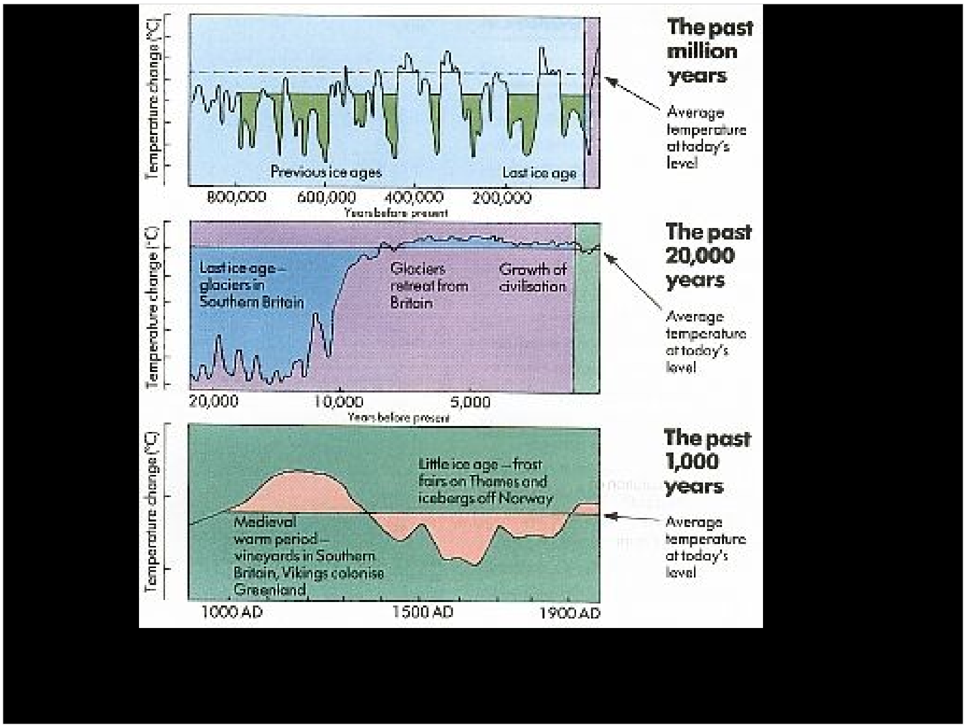
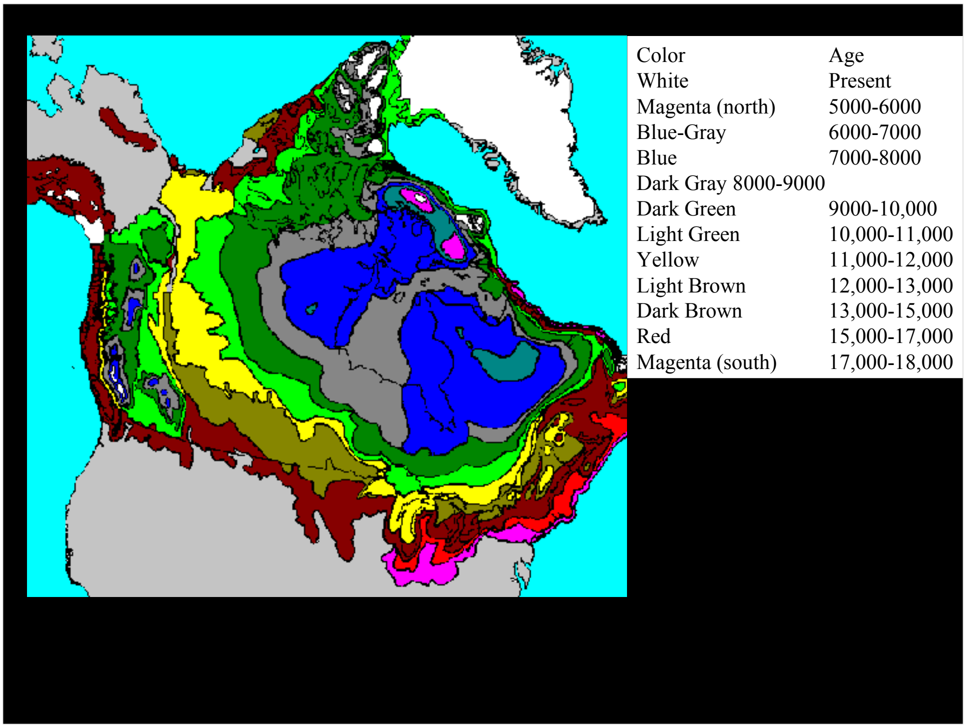
Communities are simply groups of species co-occurring at some time in some habitat or area. Primary properties of interest include:

- Species Diversity (fundamentally a community property)
    - Diversity includes RICHNESS and EVENNESS components
- Structure or physiognomy (forest, woodland, grassland, etc.)
- Productivity (later!)
- Dynamics (changes in all of above; are they predictable?)
- Environmental Relationships

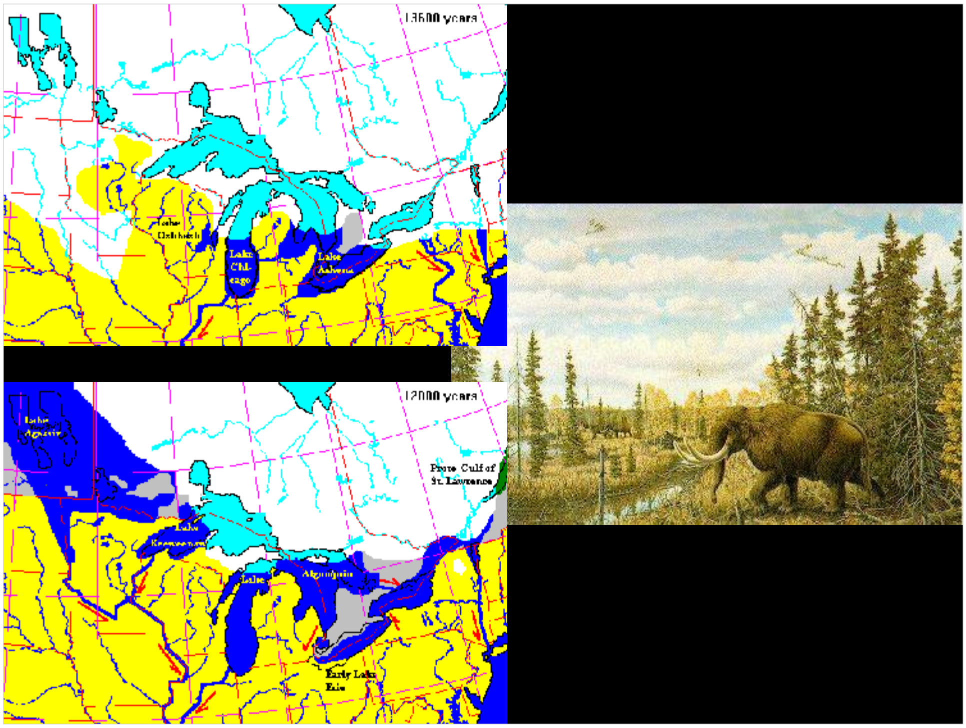
Beginning to look at *ecological communities*: some basic starting points and terms.



