Dissolved oxygen generally remained at high levels throughout the lake. It lingered at or near 100 per cent saturation most of the year. Oxygen depletion occurred at six of the locations. However, this condition was restricted to the waters within 20 feet of the bottom and persisted for only a two or three month period during late summer and fall. The water within 15 feet of the surface was never observed to have a dissolved oxygen concentration lower than 6 ppm and values which indicated supersaturation were recorded at transects 1 through 5.

Oxygen and temperature display a very close relationship. Water temperature is a major factor in determining the amount of oxygen that can be dissolved in natural waters at any one time. However, the association with oxygen is only one of the ways in which water temperature influences the aquatic community. It largely governs the physiological and reproductive activities of aquatic organisms, and may even restrict their distribution. Above 4° C, an increase in temperature causes a decrease in water density. The warming of the surface waters in a lake can cause differences in density great enough to prevent mixing. The resulting thermal stratification generally consists of a warm upper layer separated from a cool stagnant bottom layer by a middle layer of sudden temperature change. The stratification that was observed in Dale Hollow fits the general description given by Gerking (1963) for large multipurpose impoundments in the central states. Summer stratification occurred, but winter bottom temperatures remained near 10° C, and no winter stratification was observed. This is characteristic of a monomictic lake (Ruttner, 1963). The degree of summer stratification differed among the transects. At the shallow transects, such as the East and West Forks of the Obey, stratification involved only a small change in temperature and was not persistent. The deeper transects showed a much greater range in temperature which persisted for several months (Figure 4). Stratification is characteristic of lakes having relatively large inflows and outflows. The metalimnion is frequently more than 20 feet wide, and the thermal gradient in the hypolimnion is not too steep (Neel, 1963).

Dale Hollow, like most multipurpose dams, has multilevel outlets. This introduces the possibility of the formation of widespread and persistent density currents (Gerking, 1963). This could be one explanation for the erratic dissolved oxygen profiles that were observed at some transects. Thermal distribution among the transects at any given time showed some variation. Figure 5 illustrates thermal distribution throughout the reservoir during February, April, July, and October. These months were considered representative of the seasonal changes which occurred. One obvious variation in thermal distribution was the apparent increase in depth of the metalimnion as the deep waters nearer the dam were encountered. Measurements of the water also indicated that summer temperatures at transect 6 were higher than at any other transect.

SUMMARY

The surface waters of the Wolf River embayment were several degrees warmer during the summer than the waters of the other two regions. Thermal stratification first appeared during March and persisted through October and November. Stratification at transects 1, 2, and 6 was not as distinct or as persistent as it was at the deeper transects. The seasonal distribution of temperature was indicative of a monomictic lake.

Dissolved oxygen throughout the lake was characteristically high. Saturation was common and supersaturation was frequent. Depletion occurred only briefly near the bottom during late summer. Dissolved oxygen curves were intermediate between orthograde and clinograde. The appearance of numerous "oxygen maxima" along with uniformly high values suggests oligotrophic conditions.

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THUJA OCCIDENTALIS L. ON THE EASTERN HIGHLAND RIM IN TENNESSEE

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ABSTRACT

This is a first report of *Thuja occidentalis* L. from the Eastern Highland Rim of Tennessee. The stand is located in the extreme southern portion of Putnam County on the banks of Cane Creek in an area locally known as the Window Cliffs. The individual plants are growing in the crevices of rapidly eroding limestone near the bank of the creek with a fairly open southwesterly exposure. Implications of this range extension are discussed, especially in reference to other Tennessee locations of *Thuja* stands.

INTRODUCTION

A small colony of northern white cedar (*Thuja occidentalis* L.) was discovered in the extreme southern portion of Putnam County, Tennessee, in the winter of 1969 by the junior author. This constitutes the first discovery of the taxon from that physiographic region and the westernmost point at which it has been discovered in its disjunct southern range.

