migrations indicated by relict colonies of southern Ohio. *Ibid.,* **9**:284-302.

______. 1950. Deciduous forests of eastern North America. Blakeston Press, Philadelphia. 596 p.

CLARK COUNTY AUDUBON SOCIETY. 1972. A Cedar Bog report. II. 160 p. Springfield, Ohio.

COLLINS, S. L. 1977. Tree species dynamics in the arbor vitae community of Cedar Bog, Champaign County, Ohio. M.S. Thesis, Miami University, Oxford, Ohio. 47 p.

______, J. S. VANKAT AND J. V. PERINO. 1979. Potential tree species dynamics in the arbor vitae association of Cedar Bog, a west-central Ohio fen. *Bull. Torrey Bot. Club,* **106**:290-298.

CURTIS, J. T. 1959. The vegetation of Wisconsin. Univ. Wisconsin Press, Madison. 657 p.

DACHNOWSKI, A. 1910. A cedar bog in central Ohio. *Ohio Nat.,* **11**:193-199.

______. 1912. Peat deposits of Ohio. Geological survey of Ohio. *Fourth Series, Bull. 16.* 424 p.

ERMAN, D. C. 1976. Peat depth of Sierra Nevada fens and profile changes from 1958 to 1972 in Mason fen. *Great Basin Nat.,* **36**:101-107.

FOWELLS, H. A. 1965. Silvics of forest trees of the United States. *U.S. Dep. Agric. Agric. Handb. 271.* 762 p.

FORSYTH, J. S. 1974. Geologic conditions essential for the perpetuation of Cedar Bog, Champaign County, Ohio. *Ohio J. Sci.,* **74**:116-125.

FREDERICK, C. M. 1974. A natural history survey of the vascular flora of Cedar Bog, Champaign County, Ohio. *Ibid.,* **74**:65-116.

ISAAC, D., W. H. MARSHALL AND M. F. BUELL. 1959. A record of reverse plant succession in a tamarack bog. *Ecology,* **40**:317-320.

MOORE, P. D. AND D. J. BELLAMY. 1974. Peatlands. Springer-Verlag, New York. 221 p.

VALK, A. G. VAN DER. 1981. Succession in wetlands: a Gleasonian approach. *Ecology,* **62**:688-696.

WEISHAUPT, C. G. 1971. Vascular plants of Ohio, 3rd ed. Kendall/Hunt Publishing Co., Dubuque, Iowa. 292 p.

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