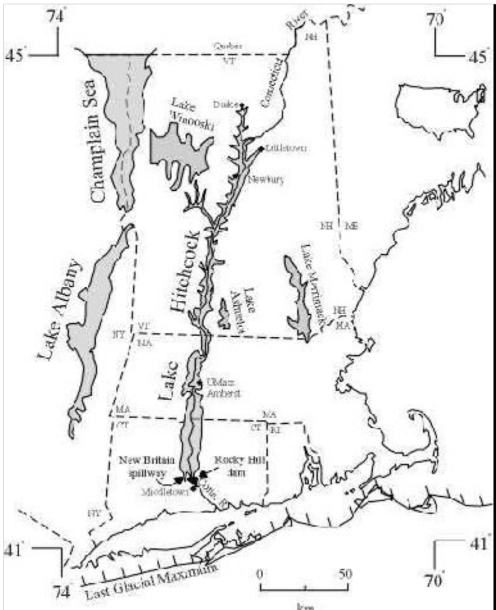
Long temporal view first: Climate has varied at multiple scales. Over last 2 million years (Pleistocene era), variation has been dominated by cyclic advance and retreat of continental ice-sheets.

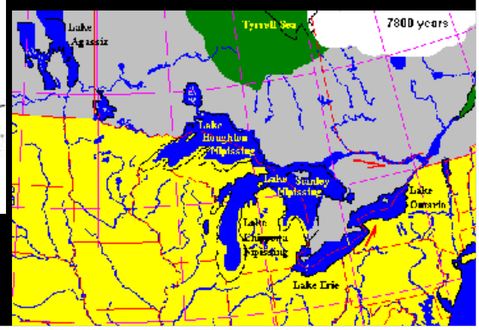


The last North American ice-sheet is referred to as the 'Wisconsin' glaciation. It lasted about 100,000 years, but reached maximum extent about 20,000 years before present (ybp) and began rapid retreat about 14,000 ybp

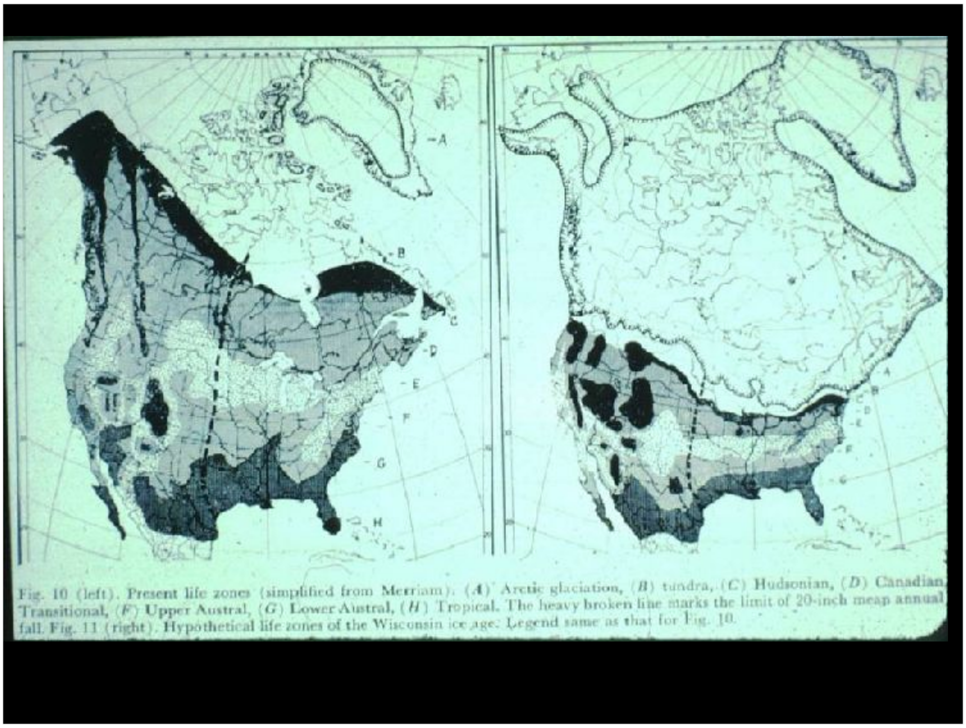


Retreating from our area about 13,000 ybp, with arrival of fauna and flora typical of tundra and treeline forests shortly thereafter. Massive proglacial lakes formed and glacial meltwater was drained off through progressively shifting channels corresponding to modern river valleys. These rivers were many times larger than any modern river.

