Subfossils of the Boreal Mosses *Calliergon trifarium* and *Meesia triquetra* in an Indiana Peatland[1]

ANTHONY L. SWINEHART[2], Department of Biology, Central Michigan University, Mount Pleasant, MI 48859

ABSTRACT. Analysis of peat cores extracted from Tamarack Bog, section 7, Noble Township, Noble County, IN, revealed the first recorded subfossils of the boreal mosses *Calliergon trifarium* (Web. & Mohr.) Kindb. and *Meesia triquetra* (Richt.) Aongstr. from the state of Indiana. The paleo-environment was characterized as a mineral-rich fen. Local extirpation was attributed to natural acidification. The regional distribution of these two species, since glaciation, has receded northward to the northern lake states. Both species are now extirpated in Indiana.

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INTRODUCTION

The mosses *Calliergon trifarium* (Web. & Mohr.) Kindb. and *Meesia triquetra* (Richt.) Aongstr. are calciphiles usually restricted to fens (H. A. Crum, personal correspondence). In the Midwest, they reach their southern extent in the northern Lake States. In these areas, *C. trifarium* and *M. triquetra* are considered boreal relics. Both species are rare in Michigan (H. A. Crum, personal correspondence), and in Indiana they are now extirpated.

The objectives of the present paper are to: 1) document the post-glacial occurrence of *Calliergon trifarium* and *Meesia triquetra* in Indiana, 2) reconstruct the paleo-environment in the peatland in which they lived, and 3) discuss the reasons for their disappearance in Tamarack Bog, as well as speculate on their apparent disappearance from the state of Indiana.

MATERIALS AND METHODS

Study Area

Tamarack Bog, section 7, Noble Township, Noble County, IN, is located within the boundaries of the Merry Lea Environmental Center, a 500 ha nature preserve owned and operated by Goshen College. The site occurs within the northern moraine and lake region (Fig. 1) and is associated with the interlobate area of the Saginaw and Erie Lobes of the Laurentide Ice sheet which receded approximately 13,000 years BP. This region is characterized by thousands of lakes and wetlands, most of which were created as a result of buried ice-blocks. Tamarack Bog represents one of these characteristic kettle depressions.

The original peatland community, characterized by tamarack and other "bog" species, is senescent because of drainage, *circa* 1899, and is succeeding into a red maple swamp (Swinehart 1994). Interestingly, the acrotelm remains semi-ombrotrophic. Values for pH taken from pools of standing water range from 3.5 to 4.5. Conductivity is 45 μMHOS. The composition of the understory flora is controlled by shading provided by the dense canopy of *Acer rubrum* L., *Acer saccharinum* L., and *Quercus palustris* Muenchh.