The colony is growing near the edge of Cane Creek (not to be confused with the Cane Creek in the Fall Creek Falls State Park area) on and at the base of a rapidly eroding limestone cliff known as the Window Cliffs. The exposure is southwesterly. An increment boring of the largest individual indicated that it was somewhat over fifty years old. Close examination revealed that the individual from which the boring was made was, in fact, derived from a branch of a tree which had fallen and was partly deteriorated so that the parent tree is of an indeterminable age, but has obviously been established for a considerable period of time. This fact and the location of the trees in the crevices of a rocky cliffside indicate the stand as native rather than introduced.

DISCUSSION

Thuja occidentalis is a distinctly northern species with a center of distribution in southeastern Canada. The southwestern limit of its continuous distribution is in northern Indiana near Chicago (Little, 1971). It extends southward along the Appalachian Mountains and in Ohio in a somewhat disjunctive pattern (Little, 1971). The known southern limit of its present distribution is immediately east of the Cane Creek Falls at Fall Creek Falls State Park in horizontal crevices in a north-facing conglomerate sandstone cliff.

The species appears to be sensitive to human disturbance in the south since native populations have disappeared from all the original sites known in North Carolina (Coker and Totten, 1937; Radford, Ahles, and Bell, 1964).

Colonies of *Thuja* are relatively common in Sullivan, Washington, Hancock, Campbell, and Anderson Counties in Tennessee (Shanks, 1952). It has now been reported from these counties, plus Roane, Van Buren, and Union (Jennison, 1935). Until the discovery of a colony at Fall Creek Falls State Park in 1950, the southern limit of native distribution was believed to be on the bluffs of the Emory River near Harriman in Roane County, Tennessee (Shanks, 1952).

Near the center of its distribution, *Thuja* appears in a variety of habitats (Cowles 1901). In the Chicago region it was confined to undrained swamps and dune cliffs, interpreted by Cowles (1901) to be the most pronounced xerophytic habitats in that region. Further south, colonies of *Thuja* have been usually associated with bogs or limestone outcrops (Braun, 1950). In Campbell County, Tennessee, all collections which indicate edaphic conditions note dolomite or limestone as the substrate (Evans, 1969). The nature of habitats in which *Thuja* occurs at its southern and southwestern limits introduces some pertinent questions particularly in light of the widely accepted principle that species near their areal limits can grow only in those plant societies which resemble most closely those related to the climatic features at the distribution center (Cowles, 1901). The southern sites in Tennessee are, at least superficially, quite different. The colony at the Fall Creek Falls area is growing in conglomerate sandstone on a cliffside with such northerly exposure that it may never be subject to direct insolation. The colony at the Window Cliffs grows in a limestone substrate in a cliff which faces southwest and is thus exposed to direct insolation throughout the afternoon. Three superficial environmental aspects are similar: (1) both colonies are associated with streams, (2) both colonies are associated with gorges, and (3) both colonies are situated on cliffs. Since the colony at the Fall Creek area is too far removed from the stream to allow a direct effect of the stream upon the water supply, the only obvious commonality of placement lies in the crevices of rocks. Such a situation is environmentally ambiguous, since cliffsides can be either very dry habitats, or, due to the percolation of water, can provide copious moisture to the roots of plants. Ecologically, what the two sites have in common is that both are generally unfavorable for the growth and the common plants of the area and are, therefore, habitats which afford little competition for the established *Thuja*.

It is possible that the concept of the calciphilic tendency of *Thuja* should be re-examined in view of the fact of its growth at the extreme edges of its range in the sandstone at Fall Creek Falls and in bogs and dune cliffs in northern Indiana. None of these habitats is calcareous.

If *Thuja* is a relict in Tennessee, as it must be assumed to be, it has outlasted two drastic epochs; one was very cold (with alternate warming periods), and one was markedly more xeric than at present. The present southern habitats of *Thuja* are very different from those of most other northern relicts (e.g., *Sambucus pubens, Oxalis acetosella, Acer pensylvanicum*) which in their southern limits are uniformly in protected areas of gorges or at high elevations. These and other aspects of *Thuja* distribution indicate either a highly variable genotype or a species very tolerant of diverse habitats. The key to the enigma of the southern distribution of disjunct colonies of *Thuja* is not simple. Their survival seems more related to the fact that they can continue to exist locally in habitats generally unsuited for competitiors than to any other factor.