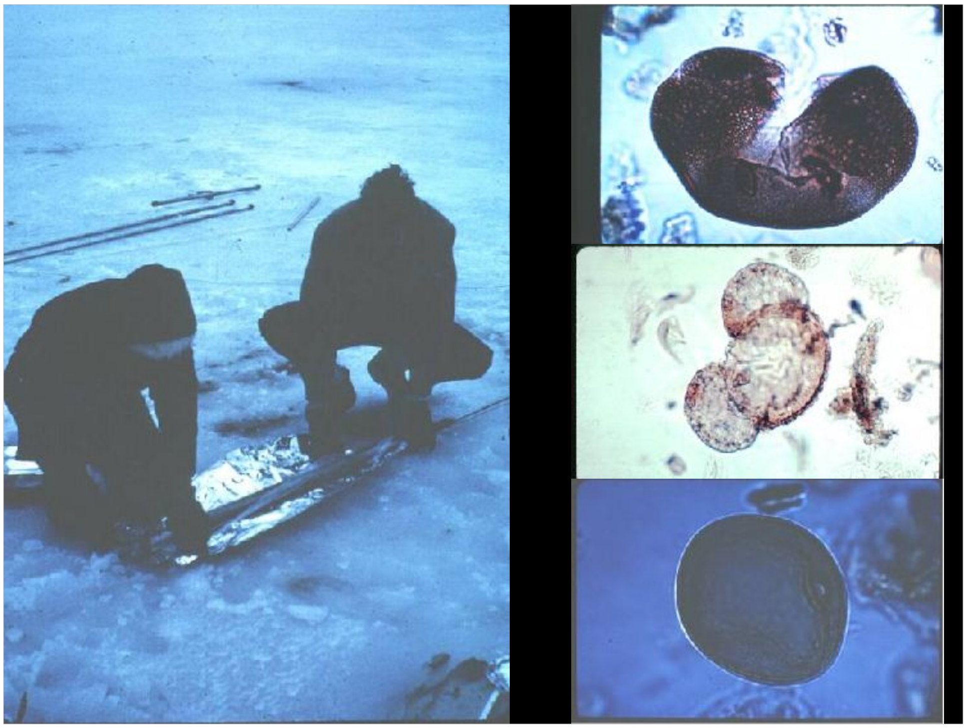




The north-south valleys of western New England and eastern New York were filled with a series of proglacial lakes. The Lake Champlain basin was, briefly, an arm of the north Atlantic before the crust ‘rebounded’ from the weight of the glacier sufficiently to lift it above sea-level. Ice did not leave the highlands of Labrador until about 5000 ybp. The crust around Hudson Bay is still rebounding so that the bay is shrinking.



For a long time, ecologists imagined that communities simply moved with the climate in zones – that communities would have been present in same sequence along, say, a transect northward from the Gulf of Mexico, just in a more compressed form, like an accordion squeezed or stretched depending on climate. This model sees communities as entities that behave as an integrated whole. However, until the 1960s, there was no easy way to reconstruct past communities to assess this model



Until researchers realized that sediments in lakes and peat accumulated in bogs contained and preserved large amounts of plant material collected from surrounding vegetation. Since these sediments are often anaerobic (or highly acidic in the case of peats), decay is very slow. Since sediments accumulate over time, remains are in temporal sequence, from the deepest sediments deposited immediately after glacial retreat to uppermost sediments being deposited currently. Technologies for extracting cores of lake sediments allowed access to a vast new data set. The most abundant fossils in lake sediments are pollen grains. Wind-pollinated species of trees shed vast quantities of pollen, and pollen walls are made of highly resistant sporopollenin (very similar to chitin). Pollen assemblages at a particular depth reflect forest composition (but complexly; different species produce pollen at different rates, some species can’t be easily distinguished from pollen, etc.)

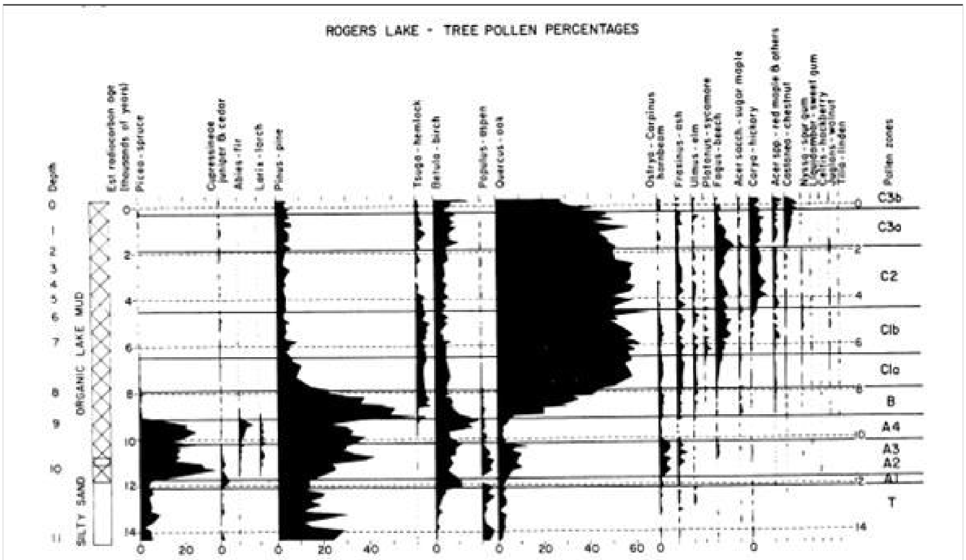
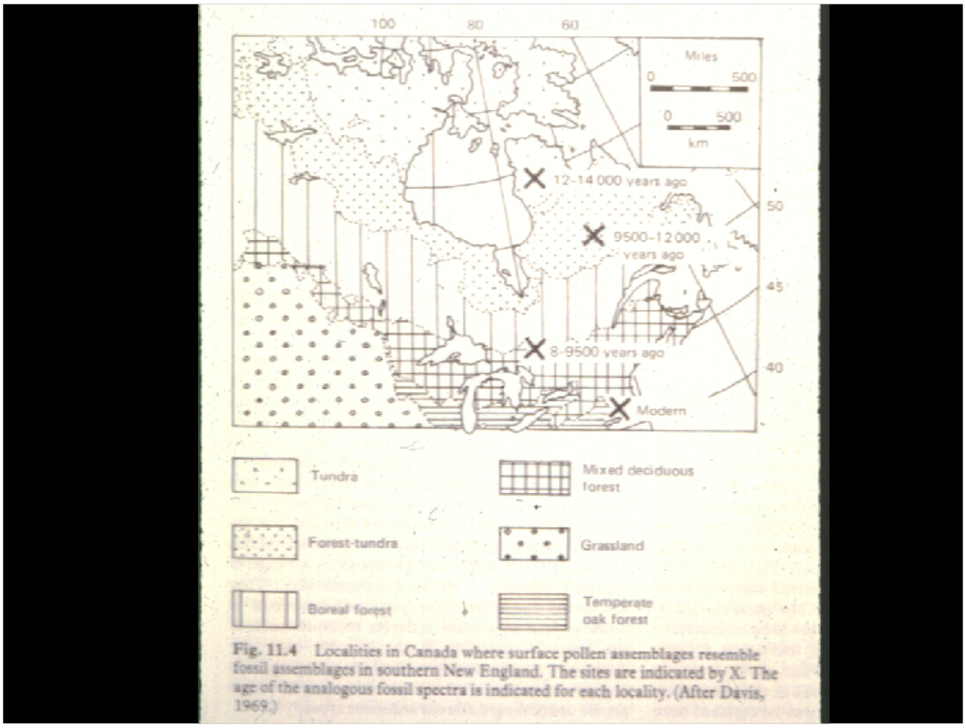
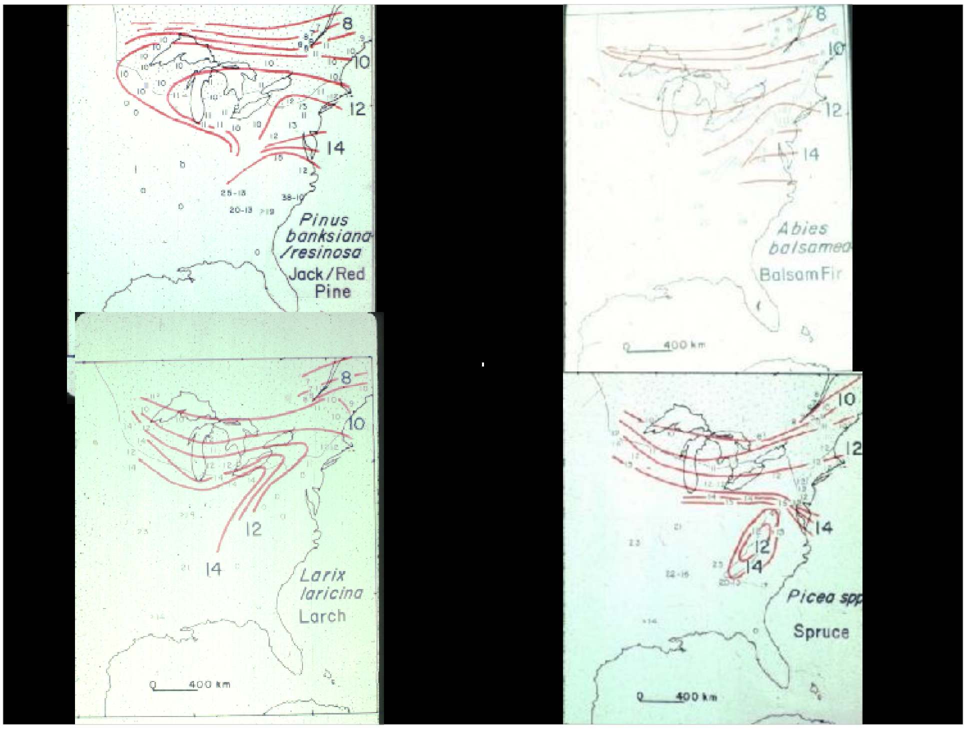