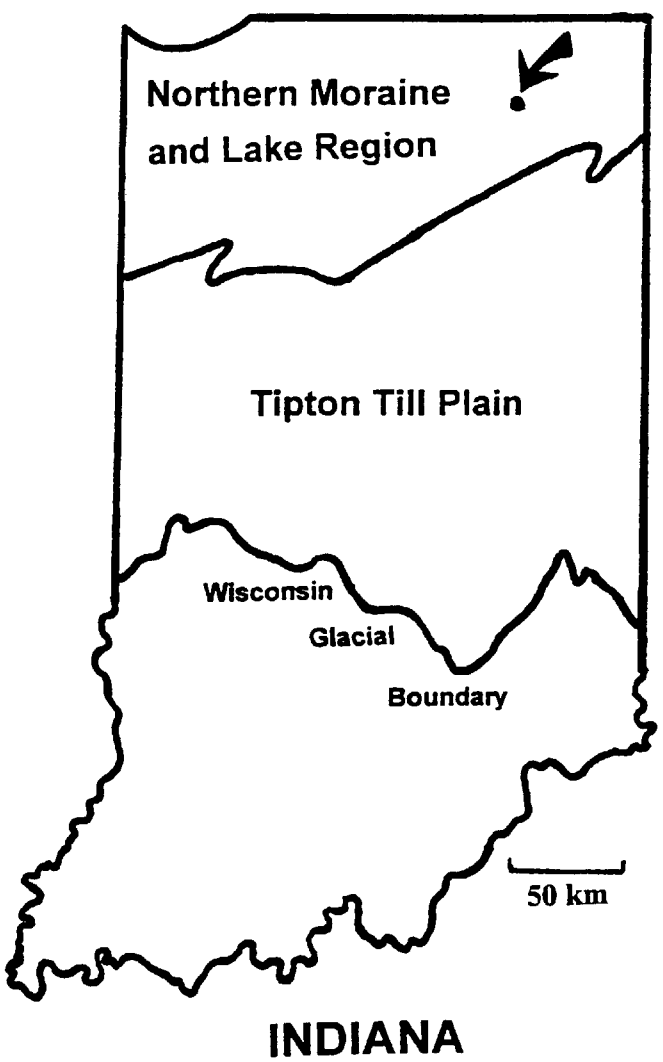

FIGURE 1. Map of Indiana showing major physiographic regions. Arrow indicates the location of the study area (Tamarack Bog).

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[2]Current Address: Purdue University, Department of Forestry and Natural Resources, West Lafayette, IN 47907

METHODS

A Hiller corer was used to obtain a profile of peat samples from the deepest sub-basin of the bog. Peat was collected at 50 cm intervals from the surface of the bog to the hardpan (clay). Peat was removed from the collection chamber of the coring device and wrapped in aluminum foil. Samples were refrigerated to hinder decomposition before analysis. The peat from each interval was placed in a sieve-series, and subfossils were sorted, identified, and preserved in formalin. Voucher specimens are held by the author.

RESULTS

The aquatic sediments in the deepest sub-basin of Tamarack Bog had a maximum depth of 10 m. Three major developmental stages were represented by the stratigraphy of the sediment. The first stage, between 5.5 and 10 m from the surface, contained equal amounts of marl, humus, and sedge remains. Stage two, occurring between the depths of 2.5 and 5.5 m from the surface, was similar to stage one. However, it was characterized by the abundance of *Calliergon trifarium* (Fig. 2). *Meesia triquetra* (Fig. 2) was an uncommon associate of *C. trifarium* in the upper part of stage two and in stage three. Stage three marked the presence and eventual dominance of *Sphagnum* peat and the elimination of marl.

In addition to mosses, the sediments in stages one and two contained achenes of *Najas flexilis* (Willd.) Rostk. & Schmidt and *Carex* spp., vegetative remains of sedges, spicules of the freshwater sponge *Anheteromeyenia ryderi* Potts, and particles of mollusc shells (Swinehart 1994). The remains were well mixed, suggesting predepositional transport from littoral margins. Sediments in stage three, unlike stages one and two, appeared to have been formed *in situ,* as subfossils of *Sphagnum* occur in articulation. Subfossil leaves of *Chamaedaphne calyculata* (L.) Moench and *Andromeda glaucophylla* Link were embedded in the *Sphagnum* peat (Swinehart 1994).

The current bryoflora of the bog is dominated by *Sphagnum*, although it has declined substantially from drainage-induced forestation. *Sphagnum palustre* L. occurs on level, saturated peat, and on hummocks, and *Sphagnum recurvum* P.-Beauv. var. *tenue* Klinggr. is found in inundated hollows and pools. Only four bryophyte taxa actually grow on exposed peat: *Sphagnum palustre*, *Sphagnum recurvum* var. *tenue*, *Pallavicinia lyellii* (Hook.) S. F. Gray (the most dominant member), and *Aulacomnium palustre* (Hedw.) Schwaegr. All are acidophiles. The remaining bryophytes found currently in Tamarack Bog (*Callicladium haldanianum* (grev.) Crum, *Mnium cuspidatum* Hedw., *Plagiothecium denticulatum* Hedw., *Rhynchostegium serrulatum* (Hedw.) Jaeg. & Sauerb., *Tetraphis pellucida* Hedw., *Thuidium delicatulum* (Hedw.) BSG, and *Lophcolia heterophylla* (Schrad.) Dumort.) grow on living or dead wood.