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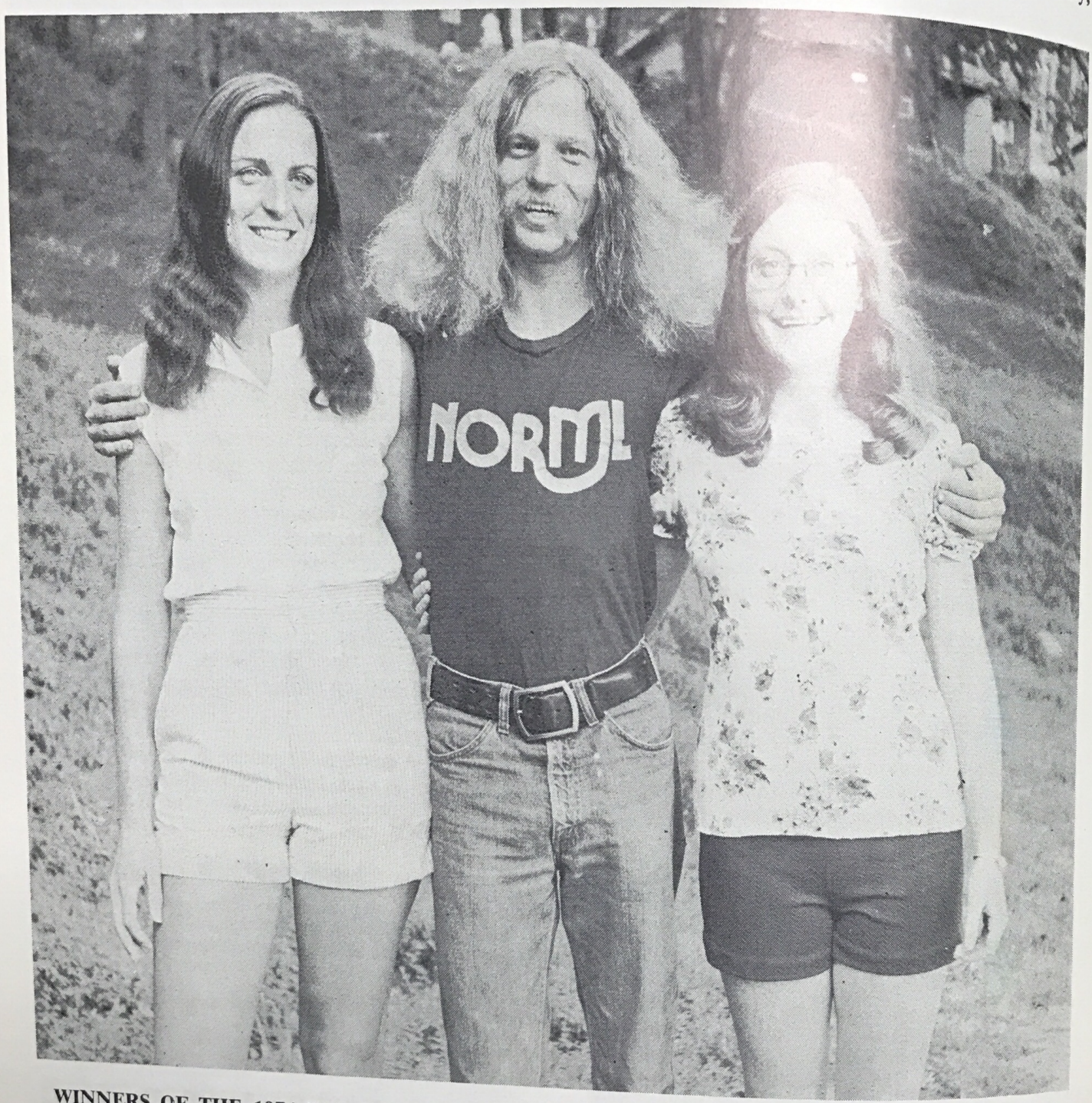

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