FIG. 4. Percentages for tree pollen types, calculated as percent total pollen from terrestrial plants, plotted against the absolute age of the sediment.

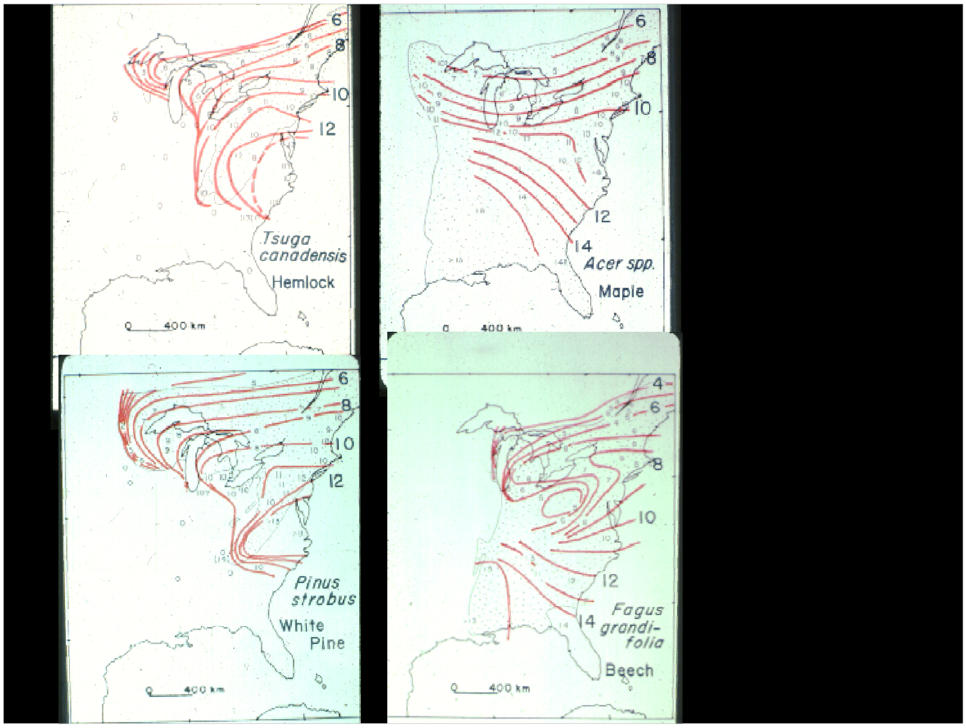
'Pollen diagrams' show trends in abundance for different species or groups of plants. The vertical axis is time, with older deposits at the bottom. Rogers Lake is in Connecticut, and sediments began accumulating here with the retreat of the ice sheet about 14,000 ybp. Note that pine and oak pollen are most abundant – but these groups are very prolific pollen producers (and it's not possible to fully discriminate the various species in each genus).



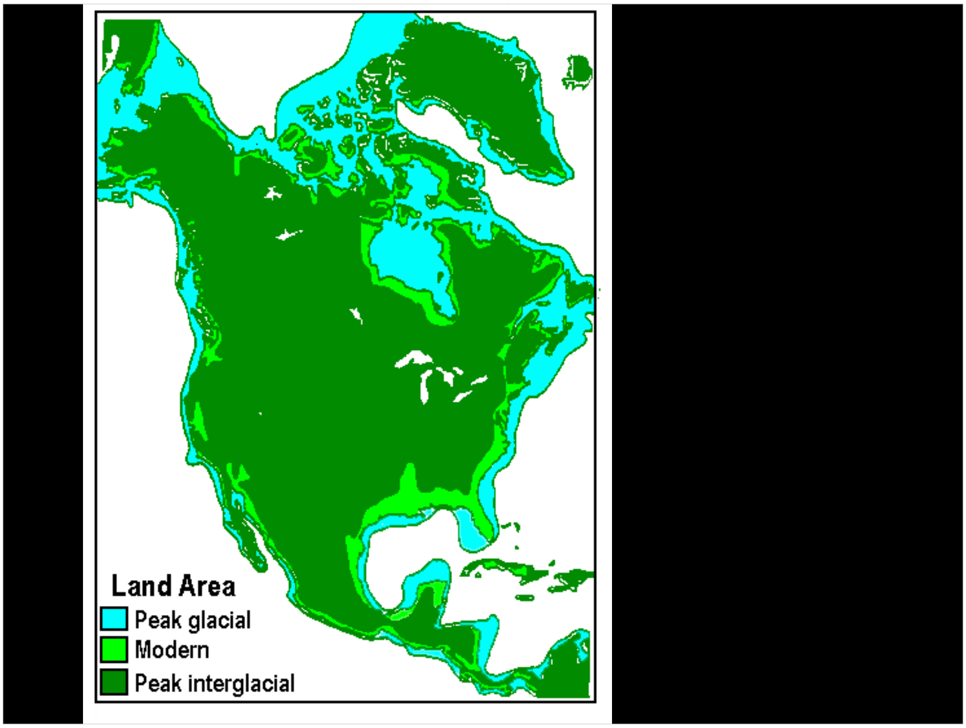
Margaret Davis compared pollen assemblages at various depths at Rogers Lake to modern assemblages elsewhere and judged what past vegetation might have looked like on the basis of the most similar modern pollen assemblages (for example, pollen assemblages at Rogers Lake from 9500-12000 years ago looked like pollen currently being deposited in lakes about 800 mi north in north-central Quebec).