DISCUSSION

The paleo-environment represented by the early strata containing the moss subfossils is probably best

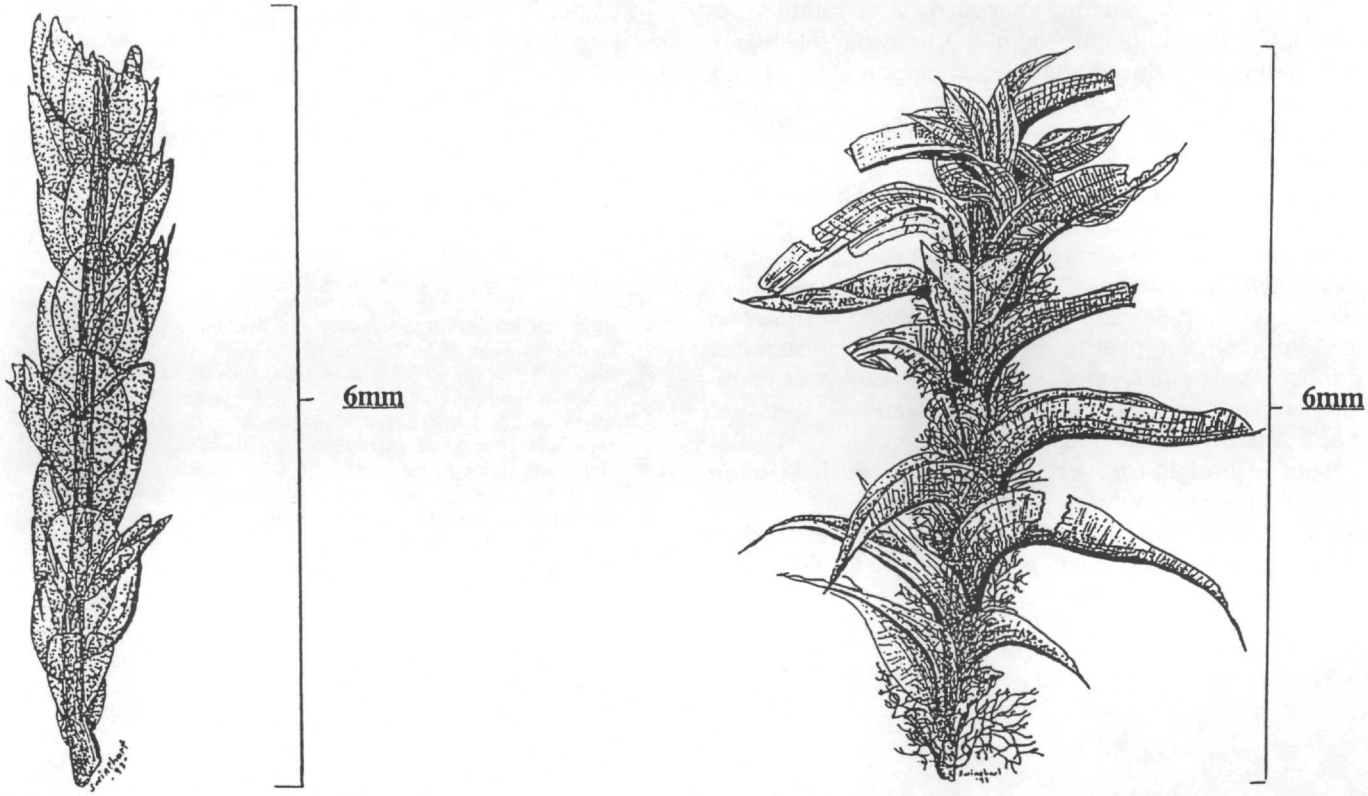

FIGURE 2. Subfossil fragments of *Calligeron trifarium* (left) and *Meesia triquetra* (right) taken from Tamarack Bog, Noble County, IN. (Illustrations by the author.)