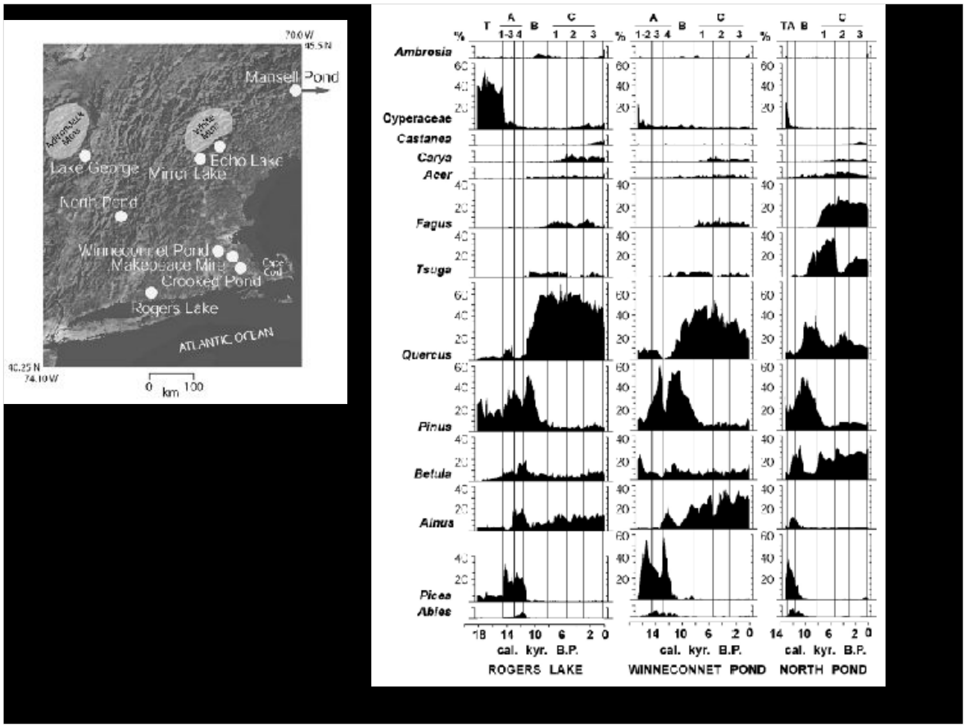
However, patterns became more complicated when data from dozens of pollen coring sites were compiled. Here, small numbers indicate the age of first occurrence of a species in 1000s of years. The red lines suggest the northern range limit of each species for a given number of millennia in the past. Larch (*Larix*), for example, appears to have occurred in the lower midwest at full-glacial (about 20,000 ybp), but never on the eastern seaboard. It spread northward to the Great Lakes region, then expanded eastward and westward into current range (stippled area). All of the species shown here currently co-occur broadly across northern North America and are typically considered co-dominants of the boreal forest community 'type'. But note that 20,000 ybp, they did not occur together anywhere; jack pine and balsam fair occurred only along the east coast, while larch occurred only inland.



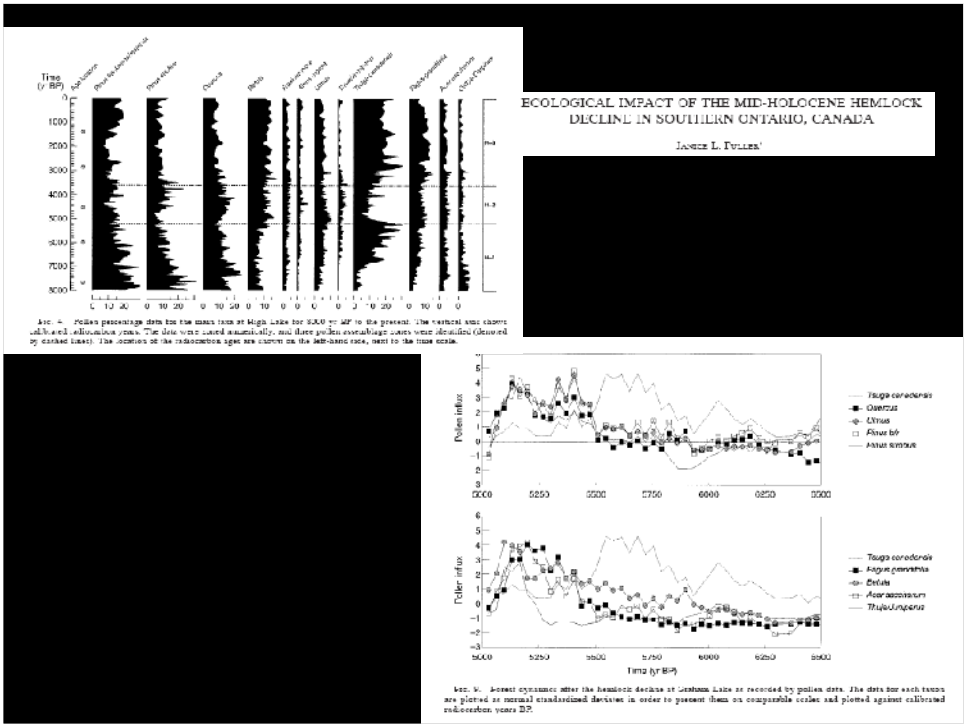
Similarly, the dominant species of the northern hardwood forests (typical of older forests on mesic sites in central and northern New England) did not occur together at full-glacial. White pine and hemlock appear to have lived in 'glacial refugia' along the east coast in areas subsequently flooded as sea level rose with the melting of the ice. At some times in the past, then, species occurred in combinations not generally observed today (and *vice versa*); these are often referred to as 'no-analogue communities'.



There was substantial additional land area available for occupancy at peak glacial.



Other striking changes (and ‘no-analogue’ situations) can be found in the pollen record. For example, eastern hemlock *(Tsuga canadensis)* underwent a massive population collapse everywhere in its range, simulataneously, at about 4800 ybp. Because the ‘hemlock decline’ happened simultaneously across its range, and other late-successional trees did not show large changes, this is usually interpreted as the result of a new disease (or, possibly, an insect pest), rather than as the result of climate changes.



Immediately following the hemlock decline, species like oak, elm, and pines showed sharp increases in pollen abundance. Beech, maple, and birch pollen increased a couple of hundred years later. These dynamics are typical responses to canopy disturbance in forests today.

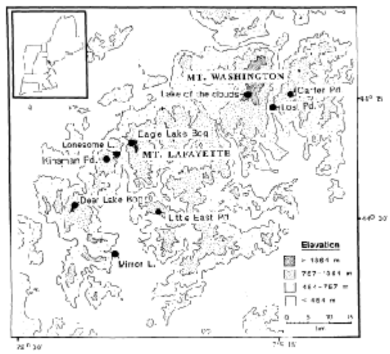


FIG. 1. Map of White Mountains study area showing elevations, site locations, and mountain massifs.

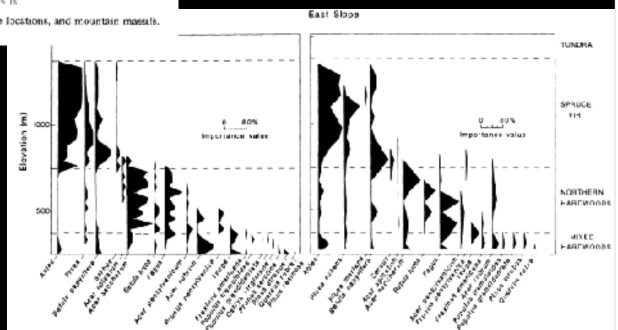


FIG. 3. Vegetation zonation based on transects from north and east slopes in the study area. Importance values have been rescaled and presented as percentages.

Ray Spear constructed pollen diagrams for lakes at various elevations in the central White Mountains of New Hampshire. Today, the slopes of these mountains show a gradient of community composition from oak and pine at lowest elevations, through northern hardwood species, to boreal forest (or ‘subalpine’ forest) species, and finally to tundra at highest elevations

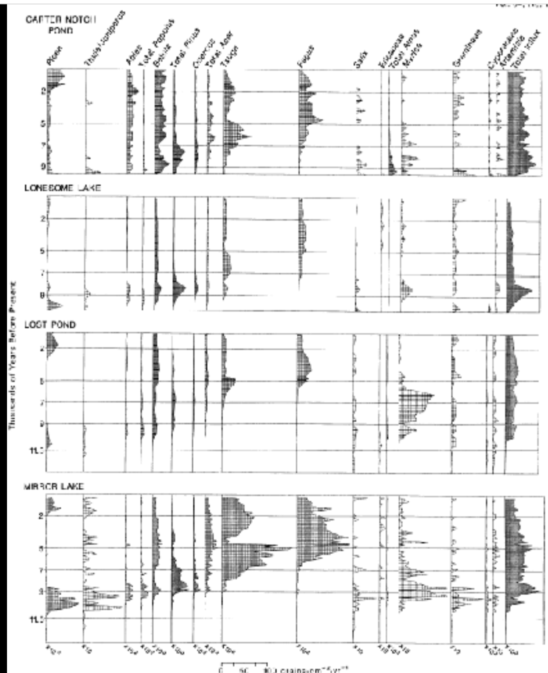


FIG. 7. Pollen influx diagrams in elevational sequence with the lowest coring site at the bottom: Mirror Lake 213 m, Lost Pond 625 m, Lonesome Lake 831 m, and Carter Notch Pond 1004 m.