described as a mineral-rich fen. This is evidenced by the abundance of marl and by the presence of the calciphilic mosses. The peatland was likely a marginal sedge-mat surrounding a bay on Old Bear Lake which is now extinct because of the drainage that occurred *circa* AD 1899 (Swinehart 1994). The presence of marl and mollusc shells in stages one and two suggests the persistence of open water. Plant remains generated in the littoral margins were likely transported to the deeper portions of the basin by water currents and gravity. Based on its representation in the peat, *C. trifarium* was the most abundant moss of the sedge-mat and likely grew in suitable microenvironments among wetland sedges. *M. triquetra* was relatively rare in the sediment. It likely grew in localized patches or as individual strands among *C. trifarium.* The habitat of both *C. trifarium* and *M. triquetra* is given as wet, calcareous or marly fen areas (Crum and Anderson 1981). These habitat descriptions support the proposed paleo-environment represented by Tamarack Bog, an extremely mineral-rich fen.

The extinction of the calciphilic mosses in the middle of stage three marks the disappearance of marl and the eventual dominance of *Sphagnum.* The elimination of marl suggests the closure of open water. Subsequent *Sphagnum* growth was probably favored by natural acidification of the wetland via cation exchange by brown mosses and production of H_2SO_4 by anaerobic bacteria. These changes eventually resulted in a transition from mineral-rich fen to *Sphagnum*-bog, thus eliminating suitable habitats for *C. trifarium* and *M. triquetra.*

The current ranges of *C. trifarium* and *M. triquetra* are similar because of their northern, perhaps boreal, affinity. In North America *C. trifarium* is found from Alaska to Newfoundland, south to Minnesota, Michigan, New York, and Ohio (Crum and Anderson 1981). It has not been reported from Indiana. Similarly, *M. triquetra* occurs from Alaska to Newfoundland, New Jersey, Michigan, Minnesota, and Manitoba across to British Columbia, and California (Crum and Anderson 1981). It has not been reported from Indiana.

Subfossils of *C. trifarium* have been found in Canada (Schweger and Janssens 1980), and Minnesota (Miller 1980, Janssens 1983). Janssens (1983) reported *C. trifarium* as being a major peat-former in certain peat strata in northern Minnesota. Prior to this study, no known subfossil records of *C. trifarium* from south of its current North American range existed.

Subfossils of *M. triquetra,* like *C. trifarium,* have been recovered from northern peatlands, including Canada (Kuhry et al. 1993), Alaska (Montagnes 1990), Minnesota (Miller 1980, Janssens 1983), and New York (Miller 1980). Two records of *M. triquetra* subfossils come from south of its current range: Iowa (899-144 years BP) and southern Ohio (19,585-19,355 years BP), indicating that the range of *M. triquetra* once stretched much farther south (Montagnes 1990).

Although radiocarbon dates were not available for the present study, the presence of post-glacial subfossils of *Calliergon trifarium* and *Meesia triquetra* to within one meter of the surface of an Indiana bog is noteworthy. The results of the present study suggest that: 1) these boreal species persisted in Indiana until relatively recent times, 2) the ranges of both species have since receded northward, and 3) natural acidification due to late successional stage brought about their local demise.

Calcareous peatlands that presumably could support these boreal mosses, still occur in other parts of northern Indiana. The disappearance of these mosses from the state may have been a result of climate change. However, extensive destruction and drainage-induced senescence of suitable habitats may have resulted in elimination of scattered refugia that might otherwise have supported the species into present times. It is equally possible that *C. trifarium* and/or *M. triquetra* still occur in a few peatlands in Indiana, but the dearth of peatland and bryological investigations in the area, may have prevented their previous location.

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