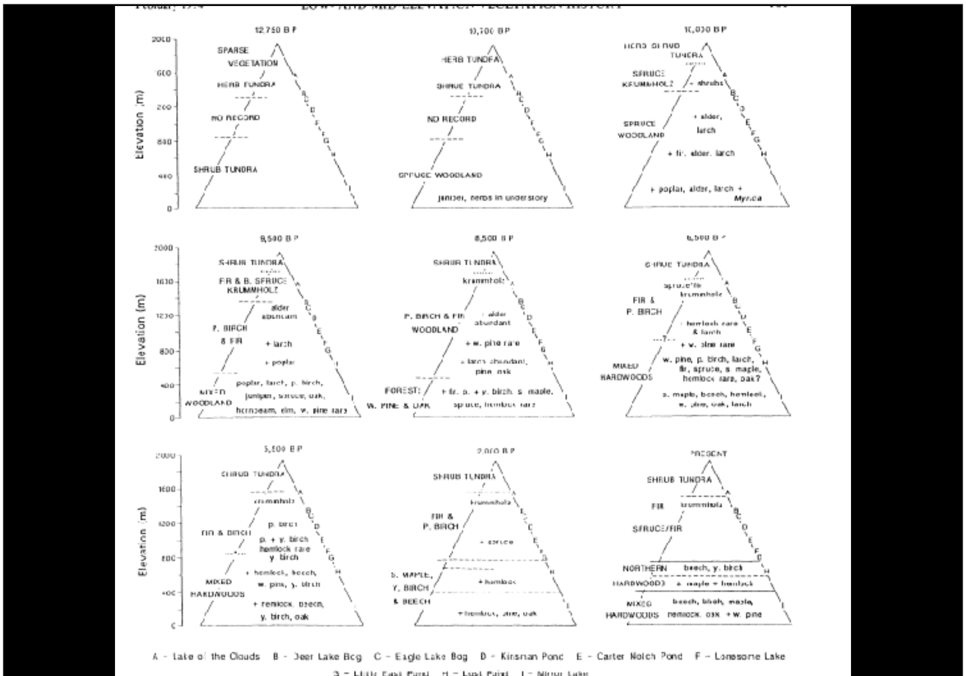
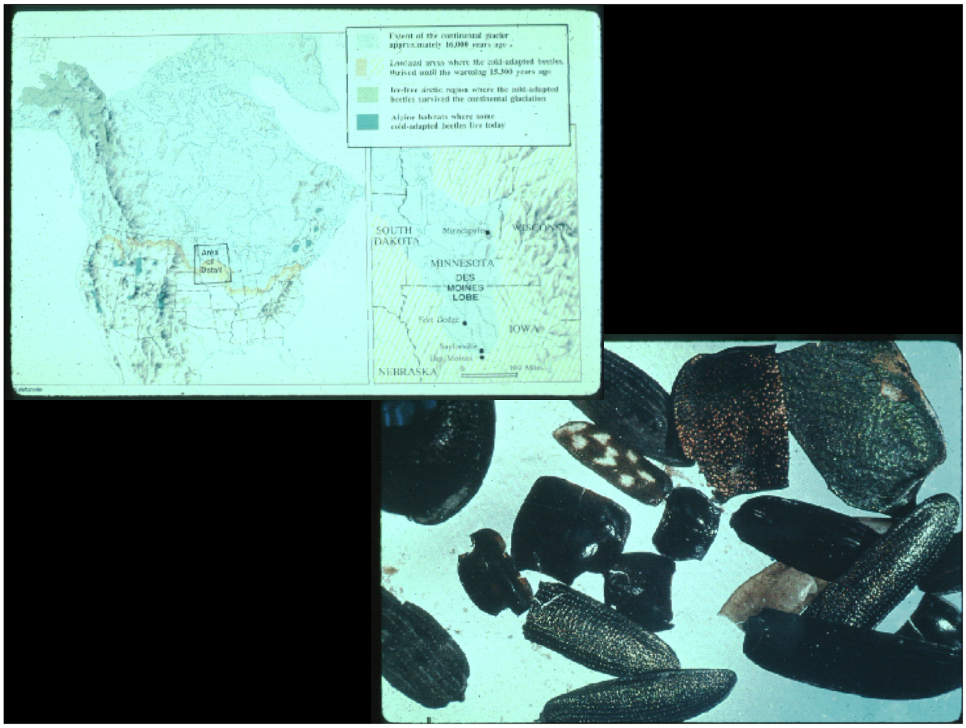
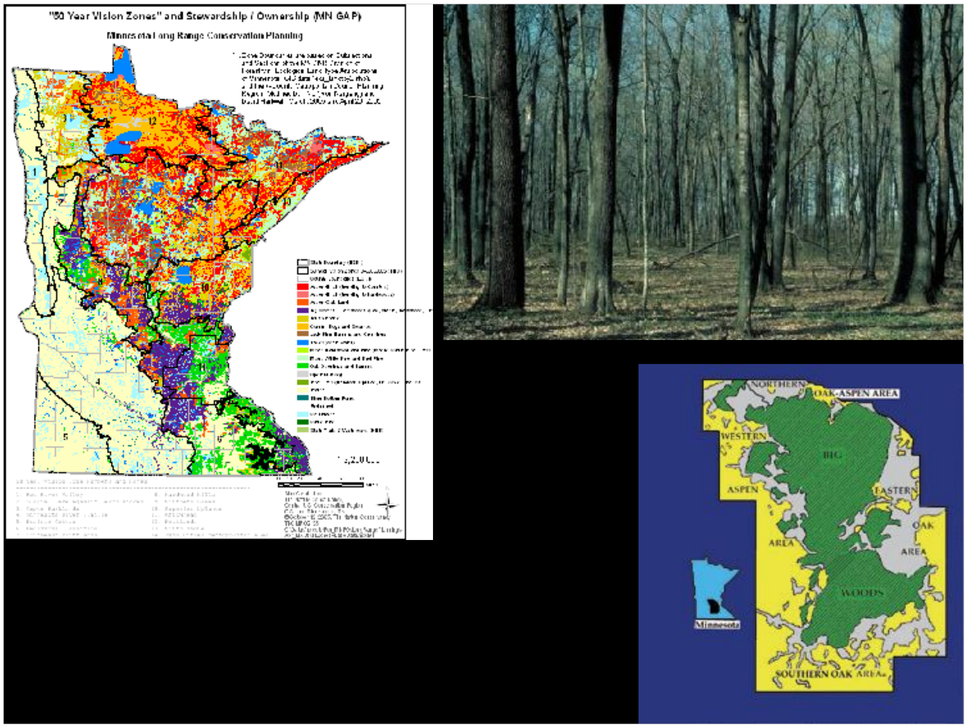


FIG. 9. Schematic summary of vegetation change through time and across elevational gradients in the White Mountains region of New Hampshire.

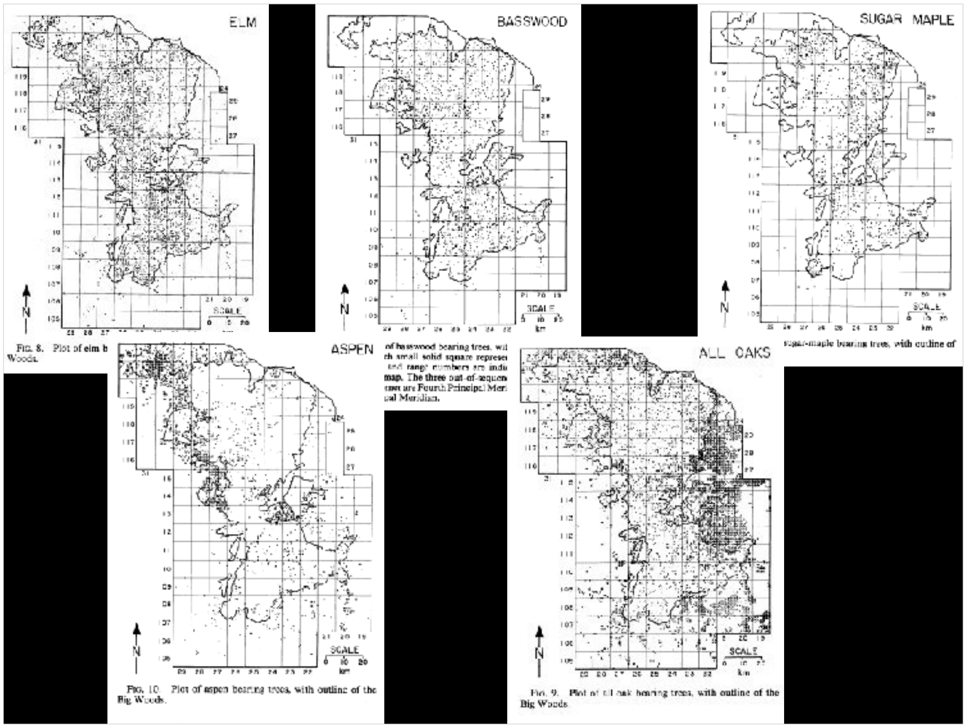
But reconstruction of vegetation patterns along this elevational transect for various intervals over the last 12,000 years show complex shifts that don't always 'make sense' in terms of modern vegetation types and patterns; again, there appear to be 'no-analogue' types of vegetation. For example, note the 'mixed woodland' type of 9500 years ago and the 'paper birch and fir woodland' of 8500 ybp.



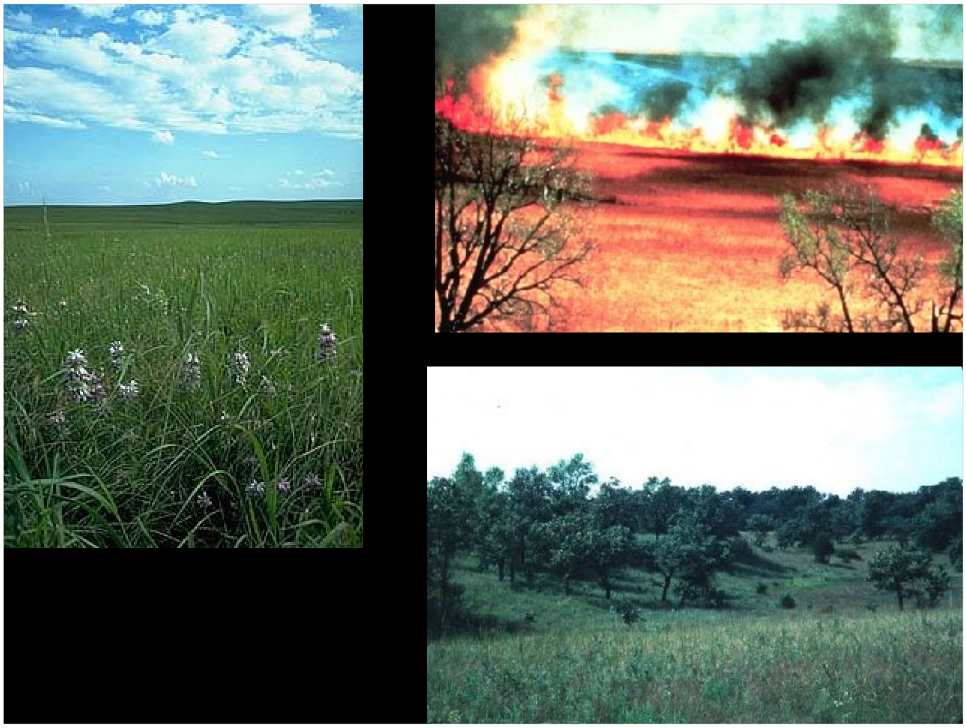
Animals show similar patterns. Beetle exoskeletons can also be well-preserved in sediments. Species found together from 16,000 ybp near the glacier's edge in Iowa are now found in widely separate locations from Alaska to the mountaintops of New England; the community that existed then is nowhere present today.



Sometimes, changes in community structure and composition appear to have been more dramatic and, perhaps, less predictable. Note that dark blue area in SE Minnesota. This is often referred to as the ‘Big Woods’ region. It was, prior to European settlement, dominated by mesic forests composed primarily of maple, basswood, and elm. To the west, south, and southeast was prairie grassland; to the northeast and north, oak woodland. Photo in upper right is a remnant stand of mesic ‘Big Woods’ at Nerstrand Woods State Park.



These reconstructions are based on 'witness trees' recorded by the early land surveyors.



Prairies and oak savanna/woodland vegetation burns very frequently (typically every few years). While mature oaks can resist fire, seedlings can't survive it. The 'Big Woods' species are completely intolerant of fire, so frequent fires can maintain grasslands. On the other hand, mesic forests of maple and basswood are extremely difficult to burn; there's little fuel on the forest floor and the foliage is not very flammable when green (unlike resinous conifer needles).

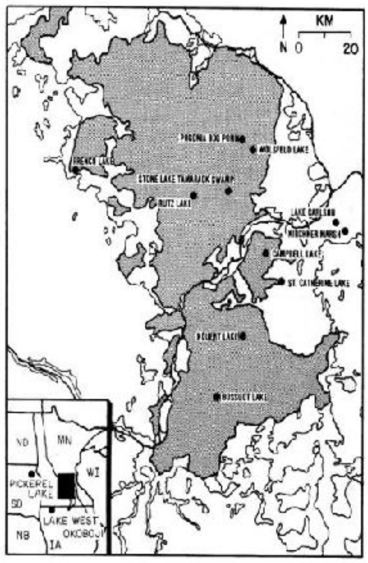


Fig. 1 Map of the study area, showing the vegetation at the time of settlement by Europeans and the locations of sites from which pollen diagrams have been made. The darkly shaded area is the Big Woods, the lightly shaded area is oak-aspen woodland; and the unshaded area is prairie. In the inset the shaded area is forest, and the unshaded area is prairie. Sites and authors are: Pogonia Bog Pond, Stone Lake Tamarack Swamp (Swain, 1979); Rutz Lake (Waddington, 1969); Lake Carlson, Kirchner Marsh (Wright *et al.*, 1963); Campbell Lake, St. Catherine Lake, Kouert Lake, Bossuot Lake (McAndrews, 1968); Pickerel Lake (Watts and Bright, 1958); Lake West Okoboji (Van Zant, 1979).

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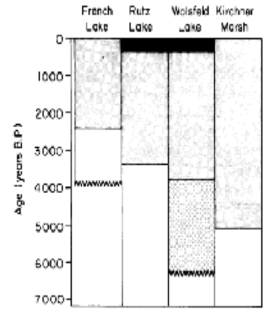

Fig. 13. Chart showing correlation of vegetation types from the pollen stratigraphy of cores from sites on a transect across the Big Woods. Time period shown is 7200–0 B.P. Sawtooth bottom line indicates position of the lowest level of the core analysed for pollen. Straight bottom line indicates levels older than 7200 B.P. have been analysed. Inferred vegetation types: ■, Bigwoods; □, oak woodland and prairie; ▨, oak woodland; □, prairie.

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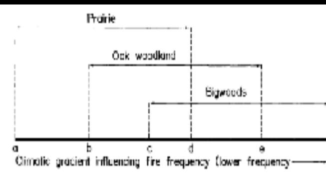

. 14. Schematic diagram showing ranges over which prairie, oak woodland, and bigwoods will persist on a one-dimensional climatic gradient influencing fire frequency.

Eric Grimm collected pollen cores from lakes across the Big Woods area. He found that the mesic ‘Big Woods’ forest had been present only for the last few centuries; prior to that, the area was occupied by either oak woodland, or even prairie. The establishment of the Big Woods forests coincided with a cool, moist period known as the Little Ice Age – but these forests persisted into drier, warmer climates subsequently. Grimm suggested that *either* mesic forest OR oak woodland OR prairie could exist in the same climate by promoting fire frequencies that are favorable to their own maintenance. Once an area burns, fire-tolerant species are favored *and they tend to promote more frequent firest*. But mesic trees of the ‘big woods’, once established, tend to suppress fire. Thus, *either type* might persist indefinitely under the same conditions unless either a) climate changes to a point where only one type *can* survive, or b) some unusual event ‘tips’ the system into the other state – a ‘two-state’ system that tends to be stable in whichever state it occupies. (Technically, a metastable system vulnerable to ‘cusp catastrophes’).